

**A Dual-Task Tool for Quantifying Normal Comprehension of Aphasic Connected
Speech Production: A Constructive Replication**

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Abstract

This study used resource allocation theory and dual-task methods to assess whether a language comprehension task and a visual-manual tracking task exhibited concurrent performance costs. Using increased tracking task demands compared to a previous study (McNeil et al., in press), results were replicated. Normal participants tracked significantly better when they listened to mildly versus moderately aphasic speakers' story retells. Contrary to predictions, no effect of tracking difficulty on story retell performance was found despite the increased tracking difficulties used compared to the previous study.

Attentional impairments secondary to brain damage have been proposed as all or part of the underlying mechanisms for the linguistic impairments that characterize aphasia (McNeil, 1988; McNeil, Odell, & Tseng, 1991; Clark & Robin, 1995; Granier, Robin, Shapiro, Peach, & Zimba, 2000; Murray, Holland, & Beeson, 1997; Tseng, McNeil, & Milenkovic, 1993). Deficits of attention or its control have also motivated the development of a tool for quantifying the difficulty that normal listeners have understanding the language production of persons with varying amounts of aphasia (McNeil et al., in press). In this study, McNeil and colleagues found a significant decrement in the visual-manual tracking accuracy of normal older individuals while concurrently listening to the connected language of a person with moderate as compared to mild aphasia. Additionally, no performance costs were observed on the listening tasks across any of the three tracking difficulty levels. Several post-hoc explanations were proposed for these unanticipated findings. One interpretation was insufficient tracking task difficulty. This explanation suggested that the tracking task did not adequately challenge the comprehension and retelling task in a manner that would be required to show a concurrent cost. In order to investigate this hypothesis, a constructive replication of the previous study was conducted. Concurrent costs of tracking and listening were investigated, using one tracking difficulty level from the previous study and a more difficult tracking level paired with the same two story levels that demonstrated an effect on tracking performance. We asked whether the increased visual- manual tracking task difficulty would demonstrate a concurrent cost on the listening task that was not evidenced in the previous study.

METHOD

Participants

A total of 24 normal individuals between 40-72 years of age, with no history of neurological involvement, served as participants. Inclusion criteria included normal speech, language and memory functions (see Table 1 for participant data and screening criteria). All participants passed a pure tone hearing screening and vision screening.

Procedure

Participants performed a visual-manual tracking task under two conditions. The first required the participants to perform the tracking task in isolation. The second involved concurrently tracking and listening under four different conditions where the difficulty of both the listening (mild and moderate aphasic story difficulty) and tracking (easy and hard) tasks were parametrically manipulated. The tracking task required the participants to manually control a cross-hair using a joystick. Participant's maintained the cross-hair on an unpredictably varying waveform that scrolled across the computer screen. In order to make the tracking tasks more difficult than those used in the previous study (McNeil et al., in press), the viewing window was reduced to one-tenth the original size in order to reduce the tracker's ability to predict the upcoming wave and preplan their response. The easier tracking condition in the current study was the difficult condition in the previous study. The more difficult condition in the current study was constructed by increasing the frequency of directional changes in the wave compared to the easier condition.

In an effort to minimize warm-up and practice effects across experimental conditions, participants performed 12 two-minute tracking-only trials prior to the single-

task tracking condition. The presentation order of the practice trials were counterbalanced, so that each participant tracked six 2-minute waves at each of the two difficulty conditions in a randomized order. These trials were not analyzed. Following the practice trials all participants performed three counterbalanced, by difficulty level, single-task tracking trials at one of the two tracking difficulty conditions prior to the dual-task condition and three trials after the dual-task conditions.

The listening task used for this study was the Story Retell Procedure (SRP) which has been shown to be a reliable, valid and sensitive index of connected speech comprehension/production performance in adults with and without aphasia (McNeil et al., 2001; McNeil, Doyle, Park, Fossett, & Brodsky, 2002). Under the dual-task conditions, each participant heard six stories produced by a person with mild aphasia and six stories produced by a person with moderate aphasia. Stimuli were derived from four story forms (consisting of three stories each), selected at each aphasia difficulty level (4 forms x 2 difficulty levels). Four digitized story forms were randomly assigned (from the eight available forms) to each participant and counterbalanced so that each story form was represented an equal number of times across each story and tracking difficulty level. Following each story in the dual-task condition, the participants stopped tracking and retold the story in their own words. The retellings were digitally recorded and subsequently scored for %IUs/Min. Participants were instructed to give their full and equal attention to both tasks.

The single and dual-task tracking data (root means square (RMS) tracking error) were analyzed using a two-way repeated measures ANOVA with two levels of tracking difficulty at each of the three story conditions (no story, mild aphasic story and moderate

aphasic story). The Story data (%IUs/Min) were analyzed with a two-way repeated measures ANOVA with two levels of story difficulty at each of the two tracking difficulty conditions.

RESULTS

Analysis of the tracking data revealed significant main effects ($p < .05$) of tracking difficulty ($F_{(1,23)} = 14.91$) and story difficulty ($F_{(2,22)} = 9.361$), and a significant interaction ($F_{(2,22)} = 22.83$). Given the presence of the significant interaction, post hoc analyses were carried out using the Bonferroni adjustment for multiple comparisons ($\alpha = .05/3 = .017$) to test for significant contrasts among the three story conditions at both tracking difficulty levels. None of the comparisons made with the harder tracking condition reached significance. Under the easy tracking condition, tracking error was reduced significantly in the dual-task condition where the mild aphasical story condition was heard compared to the single-task tracking condition and to the moderate story condition (illustrated in Figure 1).

Analysis of story performance revealed significantly more %IUs/Min in the mild aphasical story condition than in the moderate aphasical story condition ($F_{(1,23)} = 87.16$) and no significant effect of tracking on story performance (illustrated in Figure 2).

DISCUSSION

The findings from this study, using an increased level of tracking difficulty compared to the McNeil et al. (in press) study are consistent with the results obtained in that study. This replication does not support the hypothesis that the unidirectional performance cost demonstrated in the previous study (decreased tracking under varying

listening conditions but no effect of listening under varying tracking conditions) was due to the suboptimal difficulty level of visual-manual tracking task. Additionally, as speculated in the previous study, it remains possible that the measure of the language performance was not sensitive enough to detect the cost of shared processing resource incurred under dual-task conditions.

The fact that tracking performance in the single-task condition was significantly poorer than in the dual-task condition with the mild story difficulty level was unexpected relative to classical resource allocation theory. Possible explanations for this finding include the notion that single to dual-task comparisons may not call upon the same mechanisms of resource allocation (pools or strategies) or that under dual task conditions, greater quantities of resources are recruited because of increased task demands.

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Table 1.
Descriptive Participant Data and Inclusion Criteria

Subject	Age	RTT^a Percentile	SPICA^b Percentile	ABCD^c Ratio
1	48	62	60	1.13
2	49	58	35	1.15
5	44	80	55	1.0
6	67	55	95	1.0
7	45	67	5	1.06
8	55	27	90	1.06
9	49	53	50	.94
10	41	50	95	1.0
11	44	21	30	1.0
12	43	81	99	.88
13	58	78	85	1.0
15	64	84	75	1.06
16	56	80	45	1.07
17	59	56	30	1.0
18	52	62	75	1.0
19	55	28	85	1.0
21	53	82	55	1.0
22	64	78	55	1.0
23	68	22	80	1.0
24	56	38	5	.93
25	58	19	55	1.07
26	72	79	20	.92
27	53	53	35	.92
28	40	65	35	1.0
Inclusion Criteria:	40-75	≥ 5th %ile for normal adults	≥ 5th %ile for normal adults	within 2 SD of normal adults (6.8 – 1.24)^d
Mean	53.88	57.42	56.21	1.07
SD	8.88	21.59	28.27	.06
Range	40-72	19-84	5-99	.88-1.15

^aRevised Token Test (McNeil & Prescott, 1988)

^bShortened Porch Index of Communicative Ability (DiSimoni, Keith, & Darley, 1980)

^cArizona Battery of Communication Disorders of Dementia (Bayles & Tomoeda, 1993)

^dABCD Normative Data (Bayles, Boone, Tomoeda, Slauson, & Kaszniak, 1989)

Figure 1. Tracking performance during single and dual-task tracking with two story difficulty levels across two tracking difficulty levels.

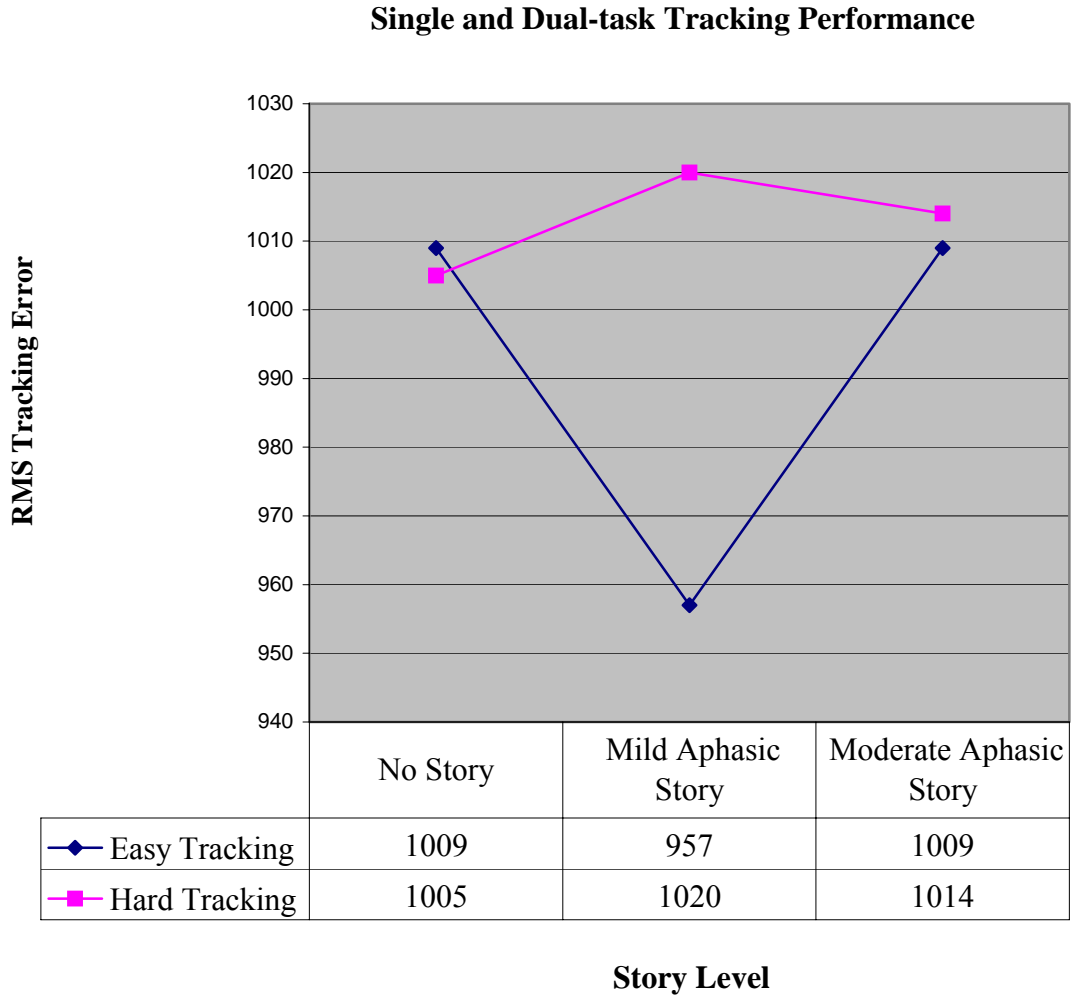


Figure 2. Effect of tracking difficulty on story retell performance.

