The Effects of Verb Network Strengthening Treatment (VNeST) on Sentence Production in Individuals with Aphasia

Some persons with aphasia exhibit a selective verb deficit (e.g., Berndt, Mitchum, Haendiges & Sandson, 1997a,b) which can impair sentence production since verbs serve as the semantic-syntactic interface of a sentence. Recent priming studies have showed that a verb primes typical agents and patients (Ferretti, McRae, & Hatherell, 2001) and vice versa (McRae, Hare, Elman, & Ferretti, in press), so there appears to be neural co-activation when a verb or its closely related noun is selected in a relevant context. The implication is that memory is structured so that when a verb is activated generalized situational knowledge is also activated.

According to Bock & Levelt's model (1994), impairment at the functional level of sentence production can produce deficits in word retrieval if the lemmas for the target content words (agent-verb-patient) are not sufficiently activated. If reduction of activation is due to a weak semantic representation of the verb (related to a verb's thematics) then sentence production can be compromised with respect to retrieval or semantic specificity of content words. Previous treatment experiments that have provided verb semantic treatment to improve verb retrieval in sentence production (Edwards, Tucker, & McCann, 2004; Marshall, Pring, & Chiat, 1998; Raymer & Ellsworth, 2002; Schneider & Thompson, 2003) have reported improvement of trained items, whereas only one reported improvement in semantically untrained verbs and their arguments in one participant (an unexpected finding) (Marshall et al., 1998).

The present treatment approach, Verb Network Strengthening Treatment (VNeST), focuses on retrieval of thematic pairs (e.g., *surveyor/land*, *chef/sugar*) related to the trained verb (e.g., *measure*) to strengthen the agent-verb-patient network to ultimately improve sentence production. Predictions are hierarchical in nature and are as follows:

1) For *trained* verbs (e.g., *measure*), generalization to production of the content words (i.e., *The carpenter is measuring the stairs*.) of a sentence in a picture description task will occur since retrieval of an appropriate verb and its thematic roles will improve due to strengthened connections between the verbs and their thematics.
2) For *semantically related untrained* verbs (e.g., *weigh*), generalization to production of content words (e.g., *The nurse is weighing the baby*.) will occur due to spreading activation from the trained verb network to the untrained verb network. Previous verb (Marshall et al., 1997) and noun (Drew & Thompson, 1999; Kiran & Thompson, 2003) treatment studies have reported semantic generalization.
3) Sentence production on the *Northwestern Sentence Production Battery* (Thompson, 2002) (without provision of the verb during testing) will improve due to increased verb retrieval/accuracy. Additionally, treatment items represent common actions similar to those tested on the *NVPB*.
4) Single noun naming on the *Boston Naming Test* (Goodglass & Kaplan, 1983) will improve due to systematic activation and retrieval of a variety of nouns during treatment.
5) No improvement will occur in an *adjective sentence completion task* (control task). Even though this task requires production of a lemma level item and only requires single word retrieval (as opposed to an entire sentence), it is hypothesized not to improve with treatment since the adjectives are unrelated to the treatment verbs.

Methods

Participants. Four right-handed participants with moderate aphasia met several standard inclusion criteria, including left hemisphere stroke involving the perisylvian area at least nine

months prior to study. All participants exhibited verb deficits as evidenced by poorer single verb naming than noun naming (on stimuli matched for frequency, imageability, and familiarity) and impaired sentence production largely due to verb errors/omissions on a variety of tasks.

Stimuli. Twenty-four verbs divided into two sets served as the basis for the primary tasks in this study. Verb pairs were matched for semantic relatedness as determined from questionnaire responses of a normal group of 11 individuals (average relatedness rating was 5.53 (SD = 0.94) (on 1-7 point scale, 7 = very related). Additionally, verb pairs shared at least one verb class (Levin, 1993) and could take at least 2 arguments. Verbs were semantically "heavy" with specific semantic meanings (e.g., *bake, drive*) rather than "light" verbs (e.g., *make, go*). Sets were matched ($p > .05$, paired t-tests) on frequency, imageability, familiarity, and number of syllables (Wilson, 1987) (see Appendix A). Agents (e.g., *carpenter*) and patients (e.g., *stairs*) depicted on picture description tasks used in probes were also matched ($p > .05$) for the same parameters across verb sets (Student's t-test) (see Appendix B for target sentences). Pictures were 5"x7" hand-colored drawings centered on 8-1/2" x 11" white paper.

Adjectives used in the control task matched the 24 verbs on frequency, imageability, and familiarity ($p > .05$, Student's t-test). An adjective task was chosen rather than a verb task because a sufficient number of semantically unrelated verbs matched on all of the control factors could not be generated.

Design. A single subject experimental design with a multiple baseline across subjects (Connell & Thompson, 1986; McReynolds & Kearns, 1983) was used.

Treatment and control tasks. Treatment steps included: 1) generating 3 agent-patient pairs (e.g., *chef/sugar*) related to the target verb (e.g., *measure*), 2) answering three *wh-* questions related to one pair (e.g., *Where/When/Why does a chef measure sugar*?), 3) deciding whether 12 orally presented sentences containing the target verb (e.g., *The chef measures the recipe.*) were semantically correct, 4) repeating step 1. Participants were never required to say the verb in any context. Criterion for terminating treatment was 80% accurate retrieval of agent-patient pairs in step 1 across all trained verbs. The adjective control task consisted of generating an adjective synonym in a sentence completion task (e.g., *Someone who is sick is also said to be ill.*)

Results

Results of sentence production accuracy and the adjective control task are presented in Figures 1-4 in multiple baseline formats showing percent correct. A sentence was deemed correct if all content words were included with proper word order (e.g., *Carpenter is measure stairs.*), as morphology/syntax was not targeted in treatment.

All participants exhibited generalization (minimum of 40% point improvement over baseline) to sentence production with sentences containing trained and untrained verbs. No improvement was observed on the adjective control task for any participant (see Figures 1-4).

Participants exhibited improvements on pre- and post-treatment measures (see Table 1). *BNT* (Goodglass & Kaplan, 1983) scores improved at least 10 percentage points for participants 1, 3, and 4 (average = 17.9). *NVPB* (Thompson, 2002) sentence production scores improved at least 14 percentage points (average = 27.7) for all participants.

Discussion

Training thematic roles resulted in predicted generalization to sentence production for sentences that contained trained and untrained verbs in picture description. Systematic retrieval of agent-patients pairs in treatment presumably strengthened connections between trained verbs and their thematic roles so that lemma activation of the agent, verb, and patient during picture description was sufficient to facilitate retrieval. Improvement on sentences containing untrained

semantically related verbs occurred as a result of spreading activation from the trained verb network, a finding consistent with previous semantically based noun treatment paradigms (e.g., Boyle & Coehlo, 1995; Edmonds & Kiran, in press).

Error analyses revealed that sentence production improvement on the *Northwestern Verb Production Battery* (*NVPB*) (2002) resulted from improved verb retrieval/accuracy which likely occurred due to spreading activation from trained verbs since treatment items (e.g., *scrub*) often represented actions similar to those on the *NVPB* (e.g., *sweep, erase*). This improvement is encouraging with respect to potential carry over to overall communication abilities. Improvement on the *BNT* indicates that VNeST also generalizes to noun naming which likely improved due to systematic activation and retrieval of approximately 60 nouns representing a variety of categories during treatment.

The current findings are encouraging but preliminary. Further investigation is needed with respect to use of VNeST with other verb and sentence types in a variety of generalization tasks.

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Figure 1. Baseline, treatment, and 1 month maintenance results of sentence production and adjective control tasks for Participant 1

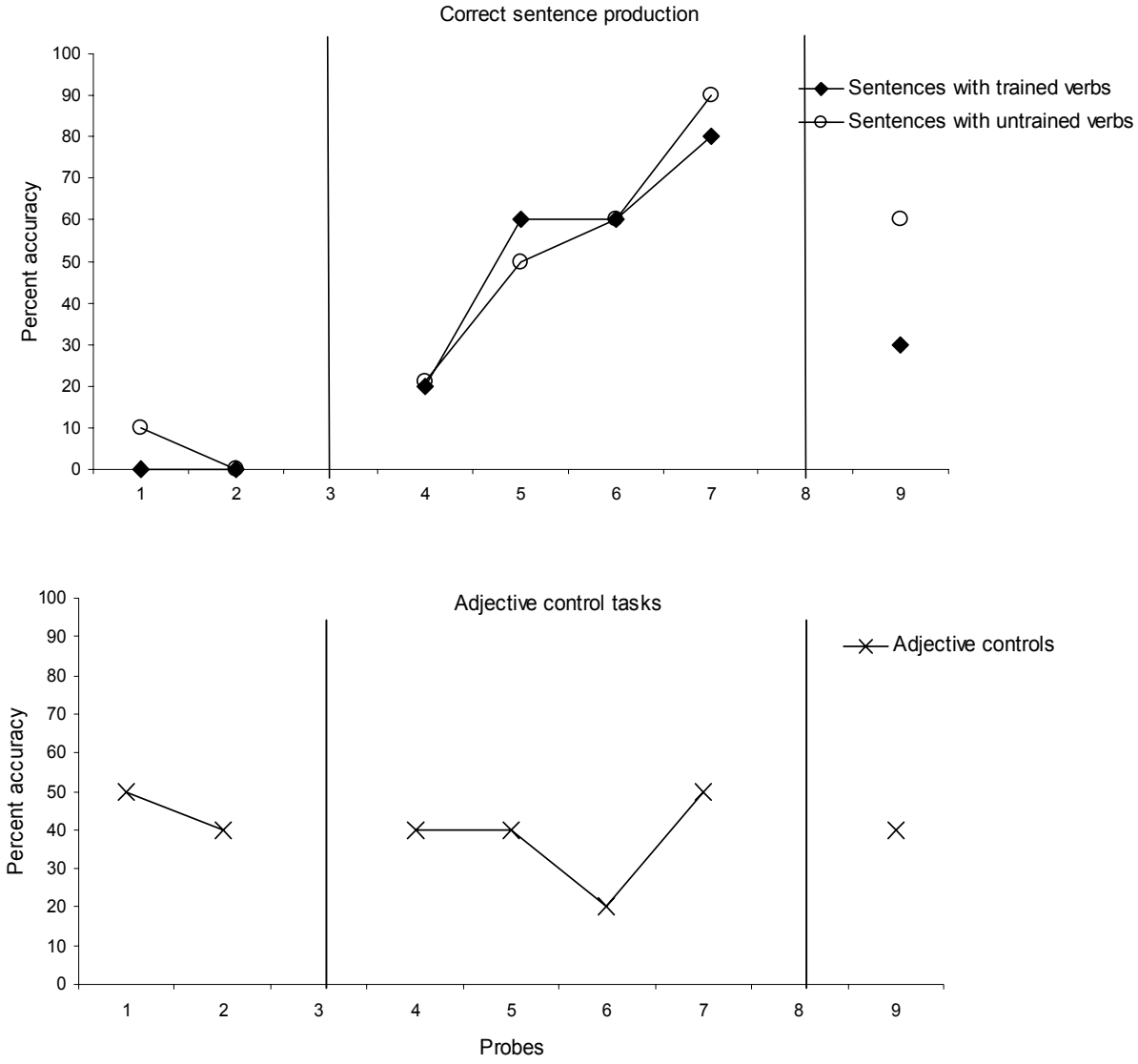

Figure 2. Baseline, treatment, and 1 month maintenance results of sentence production and adjective control tasks for Participant 2

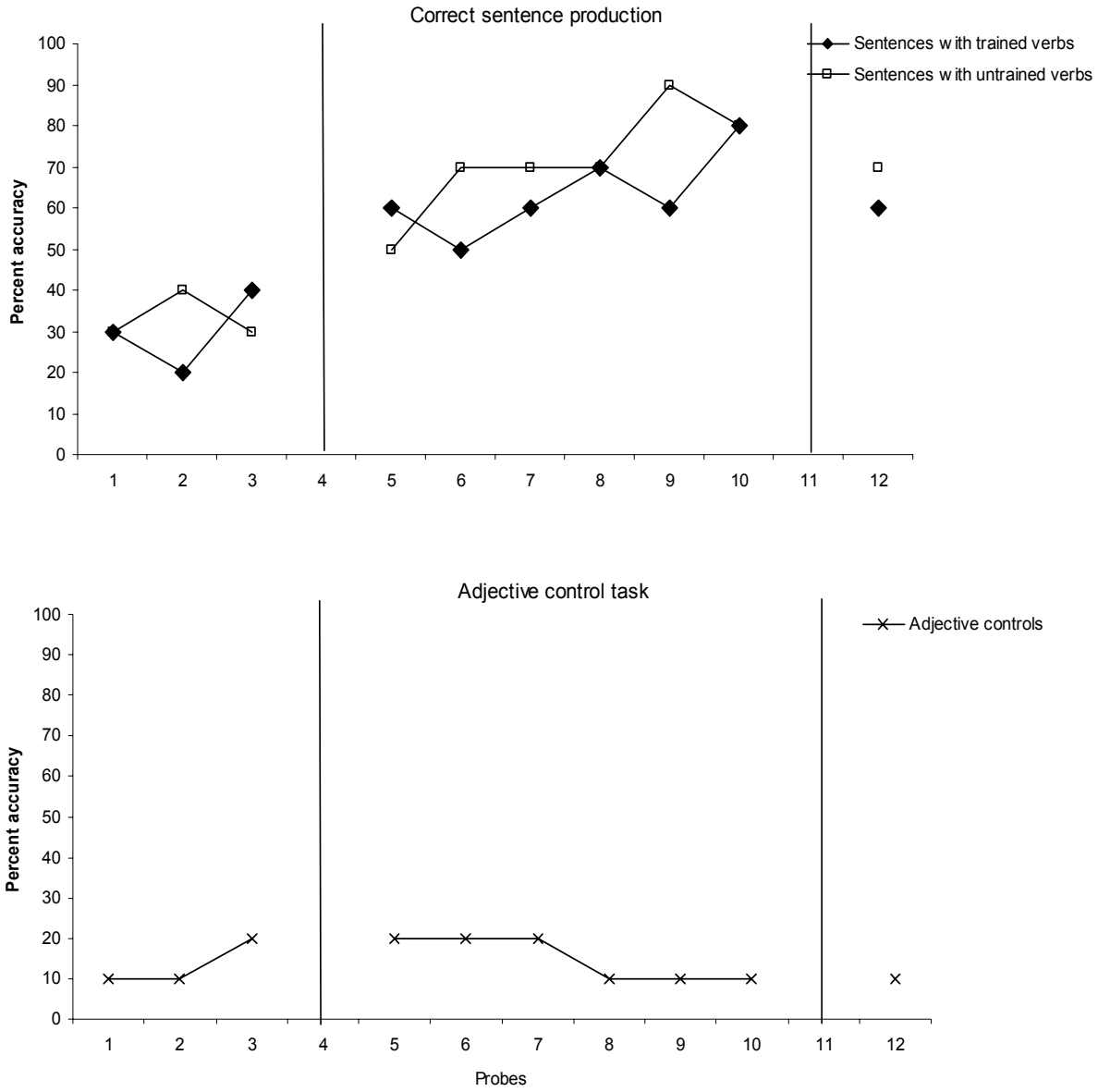

Figure 3. Baseline, treatment, and 1 month maintenance results of sentence production and adjective control tasks for Participant 3

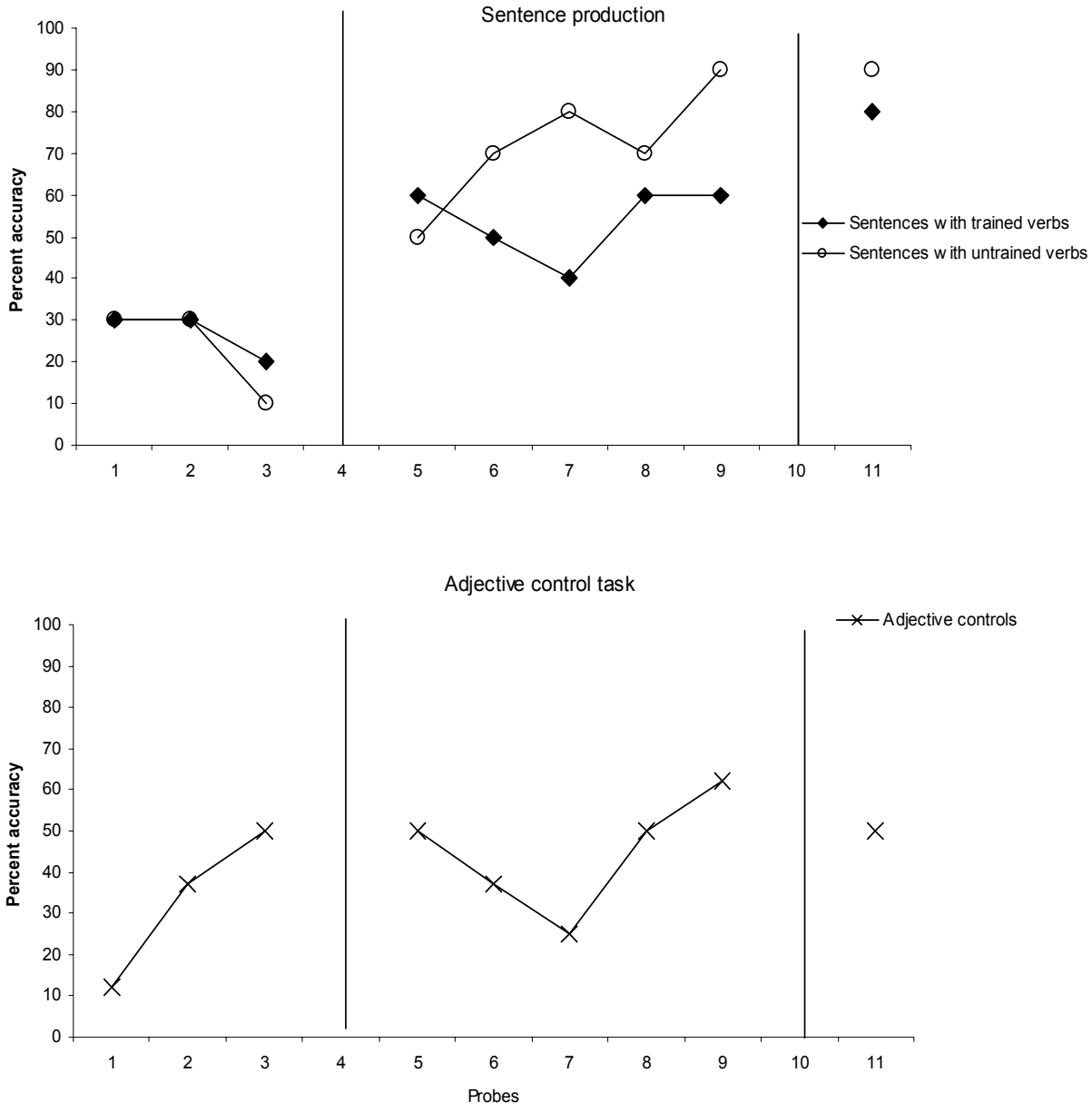

Figure 4. Baseline and treatment results of sentence production and adjective control tasks for Participant 4 (unavailable for maintenance testing)

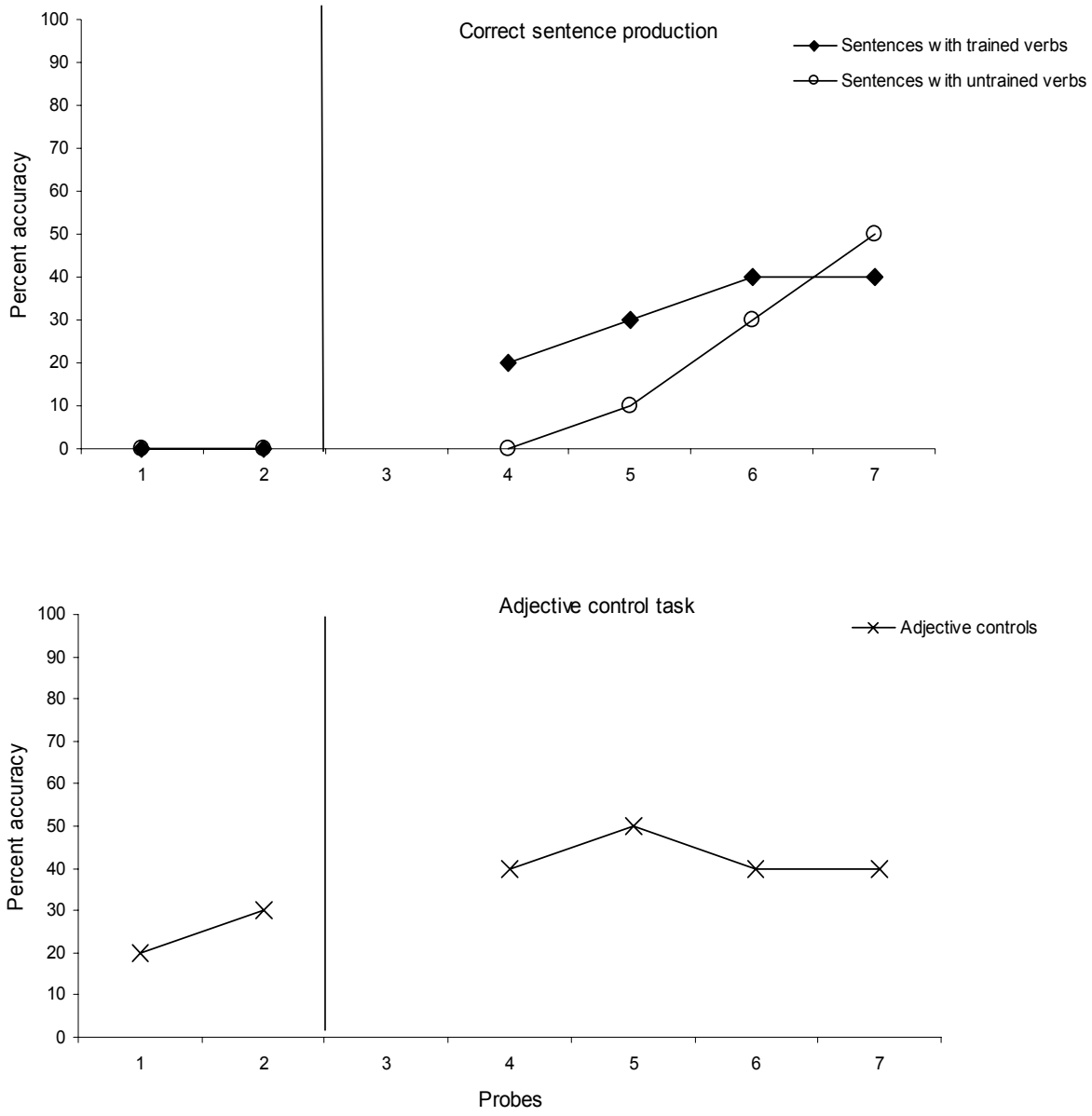

Table 1. Pre- and post treatment scores for standardized tests

	Participant 1		Participant 2		Participant 3		Participant 4	
Test	pre-tx	post-tx	pre-tx	post-tx	pre-tx	post-tx	pre-tx	post-tx
STANDARDIZED TESTS								
Western Aphasia Battery (AQ)	76.4	82.5	78.5	86.4	73.8	81.2	70.6	82.3
Information	7	9	8	9	9	9	8	9
Fluency	5	6	4	6	8	9	7	8
Comprehension	86.0	81.5	93.5	99	81.0	89.0	77.0	98.5
Repetition	94.0	98.0	96.0	95	39.0	62.0	49.0	64.0
Naming	82.0	83.0	83.0	88	79.0	75.0	77.0	79.0
**Northwestern Verb Production Battery (NVPB)*	54.2	91.3	56.5	86.9	76.2	90.5	30.6	56.6
Boston Naming Test	71.7	81.7	86.7	91.7	40.7	58.3	42.0	68.0

**NVPB* administered without providing target verb (different from standard administration). tx: treatment.