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Using Informative Verbal Exchanges to Promote Verb Retrieval in Nonfluent Aphasia

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Abstract

Purpose—The goal of this study was to determine whether positive treatment effects of a modified constraint-induced language therapy focused on verb production would generalize to unpracticed items and tasks.

Method—Four individuals participated in a single-subject treatment design protocol. The treatment involved intensive practice producing verbs in sentences in an informative communicative exchange. Direct treatment outcome was examined by measuring the accuracy of producing practiced verbs in an action description task, a task similar to those used in treatment. Generalization was assessed by measuring production of unpracticed verbs and sentence grammaticality in the action description task and by measuring verb production and sentence grammaticality in 2 relatively unstructured (unpracticed) language tasks.

Results—Two of the 4 participants showed a direct treatment effect, producing a greater number of practiced verbs in the action description task following treatment compared with before treatment. All participants improved sentence grammaticality following treatment, although grammaticality was not explicitly targeted in therapy. Generalization to unpracticed, less-structured tasks was variable across the participants.

Conclusion—Patterns of generalization may depend on participants' specific language deficits and production characteristics, on the language tasks used, and on the measures used to detect change and assess generalization.

Keywords

nonfluent aphasia; constraint-induced language therapy; verb treatment; treatment generalization

Nonfluent aphasia is characterized by difficulty with language production during spontaneous speech and often a proportionately greater difficulty producing verbs than

nouns (Bastiaanse & Jonkers, 1998; Berndt, Haendiges, Mitchum, & Sandson, 1997; Faroqi-Shah & Waked, 2010; Rossi & Bastiaanse, 2008; Thompson, Lange, Schneider, & Shapiro, 1997). Because verbs play a central role in sentence construction, many treatments for nonfluent aphasia focus on verb retrieval as a method to improve overall sentence structure (Goral & Kempler, 2009; Kempler & Goral, 2011; Raymer & Kohen, 2006).

Treatments that use explicit instruction and practice verb production in a sentence include protocols designed to strengthen argument structure (Kim, Adingono, & Revoir, 2007), semantic and phonological features of the verb (Faroqi-Shah & Graham, 2011; Schneider & Thompson, 2003), and verb-agent relations (Edmonds & Babb, 2011). These treatments all aim to improve verb production and sentence grammaticality (Edmonds & Babb, 2011; Links, Hurkmans, & Bastiaanse, 2010). Direct treatment of verbs has had mixed results: production of treated verbs and grammaticality of sentences containing treated verbs has increased, but little improvement may be seen in untreated verbs or carryover to untreated tasks (Conroy, Sage, & Lambon Ralph, 2006). Unlike protocols using explicit instruction of semantic and syntactic features of verbs (e.g., training production of argument structure), an intensive communicative approach uses activities that emphasize functional communication. The current study examines the effects of practicing functional communication targeting verb retrieval in sentences within the framework of constraint-induced (CI) therapy.

Following its success as an effective approach to recovering motor function of an upper limb, CI therapy approaches were applied to rehabilitation of cognitive function and language (Difrancesco, Pulvermüller, & Mohr, 2012; Meinzer, Rodriguez, & Gonzalez Rothi, 2012; Pulvermüller et al., 2001). In contrast to motor CI protocols that have a clear target modality and behavior—constraint of the unaffected limb and forced use of weak/paretic arm—in language and cognitive constraint therapies the targets of the constraint and the behavior to promote may be difficult to determine and are frequently debated (Lillie & Mateer, 2006). Therefore, application of the CI approach has been liberally interpreted (Difrancesco et al., 2012) as compared to the standard CI protocol used in motor therapy (for a detailed description of CI in motor therapy, see Taub et al., 2006; Uswatte, Taub, Morris, Barman, & Crago, 2006). Most constraint-induced language therapies (CILT) are variations of specific treatment approaches and in general follow the principles of massed-practice of activities, constraint of alternative modalities (i.e., forced use of spoken language), behavioral relevance of tasks, and shaping techniques.

In the application of CILT, the intensity component has been recently studied. Reviews by Bhogal, Teasell, and Speechley (2003) and Cherney, Patterson, Raymer, Frymark, and Schooling (2008) suggest that more intensive treatment, regardless of specific treatment approach and techniques, may be more beneficial than distributed therapy. In several studies of CI language treatment, the intensity of treatment ranged from 24 to 30 hr over 2–5 weeks (2.5–3 hr per session, 3–4 sessions per week). This is considerably less than the 6 hr of daily therapy and 90% waking hour restraint applied in CI motor therapies (Uswatte et al., 2006), but may be considerably more than conventional language therapy available to individuals with chronic aphasia.

The second and third basic CI principles—constraint and behavioral relevance—have been loosely applied in aphasia treatment using a CI approach. The language constraint component commonly requires that language production is verbal only while the use of gestures and writing are discouraged. Several variations of this general constraint have been employed, including: CILT+, the basic CI approach plus use of writing, homework, and real-world communication tasks, as well as everyday communication assignments with a family member (Meinzer, Djundja, Barthel, Elbert, & Rockstroh, 2005); CILT + verb treatment, the basic CI approach with specific focus on verbs, in which participants are “constrained” to produce a sentence with a semantically appropriate and grammatically correct verb (Goral & Kempler, 2009); and CILT–G, the basic CI approach plus a grammatical constraint, in which production of a temporal adverb and appropriate past-tense morphology are required (Faroqi-Shah & Virion, 2009). In several studies, a physical barrier between participants is used to prevent individuals from seeing each other's stimulus cards and to constrain production to verbal language only by blocking the view of hand gestures, facial expressions, and writing (Pulvermüller et al., 2001). Another approach is to constrain participants to the verbal modality and further constrain language output to specific target structures, such as verbs or past-tense forms (Faroqi-Shah & Virion, 2009; Goral & Kempler, 2009; Kempler & Goral, 2011).

Functional treatment activities and shaping techniques that address behavioral relevance range from the original protocol, using interactive language games in a group setting employed in Pulvermüller et al. (2001), to individual, deficit-specific therapy using shaping and cuing in a model-based approach (Faroqi-Shah & Virion, 2009; Goral & Kempler, 2009) with engagement of family members in real-world communication assignments (Meinzer et al., 2005). Regardless of the specific constraint or treatment task, all variations of CILT thus far have emphasized the use of communicative methods—that is, treatment activities that use language for communication during language games. In contrast, (non-CI) treatments that target verb retrieval through grammatical contexts (e.g., argument structure) use explicit instruction and practice of grammatical forms rather than a communicative exchange in treatment activities (Conroy et al., 2006; Meinzer et al., 2012). Kempler & Goral (2011) modified the CI protocol to examine the effect of communicative exchanges. They contrasted a drill-based approach that required participants to use particular preselected verbs in picture naming and similar noncommunicative tasks with an approach that required participants to generate their own verbs in communicative games (Kempler & Goral, 2011). Both drill and generative tasks required that the verbs be used in grammatical sentences and provided feedback on appropriateness of verbs and sentence grammaticality. The drill-based approach resulted in direct treatment effects: increased production of treated verbs in a practiced sentence production task. The generative treatment resulted in increased verb diversity, more accurate verb forms, and a greater number of complete and grammatical sentences in an unpracticed narrative task.

In summary, research evidence suggests that CI treatments that combine an intense treatment schedule, focus on verbal production, and provide a semifunctional context result in improvement as measured by tasks that are similar to the tasks used during treatment (Meinzer et al., 2012) and, in some cases, in improvement on functional measures (e.g., the Communication Activity Log in Meinzer et al., 2005). However, several questions remain

unanswered, including two questions that guided the current investigation: (a) How effective is a modified CI treatment that focuses on verb retrieval? (b) Does practice of an informative–communicative interaction facilitate generalization of the targeted aspects (e.g., verb production) to unpracticed items and tasks? In addition, we explore how patient-specific language production patterns affect the measurement of generalization.

To address these questions, the current study examined the effect of a functional communication task and deficit-specific shaping within a CI framework where participants were engaged in intensive therapy and constrained to verbal productions of a relevant verb in a sentence context that provided the clinician with new information.

Method

Participants

Four women with chronic nonfluent aphasia resulting from a single left cerebrovascular lesion participated in the treatment study. All four participants demonstrated mild–moderate right hemiparesis and exhibited nonfluent, agrammatic aphasia, as documented by clinical assessment. All participants were monolingual. Three participants were native speakers of English (P1, P2, and P3) and spoke English only. A fourth participant was a native speaker of Spanish (P4) and spoke Spanish only; she received assessment and treatment in Spanish by a native speaker of Spanish. Of the four participants, the English speakers identified themselves as nonHispanic, two Caucasians and one African American, and the monolingual Spanish speaker identified herself as Caucasian and Hispanic. Inclusion criteria did not restrict aphasia severity but did require sufficient comprehension to understand and participate in the treatment activities. The participants exhibited good auditory comprehension relative to language production, and none of the participants exhibited dysarthria or apraxia, nor did they report vision or hearing impairments. Prior to enrolling in this study, each of the participants had received individual and group speech-language therapy of varying duration from postacute through chronic stages of recovery. None of the participants received additional therapy during the course of the treatment study reported here.

In addition to the four participants with aphasia, 10 healthy adult native English speakers (five women; mean age, 56.8 years; mean years of education, 14.4) completed the three experimental tasks for comparison.

Table 1 provides a summary of participant characteristics at the time of testing and treatment.

Treatment

Stimuli—Prior to treatment, each participant was tested on a set of 96 verbs described in several previous studies (Almor et al., 2009; Kempler & Goral, 2011; Park, Goral, Verkuilen, & Kempler, 2013). The 96 verbs were divided into three subsets, matched for familiarity and frequency¹ to allow for repeated testing but to avoid fatigue (see Almor et al., 2009 for a detailed description of verb stimuli). For each participant, we selected a subset of the 96 verbs that were subsequently practiced during the treatment sessions

(henceforth “treated verbs”). Because we were interested in the participants’ ability to produce any verb in sentence context (and less in their ability to name single verbs) and because the participants ranged widely in their naming accuracy prior to treatment, a loose criterion was applied to select the treated verbs: we randomly selected a group of verbs that included some that were correctly named and some that were not correctly named on pretreatment testing. At least half of each participant’s treated verbs were named correctly pretreatment (the number of treated verbs ranged from 18 to 29 across the participants). An additional set of 20–30 verbs per participant was practiced during treatment to increase variety of stimuli and maintain interest in the task. These additional verbs were not tested pre- or posttreatment.

For the participant who was a native speaker of Spanish, we adapted the materials and target stimuli for treatment in Spanish. The three lists of English test verbs were translated into Spanish by two native speakers of Spanish. The words were also screened for cultural appropriateness and relevance. No items were excluded on this basis. Verbs that required a reflexive pronoun in Spanish were noted. For several English words, more than one Spanish verb was suitable for the picture (for example, for *balancing* both *balanceando* and *equilibrando* were accepted as targets). Nine of the English verbs could not be translated succinctly into single words given the picture stimulus and were not included, for example, *dar de comer* (feeding). In total, the Spanish-speaking participant, P4, was tested on 87 Spanish verbs across three days.

Treatment materials were colorful, realistic picture card pairs depicting one or more agents performing an action. Each picture was used to elicit a particular verb in a simple sentence. For example, a picture of a woman ironing a shirt was used to elicit the sentence: *The woman is ironing*. All picture stimuli were noncopyrighted images obtained from Internet searches. A wooden barrier (10 × 24 in.) was used in five of the six activities in the protocol to create the context for an informative exchange in which participants and clinicians could not see each other’s cards and needed to provide new information for progression of the game. Multiple picture exemplars for each treated verb were provided, and novel pictures depicting the target verbs were added throughout the course of treatment to maintain interest in treatment activities and maximize flexibility of using the practiced verbs in multiple picture and sentence contexts. The pictures used in treatment were not used in pre- and post-testing of verb production.

Protocol—All four participants received the same general treatment protocol with targeted language structures customized for each participant’s level of language production capability. Participants were constrained to verbal-only production in a relatively intensive schedule (7.5 hr per week) of individual treatment for a total of 30 hr, which took place 3 to 4 days per week over the course of 1 month. Treatment was massed-practice of producing

¹Verb lists were generated from Almor et al.’s (2009) set of 96 verbs, which included frequency and familiarity information for each verb. Almor et al. (2009) obtained familiarity ratings from young, healthy individuals. Briefly, each verb was rated on a scale of 1–7 on how familiar the action seemed to be (7 being most familiar). Mean (*SD*) of familiarity values of words in each list: list 1, 6.01 (0.61); list 2, 5.92 (0.54); list 3, 5.83 (0.54). Mean (*SD*) frequency values of words in each list, based on Francis and Kuera (1982), as noted in Almor et al. (2009): list 1, 47.25 (69.67); list 2, 42.16 (55.08); list 3, 38.97 (49.66). Frequency information for Spanish verbs was determined based on the Subtlex corpus of 41 million words used in subtitles in movies and television between 1990 and 2009 (Cuetos Vega, González Nosti, Barbón Gutiérrez, & Brysbaert, 2011).

appropriate verbs in complete sentences in an informative context—that is, participants were required to provide appropriate and communicative information in each verbal exchange. Treatment was administered by student clinicians trained in the treatment protocol under the supervision of two of the authors (MG or DK), both licensed clinicians, who monitored treatment sessions. Treatment was administered in English to the three English-speaking participants and in Spanish to the participant whose primary language was Spanish (P4). Fidelity of treatment was ensured by observation of the sessions and discussion with clinicians.

Activities—Activities were language games requiring verbal exchanges. In each activity, the participant selected cards to describe for her turn. Treatment activities were devised to elicit appropriate verbs within a sentence in an informative verbal exchange. Although the clinicians were aware of the possible actions depicted, they could not see the particular picture/action that the participant was describing on any particular turn (see Appendix A for more detailed descriptions of treatment activities).

At the beginning of each treatment activity, the clinicians modeled a sentence that contained the target verb for a set of three to five picture-card pairs corresponding to a closed set of target verbs to be used in the task. That is, the clinicians produced a grammatical sentence containing the verb for each of the target verbs for the task. Treatment activities included variations of card games; for example, the games “Go Fish” and “Memory” were used to elicit productions of verbs in a sentence, such as, “Do you have / Can you find: *The woman is floating?*” In the first two sessions, the clinicians introduced the activities, explained and demonstrated them, and ensured that the participants understood what was expected. All participants demonstrated comprehension of the activity steps and conventions. The clinicians cycled through the activities once during each therapy session.

Shaping techniques and levels—In this study, the term *shaping* refers to structuring tasks to expand participants’ verbal productions through a continuum from less complex to more complex responses. For all participants, the initial target structure was an appropriate verb in a sentence (i.e., Subject + Verb [SV] or Subject + Verb + Object [SVO], e.g., *She is feeding the baby*).² If a partial target was produced (e.g., subject only, “girl”; verb only, “feeding”), the clinician prompted the participant for the target structure by reminding the participant of the target structure (e.g., “Can you describe that in a full sentence?”). Semantic and phonemic prompts were not used.

During each participant's turn, if she produced an inappropriate verb or an incomplete or ungrammatical sentence, the clinician first prompted for a more accurate verb or for a complete sentence, then modeled the target verb in a grammatical sentence and asked the participant to repeat the modeled sentence. Because functional communication was valued, target as well as any other appropriate verbs were accepted as good responses. If the participant produced a verb other than the target verb, the clinician used her judgment to determine whether the verb was semantically appropriate to the picture and whether to

²During the language activities P4 demonstrated perseveration on pronouns and common nouns and considerable difficulty producing verbs. Therefore, P4's target structure was modified (shaped) to production of an accurate verb.

model the produced verb or a target verb in a sentence (e.g., for the target verb *sipping*, if the participant produced, *He is drinking the wine*, the clinician decided whether to model *He is sipping* the wine or *He is drinking* the wine). When the participant spontaneously produced the target or an appropriate verb in a complete sentence, the clinician repeated the response so that verb production was reinforced in a semantically and grammatically correct context. During the participant's turn, the clinician provided positive reinforcement for appropriate verbs and inclusion of the target structure but not explicitly for grammaticality.

For each participant, shaping was achieved by scaling up to a more difficult language structure after the participant met criterion: 80% correct on the tested language structure in a probe assessment (e.g., after the participant produced the target verb in an SVO sentence frame correctly in 16 of 20 trials in a probe, the target structure was scaled up to SVO + prepositional phrase). When scaling up, the choice of target was participant-specific; we selected the target by considering the participant's level of severity and relative ease of acquisition of the new structure. For example, if the participant tended to produce complete but short sentences, we targeted adding a prepositional phrase to the basic SVO structure; one participant tended to use complete longer sentences, so we targeted an additional verb tense. Following 80% accuracy on production of present progressive verbs in sentences for 20 target verbs, additional shaping was individually determined (as described in Appendix B) and included present progressive SVO + prepositional phrase, past progressive SVO, and two SVO clauses linked with a conjunction. Target structures were probed every other treatment session to determine accuracy of production and advancement to more complex sentence structures.

Testing Procedure

Prior to treatment, baselines were established on either the Western Aphasia Battery—Revised (Kertesz, 2006) or the Boston Diagnostic Aphasia Examination (BDAE-3; Goodglass, Kaplan, & Barresi, 2000) as a standardized assessment of aphasia, and on several experimental and protocol-specific measures. The same measures were administered immediately following treatment.³ For both pre- and post-treatment testing, the baseline tasks were administered over the course of 3 days, with a different stimulus subset (per task) administered each day (e.g., Day 1: verb list one, Day 2: verb list two, etc.). In each protocol-specific task participants were requested to respond in full sentences. Participants with aphasia and healthy individuals were given the same instructions.

Protocol Baseline Tasks

Action description—One of the three lists comprising the 96 verbs described above (Almor et al., 2009) was tested on each day. On each of the three assessment days, the participants viewed colorful action pictures and described them using an SV or SVO sentence (depending on verb transitivity) that appropriately described the action depicted in the picture. These picture stimuli were used to assess verb generation before and after

³For two participants (P2 and P3), scores on the Western Aphasia Battery (Kertesz, 2006) were obtained immediately prior to and following the treatment protocol. P1's language profile on the Boston Diagnostic Aphasia Examination (Goodglass et al., 2000) showed no change from several previous administrations during clinical therapy. Spanish-speaking P4 was tested on the Western Aphasia Battery, Spanish version (Kertesz, 2000).

treatment, but were not used during treatment itself. Participants were instructed to describe what is happening in the picture in a full sentence. When the participant hesitated or did not respond, the prompt “Tell me what is happening in this picture” was given.

To examine whether production of a semantically accurate verb in the SVO construction generalized to non-treatment tasks, we used two additional experimental tasks that were less structured and more naturalistic than picture description.

Sequence description—To simulate narrative production and elicit carefully controlled connected and contextualized speech, participants were asked to describe a sequence of four related pictures. For example, a mother and daughter mixing cake batter, the mother answering the phone, the daughter eating the batter from the bowl and making a mess, and the mother and daughter cleaning up. Participants were encouraged to tell the story of what was happening in the pictures. There were six sets of four pictures (two sets on each assessment day); pictures were colorful photos of people performing familiar actions taken from published materials (Stark, 1992; SuperDuper Sequence Cards, www.superduperinc.com).

Response to wh-questions—In this task, participants were required to produce an appropriate response to 30 questions (10 on each assessment day) comprising different question types. For example, a “what + be” question required a nominal segment response (e.g., “What is a notable accomplishment by someone in your family?” *Alice is a singer*), whereas “why” questions required a causal explanation (e.g., “Why do people go to college?” *To get an education*). Questions were not accompanied by visual stimuli.

Outcome Measures for the Three Baseline Tasks

The treatment goal was an increase in production of appropriate verbs in suitable linguistic contexts (e.g., SVO) in practiced and unpracticed tasks. Verb production in sentences and the grammaticality of the sentences produced were measured. Language-specific features of grammaticality were taken into account; for example, in Spanish it was noted whether the sentence was ungrammatical due to omission of the reflexive pronoun in reflexive verbs. For both English and Spanish, scoring and judgments of grammaticality were performed by native (or highly proficient) speakers of the language. Responses were examined for content and form for each of the three outcome tasks as follows.

Action Description and Sequence Description

Content: Semantically appropriate verb—For action description, a verb was considered correct if it was either the target verb for each stimulus picture as intended (Almor et al., 2009), or an appropriate nontarget verb that accurately depicted the action in the picture. For example, the picture of the target verb *nibbling* elicited the verb *eating* from all participants (and many of the healthy controls); in this case *eating* was considered correct. Light verbs were scored as correct if they accurately described the picture (e.g., *She's making an egg* was considered an appropriate response to the picture depicting *frying*).

The sequences did not contain predetermined target verbs; two independent raters determined the appropriateness of each verb produced by each participant in the sequence task. Interrater agreement was 90% or greater and scoring discrepancies were resolved in discussion.

Form: Grammatically accurate response—A response was scored as grammatically accurate if the sentence contained all required elements and was grammatical.

Wh-Questions

Wh-questions often elicited responses of single words or phrases rather than complete sentences from both healthy participants and those with aphasia. In 23 of 30 questions, a single grammatical verb phrase could adequately answer the question (e.g., *Why do people go to a church or a temple?* could be answered appropriately with *To pray*). Therefore, we scored the responses for three elements of form and three elements of content. The response to each question received a binary score (1 = present, 0 = absent) in each of six areas (three categories of form and three categories of content), for six possible points per question, and 180 total possible points over 30 questions (90 points for form and 90 points for content). Elements of form included: correct tense, verb tense in the response matched tense required by the question; accurate parts of speech, all minimal required parts of speech were present (e.g., *Why do people go to college?* requires a verb, as in *to learn*); subject, the response contained a subject if required by the question (e.g., *Why was Frank Sinatra so popular?* requires a response with a subject as in *he sang*). Elements of content included: accurate subject, the response contained the correct noun or pronoun (e.g., *How do Americans celebrate Christmas?* The response must contain *Americans* or the third person plural pronoun, e.g., *They or we go to church but not I go to church*); content accuracy, the information in the response was sufficient to answer the question (e.g., a *why* question requires a description of cause and effect); and relevance, the response contained information that was relevant to the question. Table 2 provides additional examples of the *wh*-question scoring rubric.

Error Scoring

To determine whether posttreatment changes in grammaticality were related to accuracy of the verb form or to other elements in the sentence, responses marked as “ungrammatical” were further analyzed for the type of error according to the following criteria.

Verb form (conjugation) errors comprised agreement error (verb number error), tense error (most often missing an obligatory *-ing*, e.g., *The boy is . . . skate*), missing auxiliary, and addition of an incorrect morphological ending (e.g., *boxings*).

Verb phrase errors were defined as errors in the verb phrase other than conjugation errors and included the absence of a verb or the presence of an inappropriate verb, missing prepositions in the verb phrase, argument structure errors (missing object or direct object), and missing articles of any required argument (e.g., *The boy is locking chain*).

Other errors included grammatical errors in adjuncts that were not required by the verb (e.g., *He is eating cookies in the outside*) and additional elements that resulted in an ungrammatical response.

Analysis

Treatment effects were assessed on two measures in all experimental test tasks: a *content variable* (was a semantically appropriate verb produced in the task?) and a *form variable* (was the entire response grammatical?) For the practiced task (action description), a treatment effect on verb retrieval was determined by change in semantically appropriate treated and untreated verbs produced following treatment compared to before treatment (content variable). Generalization of treatment was assessed in terms of production of grammatical sentences in the treated task (i.e., form variable in the action description) and production of appropriate verbs in grammatical sentences in the untreated tasks (i.e., describing a picture sequence and answering *wh*-questions). In the sequence description task, semantic appropriateness was scored for each different verb. One participant repeated verbs for emphasis (*they are waiting, still waiting, and still waiting*) and another appeared to repeat verbs due to perseveration. Different verb types, rather than tokens, were counted to avoid inflating scores of appropriate verbs.

Determining what constitutes a significant change in single-subject design is notoriously difficult and appropriate methods are still debated (Gliner, Morgan, & Leech, 2009). Several authors suggest, when possible, combining multiple measures to assess treatment effects (Farooqi-Shah, 2008; Kratochwill et al., 2010; Ramsberger & Marie, 2007), an idea we applied here, and selecting statistical analyses appropriate for each data set. For all three data sets (action description, sequence description, and *wh*-questions), we compared percent change from pretreatment to posttreatment and considered 20% positive change as an indication of clinically significant improvement (Kempler & Goral, 2011; Ramsberger & Marie, 2007). In addition, for action description, which consisted of a single response to the same 96 items before and after treatment, we used McNemar's chi-square test for matched pairs (Sainani, 2010). For sequence description, which resulted in different numbers of verbs produced before and after treatment, we used Fisher's exact test. For the *wh*-questions, which resulted in a composite score for content and a composite score for form, neither the McNemar's nor the Fisher's exact tests were deemed appropriate (Waddell, Nassar, & Gustafson, 2011); hence, we report percent change from pre to posttreatment.

All testing sessions were audio-recorded and recordings were reviewed for transcription accuracy by a listener blind to the test time. Twenty-five percent of each transcript for each task was re-coded by a second scorer, and 90% or greater interrater reliability was achieved. Scoring disagreements were discussed and resolved by the authors.

Results

Action Description

Semantically appropriate verbs—Three of four participants significantly increased their production of semantically appropriate verbs (Table 3) following treatment

(McNemar's test: P1, P3, and P4, $p < .05$, one-tailed). The two more severely impaired participants showed a direct treatment effect; that is, both participants produced a greater number of treated verbs following treatment (McNemar's test: P3, $p < .01$; P4, $p < .05$). For these two participants, improvement in treated verbs may have driven overall improvement (as seen in Table 3). A less impaired participant, P1, produced a greater number of untreated verbs in the action description task after treatment than before treatment (McNemar's test: P1, $p < .05$). P1's total increase in appropriate verbs (treated and untreated) following treatment was due to increased accuracy in production of untreated verbs, indicating generalization of accurate verb production. P2 was quite accurate on this task before treatment and her verb production accuracy did not change following treatment.

Grammatically accurate response—Following treatment all participants produced more complete sentences (i.e., SVO) containing an appropriate verb and fewer ungrammatical sentences compared to before treatment. In addition, three participants increased production of grammatical responses containing an appropriate verb by at least 20%, and one by 17%; this improvement was statistically significant for all participants (McNemar's test, $p < .05$, one-tailed).

Errors—Two of four participants (P2 and P4) decreased total errors by 20% or more (P2, 30% fewer errors, 23 to 16 total errors; P4, 20% fewer errors, 15 to 12 total errors). P1 produced relatively few errors pretreatment (11 total errors) and had minimal change (10 errors posttreatment). P4 produced the greatest number of grammatical errors of all participants (46) and produced as many total errors post-treatment as pretreatment, but showed a shift from errors of verb conjugation and tense errors to “other errors” in the sentence, for example, prepositional phrase errors.

Sequence Description

Semantically appropriate verbs—Verbs that were produced in the sequence description task were generally appropriate to the pictures before treatment and did not improve following treatment (Fisher's exact test, $p > .05$ for all participants). Although verbs produced were accurate, three of four participants failed to produce at least one different verb per picture pretreatment, and did not increase production of different verbs following treatment, despite engaging in treatment activities of producing a full sentence for each picture presented during therapy. The number of different verbs produced varied among the participants (see Table 4).

Grammatically accurate response—One participant (P2) showed greater than 20% increase in the number of grammatical sentences produced (trend toward significant, Fisher's exact test, $p = .08$). This improvement may indicate carry-over of production of grammatical sentences from the treatment task (action description) to the sequence description task.

Errors—Following treatment, both P1 and P2 (both mild–moderately impaired) demonstrated 30% or greater decrease in verb-form errors in sequence descriptions (P1, –59% change, 11 to 5 verb-form errors; P2, –69% change, 16 to 5 verb-form errors). The

more impaired participants showed minimal or no change (P3, an 8% increase in verb-form errors; P4, no verb-form errors pre- or posttreatment).

Wh-Questions

P1 and P2 (both mild–moderately impaired) were 81%–91% accurate in form and content before treatment and showed no change on this measure following treatment. In contrast, the performance of the more severely impaired participants (P3 and P4) improved in content following therapy and P3 improved in form as well (Table 5).

Discussion

In this study, we administered a modified CILT that focused on verb production of four women with chronic nonfluent aphasia. We found support for positive treatment effects and for generalization to unpracticed items and tasks. We defined a direct treatment effect as improved verb production in the practiced task. *Generalization* was defined as improved verb production in unpracticed tasks and improved sentence grammaticality, which was not explicitly trained during therapy, in either practiced or unpracticed tasks. We interpret the findings as evidence for the effectiveness of the use of protocols that allow participants to engage in the mutual transfer of new information. In the following discussion we address what the data collected in this study can tell us about the influence of task and individual variability on the process and measurement of generalization.

Direct Treatment and Generalization Effects in the Practiced Task: Action Description

Consistent with previous treatment studies that targeted verb production and included the practice of sentence production during therapy (e.g., Edmonds & Babb, 2011; Links et al., 2010), our participants increased the number of appropriate verbs (treated and untreated) they produced correctly in an action description task, a task similar to those used in treatment. A direct treatment effect—increase in accurately produced treated verbs—was seen in the two moderate–severely impaired participants (P3 and P4) but not in the two mildly impaired participants (P1 and P2). P1 had a relatively low number of verbs treated (18); P2 did not meaningfully increase the proportion of appropriate verbs from pre- to posttreatment, possibly due to a baseline ceiling effect (>83% accurate for both treated and untreated verbs prior to treatment).

Another indication of a positive treatment effect would be increased consistency of items correctly produced. We found two patterns in our participants. The two more impaired participants (P3 and P4) showed high consistency on treated verbs (i.e., all treated verbs that were correct before treatment were also correct following treatment), but were inconsistent in their production of untreated verbs. Specifically, several verbs that had been inaccurate before treatment were produced accurately following treatment, but this improvement was offset by inaccurate production of verbs that had been produced correctly prior to treatment (and were not treated). Therefore, there was a minimal increase in total number of appropriate untreated verbs (P3 increased by two verbs and P4 increased by one verb). In contrast, both of the less-impaired participants (P1 and P2) showed stability in their production of treated and untreated verbs, that is, few items that were correctly produced

pretreatment were inaccurately produced posttreatment. Inconsistency in word retrieval of the same targets has long been noted in the aphasia literature (Freed, Marshall, & Chuhlantseff, 1996; Howard, Patterson, Franklin, Morton, & Orchard-Lisle, 1984; Wingfield, Brownell, & Hoyte, 2006) and has been addressed, to some extent, with the now common practice of repeated measurement during testing. Change in production consistency is a sensitive measure that could be incorporated in the assessment of improvement in aphasia.

We observed one form of generalization in the action description task insofar as the participants increased the proportion of grammatical sentences they produced. Following treatment, in addition to retrieving a greater percentage of verbs, those verbs were also more likely to be produced in syntactically and morphologically correct sentences compared to before treatment. Of interest, P2, who was highly accurate on action naming and showed no noticeable improvement on naming accuracy, demonstrated marked improvement on the grammaticality of her sentences in this task. Whereas the task of action description is similar to the ones practiced during treatment, grammatical aspects of the production were not explicitly addressed during therapy. Grammatically correct sentences were always modeled, but, unlike treatment protocols that directly target verb-form accuracy (e.g., Farooqi-Shah, 2008), here the participants were not required to produce grammatically correct sentences or to correct their ungrammatical production. If the participants produced an appropriate verb, their responses were accepted as correct even if the sentence was ungrammatical. Moreover, no explicit training of verb conjugation and argument structure was pursued during treatment, yet two participants (P3 and P4) decreased the number of verb-form errors following treatment, demonstrating generalization from a lexically focused treatment to grammatical production.

Generalization to Unpracticed Tasks: Sequence Description and Responses to Wh-Questions

We found variable generalization patterns among our participants. This variability can be attributed, at least in part, to task demands. In the sequence description, all participants produced a high proportion (at least 80%) of verbs that were relevant to the picture sequences prior to treatment; therapy did not increase the number of appropriate verbs produced in this task. Given that all participants produced a majority of appropriate verbs before treatment, it is not surprising that there was no increase in this measure. We note, however, that this task differed in several ways from the treatment tasks. Unlike the action description task, the sequence description presented a set of pictures, rather than one picture at a time, and each picture stimulus depicted a scene that could potentially elicit several different verbs. Thus, at the verb level, participants could have elected to produce verbs that they could easily retrieve, use light verbs, and repeat the verbs they already used. At the story level, presenting multiple, related pictures with the goal of “telling a story” about the events requires global skills of attention, organization, and cohesion (Olness, 2006) in addition to the ability to retrieve an appropriate verb and place it in a correct sentence structure. The four participants produced varying numbers of verbs (ranging from five to 80), generating stories that differed in how well they described the events in the pictures. The challenge of determining target verbs in connected language production has been noted

in studies that used semispontaneous speech as a measure of language change in aphasia (Prins & Bastiaanse, 2004). Lexical measures in connected language production have been typically limited to type/token ratios (e.g., Rochon, Saffran, Berndt, & Schwartz, 2000; Wright & Capilouto, 2009), and in at least one study, proportions of light verbs (Mayer & Murray, 2003). Here, too, we found that the freedom the participants had to select any verb limited our ability to assess verb diversity.

One participant (P2) improved her sentence grammaticality in the task of sequence description. She maintained a relatively low number of total utterances produced preand posttreatment, but of those, the number of grammatical utterances doubled. She decreased the number of verb-form errors following treatment, which contributed to her improved grammaticality. P3 produced few sentences pre- and posttreatment, including a single grammatical sentence pre-treatment and two grammatical sentences posttreatment.

The two remaining participants, who did not improve their sentence grammaticality in this task, differed in their production patterns, as noted in Table 1. P1 was very productive in the sequence description task and increased her verbal productivity following treatment. Increased productivity may also have increased her opportunity for error: following treatment she attempted multiverb and multiclausal phrases, but did not produce these more accurately than the simpler sentences she produced before treatment. Interestingly, both before and after treatment P1 produced a greater number of sentences in the sequence description task than the healthy individuals. We noticed that most healthy individuals produced one short sentence per picture, describing the main action in the picture. For example, in describing a couple building a bookshelf, one healthy individual described one picture with the sentence: *And they are constructing a book shelf*. In contrast, P1 produced multiple sentences for the same picture, adding some less-pertinent descriptions: *They're building a bookcase. Uh . . . he is uh . . . dressed up and she is dressed up also. She is wearing sneakers*. The comparison of the production by the participants with aphasia to that of neurotypical speakers is useful, particularly in language tasks that may elicit great interindividual variability (e.g., Andreetta, Cantagallo, & Marini, 2012). Although P1 produced more language following treatment, she did not show better control over grammatical structure and therefore there was no increase in proportion of grammatical sentences she produced.

P4 was quite productive pretreatment (although less than P1) but had a small proportion of grammatical sentences. She produced fewer utterances following treatment, which may have been beneficial because several of her utterances prior to treatment were prolonged, unsuccessful attempts. She produced six grammatical sentences following treatment, resulting in no change in the proportion of grammatical sentences.

We note that, in contrast to the action description task, the proportion of sentences that were grammatical in the sequence description task was relatively low. This reflects the increased difficulty of the sequence task (e.g., Olness, Ulatowska, Wertz, Thompson, & Auther, 2002). Even though the participants were encouraged to produce a sentence to describe each picture in the sequence—not unlike the sentences they were encouraged to produce in the action description task—the added difficulty presented by the set of picture stimuli is evident in the

prevalence of incomplete and ungrammatical sentences generated by the participants in this task, and in the paucity of verbs produced (P2, P3, and P4 produced between six and 20 different total verbs for this task, and failed to produce one different verb per picture). Data from 10 healthy individuals confirm typical variability in the number of different verbs produced, but healthy individuals maintained sentence grammaticality (with a mean of 88% grammatical sentences). The additional task demands that may impede sentence grammaticality when people with aphasia attempt to produce segments that are longer than a single sentence may include paralinguistic abilities, such as working memory (e.g., Martin & Reilly, 2012). Whereas this is beyond the scope of the present paper, it is a fertile realm for future research. An understanding of the source of the added difficulty in the transition from single sentences to connected language production may be key to improving the quality of communication in aphasia.

The *wh*-question task, in contrast, differed from the picture sequence task in that it required participants to answer questions with sentences or subsentential clauses, and did not involve visual stimuli, that is, the participants could not benefit from the presence of pictures as cues for word retrieval. Despite a growing interest in functional communication measures in aphasia (e.g., Armstrong & Ferguson, 2010), few studies published to date employed common, functional questions as a measure of treatment generalization. We included this measure because it has the potential of revealing functional communication abilities using objective, rather than subjective assessment. However, we found the analysis of the answers produced by the participants somewhat challenging, and noted mixed results. Two of the participants showed improved appropriateness in their answers to the conversational *wh*-questions, suggesting generalization from the treatment activity to an open-ended, unpracticed task, although this finding should be interpreted with caution given the absence of a more robust statistical analysis for the results of this task. The two participants who did not show change fell within the range of performance of ten healthy controls.

In summary, to answer the two research questions set out in the introduction regarding the effectiveness of CI treatment focused on verb production in informative interactions, all four participants responded to the treatment, demonstrating increased appropriate verb production and sentence grammaticality when describing action pictures. When assessing generalization of treatment to unpracticed tasks, we found mixed results across our participants. For example, one participant produced more grammatical sentences in the unpracticed sequence description task (P2), whereas two other participants (P3 and P4) produced more appropriate responses to *wh*-questions following treatment, and one of these two (P3) produced more grammatical responses for this task as well. Sentence grammaticality in language production can be useful because it often reduces ambiguity. For example, P3 produced ungrammatical, ambiguous sentences when describing the action pictures before treatment (e.g., A boy is scissors cut, no, boy is cut paper scissors). Practicing the present progressive form in treatment may have “automatized” this form and allowed her to produce clearer sentences such as: *The man is cutting paper in the classroom* following treatment. Similarly, P2's increased grammaticality helped her convey less ambiguous information in the sequence descriptions. For example, before treatment, when describing the picture of a couple putting together a bookshelf with the woman reading

instructions and the man assembling it, she said: *Man and women building*. This was ambiguous and possibly misleading, in part due to the absence of the obligatory object. Following treatment, when describing the same picture, she included the object and produced two unambiguous and grammatical sentences: He's um building a shelf. Um, the woman is reading directions.

Generalization Measures and Participant-Specific Variables

A final objective of the current study was to explore how participant-specific variables affect the measurement of generalization. In addition to the task variables discussed above, inconsistent generalization across participants could also be due to variability in the severity of their aphasia. The original CI motor therapy was restricted to individuals who met minimum and maximum criteria for range of motion and physical condition of the limb (Taub, Uswatte, & Pidikiti, 1999). Similar to other CILT studies (see Cherney et al., 2008), we included participants who varied in severity and to some degree the characteristics of their aphasia. All participants, regardless of severity level, improved their grammaticality in the action description (practiced) task; however, they differed with respect to treatment generalization. P1 and P2, who both had mild–moderate aphasia, diverged in their responsiveness to the treatment. P2 showed generalization to the unpracticed sequence description task; P1 did not. In contrast, P3 and P4 had moderate–severe aphasia and had limited output; whereas neither showed drastic change in the sequence description task, both improved their ability to respond appropriately to *wh*- conversational questions. This suggests that severity level may not affect the direct effects of treatment but that it does, albeit in a complex way, influence the extent of generalization to unpracticed tasks.

Conclusions and Future Directions

Following a modified CI protocol targeting verb retrieval through informative exchanges, we saw improved production of verbs after treatment, and some degree of generalization, either by improved sentence structure on a task similar to the treatment task or by the transfer of sentence production skills to more open-ended, unpracticed tasks. Performance on these more linguistically demanding tasks varied by participant, as aphasia severity and participant-specific verbal production patterns appeared to interact with task demands. CI protocols for language therapy have been used with liberal modifications to the therapy protocols, and variability in treatment protocols has led to a promising technique but one that still lacks details about effectiveness and potential for generalization of treatment effects.

We have used these techniques with only a handful of participants who all had nonfluent characteristics of aphasia. It would be of great interest to expand this type of treatment research to additional individuals, both with similar participants with a greater range of severity as well as those with contrasting aphasia profiles. Accumulation of data from a larger group of participants will allow greater generalization to the population at large. Although we have focused this study on verb retrieval, it is an open question of how well these methods can be adapted to other aspects of language (e.g., nouns, specific sentence structures).

Additionally, our measures of generalization to functional communication, although chosen to elicit connected speech and simulate conversational interaction, do not go far enough in assessing functional outcomes in discourse. Naturally, our aim is for the participants to demonstrate improvement both inside and outside the treatment setting. The closer our outcome measures can come to natural discourse, the greater power they will have.

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Appendix

Appendix A

Description of Treatment Activities

Activity	Carrier/Prompt	Protocol	Informative context
Go fish	"Do you have the picture <i>'the man is washing his dog'</i> ?"	Ask for match to one of multiple cards.	With a 6-in. tall barrier between them, the client and participant view cards on each side of the barrier.
Memory	"Can you find the picture...?"	Find match to the card of multiple cards lying face down; participant produced sentence each turn whether the chosen card forms a match or not.	In this task, both client and participant view the same card simultaneously.
Picture description	"Tell me what's happening here. Try to say one sentence per picture."	Select one picture at a time; describe the action in the picture.	Clinician and client have three cards; each has one card of a pair. Client places cards face up on her side of the barrier. Clinician guesses one card at a time based on information provided by the client.
Sequence description	"Tell me what's happening here. Try to say one sentence per picture."	Arrange pictures; tell a story (one sentence per picture).	Similar to picture description, but client must indicate a sequence of events (e.g., same subject in each sentence, same topic).
Story construction	"Let's tell a story about what is happening in this picture."	Clinician and participant take turns producing a sentence about one stimulus picture; consecutive sentences should form a story about the picture.	Shared knowledge of stimulus picture, but participant must provide new information.
Map task	"Describe the pictures in a sequence. I will number the pictures 1-2-3-4 based on the order in which you describe them."	Select one picture at a time; describe the action in the picture.	Picture images are arranged on a single sheet of paper. Clinician and client each have a copy of the picture "map" on her own side of the barrier. Clinician must guess correct sequence of images based on information provided by client.

Appendix B

Participant-Specific Shaping Constraints on Language Production

Target	P1	P2	P3	P4
Baseline target structure	Present progressive SVO	Present progressive SVO	Present progressive SVO	Appropriate verb ^a
Target 2	Past progressive SVO	Present progressive (PN + V)	Present progressive SVO	Present progressive SVO
Target 3		Present progressive + NP and PP	Present progressive SVO + PP	Present progressive SVO
Target 4		SVOs linked with conjunction		
Target 5		Regular past tense SVO		

Note. Targets were added as a participant reached criterion. S = subject; V = verb; O = object; PN = pronoun; NP = noun phrase; PP = prepositional phrase.

^aInitially, P4 had difficulty producing subjects and verbs and was directed to focus on the verb.

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Table 1

Characteristics of participants with aphasia.

P	Gender	Language	Age (years)	Handedness	Years postonset	Lesion	AQ	Language production characteristics
1	Female	English	60	R	3.5	LH-MCA	— ^a	Word-finding difficulty, pauses and false starts, frequent semantic errors, and infrequent grammatical and phonological errors
2	Female	English	52	R	2.0	LH-MCA	75.9	Slowed production, frequent pauses, semantic and grammatical errors
3	Female	English	38	R	7.0	LH-MCA	65.2	Exclusive use of nouns in spontaneous speech. Slow multiword utterances, long pauses, and occasional morphological, semantic, and phonological errors
4	Female	Spanish	53	R	1.5	LH-MCA	62.4	Few function words and verbs; frequent perseveration, false starts, semantic and phonological errors

Note. P = participant; R = right-handed; LH = left hemisphere; MCA = middle cerebral artery; AQ = aphasia quotient.

^aP1 received a score of 3 on the Boston Diagnostic Aphasia Examination (BDAE) prior to participation in the study.

Table 2

Wh-question scoring rubric.

Form			
Rating	Preservation of tense	Part of speech requirement	Subject inclusion
Explanation	The response tense matched the requirements of the question.	Participant produced the minimal elements, e.g., nouns, verbs, causal clause, etc., required to satisfy the question.	If the question required, a subject was included in the response.
Example	“What did you do this morning?” requires a verb in the past tense, as in “I ate breakfast.”	“Why do people go to college?” requires a verb, as in “to learn.”	“Why was Frank Sinatra so popular?” requires a sentence with a subject.
Content			
Rating	Subject specificity	Content specificity	Relevance
Explanation	The response referred to the appropriate noun.	The information in the response was sufficient to answer the question.	The response included any information related to the question.
Example	“How do Americans celebrate Christmas?” requires that the subject is “Americans” or third personal plural pronoun “they.”	“Why was Frank Sinatra so popular?” requires an answer that contains a reason.	Scoring was item-specific.

Table 3

Results of action description task.

Appropriate verbs					
P	Condition	Pre-post change for participants			Healthy individuals ^a
		Pre appropriate verbs, <i>n</i> (%)	Post appropriate verbs, <i>n</i> (%)	Change in appropriate verbs produced (%)	<i>M</i> (<i>SD</i>) of appropriate verbs (% appropriate)
1	Treated (18)	11 (61)	14 (78)	3 (28)	92.6 (2.5) (97)
	Untreated (78)	55 (71)	63 * (81)	8 (14)	
	Total (96)	66 (69)	77 * (80)	11 (17)	
2	Treated (29)	25 (86)	27 (93)	2 (8)	
	Untreated (67)	55 (82)	56 (84)	1 (3)	
	Total (96)	80 (83)	83 (87)	3 (3)	
3	Treated (32)	25 (78)	32 * (100)	7 (28)	
	Untreated (64)	42 (66)	45 (70)	3 (6)	
	Total (96)	67 (70)	77 * (80)	10 (15)	
4	Treated (23)	1 (4)	7 * (30)	6 (650)	
	Untreated (64)	30 (47)	31 (48)	4 (2)	
	Total (87)	31 (36)	38 * (44)	7 (23)	
Grammatical sentences					
P	Pre grammatical sentence (%)	Pre-post change for participants		Change in grammatical sentences (% change)	Healthy individuals ^a
		Post grammatical sentence (%)			<i>M</i> (<i>SD</i>) of grammatical sentences (% grammatical)
1	55 (57)	67 * (70)		12 (22)	92.4 (2.4) (96)
2	57 (59)	66 * (69)		9 (17)	
3	28 (29)	41 * (43)		13 (46)	
4	16 (18)	26 * (30)		10 (63)	

Note. The mean numbers of appropriate verbs and grammatical sentences from 10 healthy individuals are provided for comparison.

^aThe last column provides data from healthy individuals for comparison. A group of 10 healthy individuals was assessed at one time point (thus, “pre/post” and “treated/untreated” data are not applicable in this column). The mean response for the group is provided, for one measure.

^{*}
p .05 on McNemar's chi-square test.

Table 4

Results of sequence description task.

Appropriate verbs					
P	Pre-post change for participants			Healthy individuals^a	
	Pre appropriate verbs / different verbs produced (%)	Post appropriate verbs / different verbs produced (%)	Pre-post % change appropriate verbs	<i>M (SD)</i> of different verbs	<i>M (SD)</i> of appropriate verbs (% appropriate)
1	55/57 (97)	56/58 (97)	0	46.3 (14.3)	40.9 (11.4) (88)
2	19/20 (95)	18/20 (90)	-5		
3	8/9 (89)	5/6 (83)	-6		
4	13/15 (87)	10/16 (63)	-28		
Grammatical sentences					
P	Pre-post change for participants			Healthy individuals^a	
	Pre grammatical utterances / utterances produced (%)	Post grammatical utterance / utterance produced (%)	Pre-post % change grammatical utterances	<i>M (SD)</i> of sentences	<i>M (SD)</i> of grammatical sentences (% grammatical)
1	36/60 (60)	49/80 (61)	2	28.0 (3.4)	24.6 (4.8) (88)
2	5/27 (19)	10/25 (40)	116		
3	1/11 (9)	2/12 (17)	83		
4	8/42 (19)	6/32 (19)	-2		

Note. Mean number of sentences and mean number of grammatical sentences from 10 healthy individuals are provided for comparison.

^aThe last column provides data from healthy individuals for comparison. A group of 10 healthy individuals was assessed at one time point (thus, "pre/post" and "treated/untreated" data are not applicable in this column). The mean response for the group is provided, for one measure.

Table 5Results of *wh*-questions task.

Content				
P	Pre-post change for participants			Healthy individuals^a
	Pre (%)	Post (%)	Change in score (%)	<i>M (SD)</i> (%)
1	85 (94)	84 (93)	-1 (-1)	87.2 (2.4) (97)
2	80 (89)	81 (90)	1 (1)	
3	40 (44)	48 (53)	8 (20)	
4	38 (42)	53 (59)	15 (39)	
Form				
P	Pre-post change for participants			Healthy individuals^a
	Pre (%)	Post (%)	Change in score (%)	<i>M (SD)</i> (%)
1	78 (87)	79 (88)	1 (1)	87.9 (2.4) (98)
2	73 (81)	70 (78)	-3(-4)	
3	24 (27)	34 (38)	10 (42)	
4	52 (58)	55 (61)	3 (6)	

Note. Values listed are scores achieved out of total of 90 points in each area, form and content. Mean values of form and content for 10 healthy individuals are provided for comparison.

^aThe last column provides data from healthy individuals for comparison. A group of 10 healthy individuals was assessed at one time point (thus, “pre/post” and “treated/untreated” data are not applicable in this column). The mean response for the group is provided, for one measure.