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Informativeness ratings of messages created on an AAC processing prosthesis

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Abstract

Background—*SentenceShaper*™ (SSR) is a computer program that supports spoken language production in aphasia by recording and storing the fragments that the user speaks into the microphone, making them available for playback and allowing them to be combined and integrated into larger structures (i.e., sentences and narratives). A prior study that measured utterance length and grammatical complexity in story-plot narratives produced with and without the aid of *SentenceShaper* demonstrated an "aided effect" in some speakers with aphasia, meaning an advantage for the narratives that were produced with the support of this communication aid (Linebarger, Schwartz, Romania, Kohn, & Stephens, 2000). The present study deviated from Linebarger et al.'s methods in key respects and again showed aided effects of *SentenceShaper* in persons with aphasia.

Aims—Aims were (1) to demonstrate aided effects in "functional narratives" conveying hypothetical real-life situations from a first person perspective; (2) for the first time, to submit aided and spontaneous speech samples to listener judgements of informativeness; and (3) to produce preliminary evidence on topic-specific carryover from *SentenceShaper*, i.e., carryover from an aided production to a subsequent unaided production on the same topic.

Methods & Procedures—Five individuals with chronic aphasia created narratives on two topics, under three conditions: Unaided (U), Aided (SSR), and Post-SSR Unaided (Post-U). The 30 samples (5 participants, 2 topics, 3 conditions) were randomised and judged for informativeness by graduate students in speech-language pathology. The method for rating was Direct Magnitude Estimation (DME).

Outcomes & Results—Repeated measures ANOVAs were performed on DME ratings for each participant on each topic. A main effect of Condition was present for four of the five participants, on one or both topics. Planned contrasts revealed that the aided effect (SSR >U) was significant in each of these cases. For two participants, there was also topic-specific carryover (Post-U >U).

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Conclusions—Listeners judged functional narratives generated on *SentenceShaper* to be more informative than comparable narratives spoken spontaneously. This extends the evidence for aided effects of *SentenceShaper*. There was also evidence, albeit weaker, for topic-specific carryover, suggesting that the program might be used effectively to practise for upcoming face-to-face interactions.

SentenceShaper™ is a computer program designed to allow aphasic speakers to produce more grammatical and informative utterances than they are able to produce spontaneously.[1,2] Its development was guided by the view that aphasic language production is hampered by performance factors, in particular, slow retrieval or rapid decay of linguistic information (Kolk, 1995;Kolk & van Grunsven, 1985). Such limitations may give rise to fragmented and ill-formed utterances by preventing the speaker from assembling simultaneously in memory the constituents of a sentence or other grammatical structure. For example, the first element of a sentence may be activated and then decay as the aphasic speaker struggles to retrieve subsequent material. Recent evidence suggests that persons with aphasia may also experience performance limitations in the form of difficulty in resolving competition among sentential elements in a timely and accurate manner (Gordon & Dell, 2003;Martin & Freedman, 2001;Schnur, Schwartz, Brecher, & Hodgson, 2006;Schwartz & Hodgson, 2002).

SentenceShaper minimises the performance demands of spoken language production by taking some computations off line. The program allows the user to record his or her spoken fragments and to associate these saved fragments with visual icons that can be manipulated on the computer screen. Replaying an icon triggers playback of the recorded material linked to it, and these icons can be dragged to different areas of the screen in order to be combined and integrated into larger structures. Thus, the program, acting as a "processing prosthesis", allows the user to continually refresh their memory of previously articulated sentence elements, and to produce larger structures (i.e., sentences and narratives) by visually arranging icons, without having to re-retrieve the constituent elements. In this way it "turns off the clock", giving aphasic individuals as much time as necessary for activating, selecting, recording, and ordering lexical elements and structural units. In its core functionality, detailed below, *SentenceShaper* can be described as a word-processing program for spoken language.

To date, only one study has compared aphasic speech samples produced on and off *SentenceShaper* (Linebarger et al., 2000). The samples, representing participants' retelling of silent film plots, were scored on quantitative measures of production. As predicted, scores were higher for the speech samples produced on the program. The present study sought to extend the evidence by varying the nature of the language samples and having unfamiliar listeners rate their informativeness. The remaining sections of the introduction develop the rationale for the study, starting with a description of *SentenceShaper*'s core functionality and modes of use.

The term *SentenceShaper* is used here to refer both to the program itself and to any computer running this program. Figure 1 shows *SentenceShaper*'s user interface, with major components labelled. (Note: The following description assumes a touch screen, although the program can be used with a mouse or other user input device.) The user begins by recording words or phrases by touching the sound recorder *On/Off Buttons* at the bottom of the screen. When the "Off"

[1]*SentenceShaper* uses methods and computer interfaces covered by U.S. Patent No. 6,068,485 (Linebarger & Romania, 2000) owned by Unisys Corporation and licensed to Psycholinguistic Technologies, Inc., which has released *SentenceShaper* as a commercial product. A potential conflict of interest arises because ML serves as Director of Psycholinguistic Technologies. Therefore, ML has not participated in testing or in scoring of raw data in the study reported here.

[2]*SentenceShaper* is the latest version of a program whose earlier prototype went by the name "CS" for "Communication System". From the user's perspective, CS and *SentenceShaper* are the same, except for cosmetic features such as changes to the colours, shapes, and/or location on the screen of program elements. Consequently, in sections of this paper that describe prior results with the program, past and current versions are not distinguished, and the current name, *SentenceShaper*, is applied to both. Interested readers are invited to compare the prototype's interface, depicted in Linebarger et al., 2000, with that of *SentenceShaper*, shown in Figure 1.

button is touched, an arbitrary icon (or *shape*) appears in the Work Area. Touching this shape causes its associated sound file to be replayed. Shapes in the Work Area can be dragged to the *Trash Hole* on the lower left or moved to the *Sentence Assembly Area*, where sentence elements are ordered from left to right. The entire contents of the Sentence Area can be replayed by touching the *Play Sentence Area* button. When the user deems the "sentence" to be complete (it is often an agrammatic approximation), she/he clicks the "*Make a Bean*" *Button*; this causes the entire contents of the Sentence Area to be concatenated and associated with a single "purple bean" icon, which is displayed in the *Narrative Assembly Area* at the top of the screen. Purple beans in this area can be reordered, deleted, or dragged back to the Sentence Area for revision.

SentenceShaper incorporates tools for word-finding support, which can be disabled for testing or customised by the clinician. The primary support is a set of up to 36 buttons on both sides of the screen. These *Side Buttons* typically display the printed text of high-frequency words such as prepositions, pronouns, and semantically flexible verbs (e.g., "make", "take", "give"); clicking on a Side Button causes the program to play a pre-recorded sound file pronouncing that word. In order to incorporate this word into a *SentenceShaper* production, the user must repeat the word and record it on the program. It should be emphasised that the Side Buttons do not represent pre-recorded messages ready for delivery to a listener. Rather, they support the user's own spoken language production by cueing his/her production of syntactically important elements such as verbs or pronouns, which help to create more structured utterances; and in so doing they may also help the user retrieve other words that are associated with the cued word in that context (Cloze effect). For example, in the context of a description of a marathon, the preposition "to" may trigger "to the finish line" or "give water to the runners" in an individual who cannot retrieve these nouns without such a cue (Linebarger & Schwartz, 2005).

The term "SSR production" denotes the final output of a *SentenceShaper* session: the set of utterances that the user has spoken, recorded, ordered, and saved. This definition excludes utterances spoken with the sound recorder off, and utterances recorded but subsequently deleted by the user. As noted, *SentenceShaper* can be compared to a word-processing program for speech rather than text; an SSR production is comparable to the final version of a text created on a word processor.

ASSISTIVE AND THERAPEUTIC MODES OF USE

Previous studies of *SentenceShaper* have examined its use in two somewhat distinct modes: as an assistive device and as a treatment tool. The results of these studies are examined in the following section, but first it is necessary to clarify the distinction between these two modes.

When a computer running the *SentenceShaper* program is used to facilitate a speaker's communication with other people, then this computer may be described as an *assistive device* or an *Augmentative and Alternative Communication (AAC) aid*. Note that even a program installed on a desktop computer can serve to facilitate communication; the user can record utterances that express his/her thoughts and desires intending that others (clinicians, family members, friends) hear the production; and a desktop system can also be used for speeches, web postings, or messages to be played over the telephone.

SentenceShaper may also be used as a *treatment tool*. A program that allows the user to create more complex and well-formed utterances may facilitate a kind of practice that would not be possible without such support. When *SentenceShaper* is used as part of a treatment program, different kinds of materials may be employed than when it is used to assist communication; therapeutic use may require the training of particular linguistic structures, and subject matter may be less constrained than in typical communicative situations.

OUTCOMES OF ASSISTIVE AND THERAPEUTIC MODES OF USE

Aided effects

Positive outcomes associated with the assistive mode are termed "aided effects". Aided effects are demonstrated by comparing a user's aided production (the final output of a *SentenceShaper* session, as defined above) with an unaided production generated by that same user, on the same topic, at a comparable point in time. (The term "unaided" is used interchangeably with "spontaneous" to refer to speech produced without the use of *SentenceShaper*.). Generation of aided and unaided productions is preceded by a period of training towards operational competence on *SentenceShaper*, and guided and independent practice in using *SentenceShaper* to produce narratives on a variety of topics, all different from the assessed topics. Henceforth, this combination of training and practice on *SentenceShaper* will be designated "training". Table 1 (top panel) outlines the minimal design suitable for investigating aided effects of *SentenceShaper*.

The study by Linebarger et al. (2000) referenced earlier demonstrated aided effects in six participants with agrammatic aphasia. Following several sessions of *SentenceShaper* training, narrative samples were elicited by having the participants view, then retell, two short, unfamiliar, wordless films. Each film was retold twice (each time after viewing), once with the aid of *SentenceShaper* and once without it. Condition and topic order were counterbalanced. Aided and unaided transcripts were then compared on measures of structural and morphological production, using the Quantitative Production Analysis (QPA) (Saffran, Berndt, & Schwartz, 1989). Results showed that unaided and aided samples were not reliably different on morphological measures; however, aided effects were seen on measures of length and structural complexity. These effects were in the right direction for five of the six participants and statistically significant ($p < .05$) in the group analysis. It is noteworthy that the version of *SentenceShaper* used in Linebarger et al. (2000) provided no word-finding support of any kind; thus, the aided effects observed there were solely due to the features of the program that minimise the performance demands of spoken language production.

Treatment effects

Positive outcomes associated with the therapeutic mode are termed "treatment effects". Treatment effects are demonstrated by comparing two *spontaneous* productions on the same topic(s), elicited before and after "treatment" with *SentenceShaper*. Treatment consists of clinician-guided and independent practice in using *SentenceShaper* to produce narratives on a variety of topics, all different from those pre and post. This is basically an extension of the training phase, involving increased emphasis on user independence, longer narratives, and in some cases, the use of particular grammatical structures (e.g., prepositions). The middle panel of Table 1 shows the minimal design for assessing treatment effects.

This design has been used in a few small studies, each of which investigated treatment effects at the individual level, in participants who differed in aphasia severity and subtype (Linebarger, McCall, & Berndt, 2004; Linebarger, McCall, Virata, & Berndt, 2007; Linebarger & Schwartz, 2005; Linebarger, Schwartz, & Kohn, 2001). Most were nonfluent, with Broca's aphasia or anomia. Before and after a phase of *SentenceShaper* treatment, spontaneous speech samples were generated by having participants retell the plots of silent films, fairy tales, or wordless picture books. Goals and procedures in the treatment phase varied across participants, and in each study some participants benefited while others did not. The most consistent gains were observed on the structural measures of the QPA. Proportion of Correct Information Units (CIU) (Nicholas & Brookshire, 1993) also showed treatment effects in the studies that additionally performed the information-unit analysis (Linebarger et al., 2004, 2007).

Topic-specific carryover

This body of treatment studies attests to the fact that in some patients the practice and effort involved in using *SentenceShaper* during a treatment phase leads to improved spontaneous production on topics different from those that were practised during treatment. As yet, no data exist on whether spontaneous production improves for the *same* topics that were practised, or on how much practice is required to generate such "topic-specific carryover". In a preliminary investigation of this issue, this study investigated whether topic-specific carryover to spontaneous speech could be demonstrated after a single production on *SentenceShaper* generated a few days earlier. The bottom panel of Table 1 outlines the steps in the design used to measure aided effects and topic-specific carryover.

FUNCTIONAL NARRATIVES

In this study, narratives were elicited using stimuli and procedures from the Amsterdam-Nijmegen Everyday Language Test (ANELT) (Blomert, Kean, Koster & Schokker, 1994), which presents participants with hypothetical daily life situations to which they must respond. On a typical item, the examiner says: "The kids on the street are playing football in your yard. You have asked them before not to do that. You go outside and speak to the boys. What do you say?" The participant's spoken response is an "ANELT narrative". Different items of the ANELT are here designated "topics".

From a discourse perspective an ANELT narrative, like a story-plot narrative, is a monologue, lacking the free exchange of turns that characterises conversation (Clark, 1996). However, unlike story-plot narratives, ANELT narratives are expected to convey a first-person perspective that takes account of what the imagined hearer does and does not know about the situation, and what the hearer can and should do to resolve the problem. There is a second, related difference: story-plot narratives mainly serve to communicate specific content, whereas ANELT narratives additionally express personal attitudes and social relations. In the terminology of Brown and Yule (1983), this adds an "interactional" element to the mostly "transactional" function of a story-plot narrative.

The relevance of the ANELT narratives to communication situations that arise in everyday life justifies their characterisation as "functional" in the present context. An aim of this study was to investigate whether aided effects, previously measured in story-plot narratives, would extend to functional narratives of this type.

LISTENER JUDGEMENTS OF INFORMATIVENESS

As the prior demonstration of *SentenceShaper*'s aided effects employed quantitative measures of production (Linebarger et al., 2000), a second aim of the current study was to extend the evidence to a new measure that arguably has greater functional relevance; that measure is "informativeness" as judged by unfamiliar listeners. Listener judgements were obtained by the methods of Direct Magnitude Estimation (DME). DME does not provide judges with a single, equal-interval rating scale (cf. Ballard & Thompson, 1999; Doyle, Goldstein, & Bourgeois, 1987; Hickey & Rondeau, 2005; Olness, Ulatowska, Carpenter, Williams-Hubbard, & Dykes, 2005; Ross & Wertz, 1999). Rather it asks them to assign numbers of their own choosing to express the ratio of stimulus magnitudes. A review of prior studies employing DME indicates that some had participants rate experimental samples against a standard or "modulus" (e.g., Schiavetti, Metz, & Sitler, 1981; Schiavetti, Sacco, Metz, & Sitler, 1983), whereas others had them rate each sample in relation to the others (Campbell & Dollaghan, 1992; Doyle, Tsironas, Goda, & Kalinyak, 1996; Jacobs, 2001; Schiavetti et al., 1983). This study employed the latter method.

DME methods are recommended in cases where the rated dimension is known to resist partitioning into equal intervals, or when evidence on the matter is lacking (Stevens, 1975; see also Campbell & Dollaghan, 1992; Doyle et al., 1996). Since informativeness and related dimensions of spontaneous language qualify as lacking the relevant evidence, DME has been used in several investigations of connected discourse produced by persons with speech or language impairment (Campbell & Dollaghan; 1992; Doyle et al., 1996; Jacobs, 2001; Schiavetti et al., 1981, 1983).

The study by Doyle et al. (1996) is noteworthy for having demonstrated strong correlations between DME informativeness ratings and laboratory measures derived from information-unit analysis (Brookshire & Nicholas, 1994; Nicholas & Brookshire, 1993). While the purpose of that study was to obtain social validation support for the laboratory measures, the results can also be viewed the other way around, as validating the DME method for measuring informativeness in aphasic speech samples. Accordingly, the current study used listeners' DME judgements as the primary dependent variable in this investigation of functional narratives produced on and off *SentenceShaper*.

METHOD

Participants

Aphasic participants—Five people who were diagnosed with mild to moderate aphasia on the basis of clinical testing participated in the experiment. Two were male and three were female. Participants ranged from 32 to 62 years of age (M = 51.6; SD = 11.5) and had received between 12 and 20 years of formal education. Four of the five participants were monolingual native speakers of English. One (DCN) was bilingual with Spanish as his first language. All five participants were right-handed and all had sustained a left-hemisphere stroke between 43 and 201 months prior to the experiment (M = 105.8; SD = 70.9). The participants varied with respect to aphasia type and severity as measured by the Western Aphasia Battery (WAB; Kertesz, 1982). Individual profiles are presented in Table 2.

The five participants were selected because they had prior familiarity with *SentenceShaper*™. More than a year earlier, they had participated in a treatment study that combined regular language practice on *SentenceShaper* with weekly conversation groups, with the aim of improving spontaneous language production (Schwartz et al., 2005). In the comparison of unaided fairy tale narratives produced before and after that study, two of the current participants (DCN and OT) showed a treatment effect on all or most of the QPA structural measures; one (EC) showed an effect on some; and two (MAI and MO) showed no effect on any of the structural measures of interest. This prior study did not evaluate differences in aided versus unaided language production. Participant EC also participated in Linebarger et al. (2000), where she demonstrated strong aided effects on QPA structural and length measures.

Study participants were tested under a research protocol approved by the Institutional Review Boards of Albert Einstein Healthcare Network (AEHN). They gave written informed consent and were paid for their participation. As human subjects policy at AEHN precludes the identification of participants by their actual initials, all identifiers used here are codes.

Raters—Raters were 13 female, monolingual, native speakers of English, ranging in age from 21 to 28 (M = 22.7; SD = 2.2). They were graduate students in a Speech-Language-Hearing Science programme, who were currently enrolled in an introductory course in adult language disorders. All had been exposed to the major aphasia syndromes through videotapes and, in some cases, practicum experience, but they had no familiarity with the study participants and had never heard them speak. They were also naïve to the purpose of the study. All raters had normal or corrected-to-normal vision and had passed a pure-tone audiometric screening at 25

dB HL at 500, 1000, 2000, and 4000 Hz in both ears. They gave informed consent to participate under a research protocol approved by the IRB of AEHN.

Design

The following description conforms to the Phases outlines in Table 1 (bottom panel), with one addition: Phase 1, *SentenceShaper* training, was performed in two stages, each with different goals and stimuli.

Phase 1a. Training to operational competence—Participants generated complex picture- and story-plot descriptions on *SentenceShaper* as a means of becoming reacquainted with the basic features of the program and its updated appearance. Within three sessions of practice, each demonstrated competence in the core behaviours that constitute operational competence: recording sound files, moving icons across the three staging areas (Work, Sentence, Narrative), replaying and reordering elements within the Sentence and Narrative areas, deleting elements from all three areas, and using the Side Buttons as needed to assist sentence construction.

Phase 1b. Training to create ANELT narratives on SentenceShaper—This stage, lasting two to three sessions, had two goals: to familiarise participants with the ANELT elicitation format (Blomert et al., 1994), and to provide training and practice in producing ANELT narratives on a version of *SentenceShaper* that was customised to display five new Side Buttons (see below). The stimuli were seven ANELT topics used only in this phase. The first two were used to introduce the procedure and did not involve *SentenceShaper*. For the remaining five topics, participants generated the response on *SentenceShaper*.

The five new Side Buttons were displayed on the left side of *SentenceShaper*'s screen. The labels on these buttons read as follows: "hello", "the problem is …", "I want you to …", "I will …", and "goodbye". Touching a button activated a sound file pronouncing that word or partial phrase; and the user was free to repeat and record the word(s) and incorporate them into his/her *SentenceShaper* production. The remaining buttons on *SentenceShaper*'s screen included prepositions, verbs, and pronouns.

As explained earlier, Side Buttons provide specific words for incorporation into the user's utterances and can also induce a Cloze effect. The new buttons had the same functionality; additionally, they were intended to provide the user with a skeletal framework for the functional narrative (greeting, statement of the problem, request for assistance, statement of the speaker's intentions, and farewell), potentially guiding narrative creation itself. Henceforth, the new Side Buttons are referred to as "Discourse Cues".

Early in the training, the examiner provided instruction, modelling, and feedback to demonstrate the benefits of using the Discourse Cues to organise and enrich the content of the narratives. With the last three topics, the examiner encouraged independence by leaving the room while the participant generated the narrative on *SentenceShaper*. All participants learned the procedure quickly; on *SentenceShaper*, each adopted the routine of reading and playing the Discourse Cues during the narrative composition and incorporating one or more Discourse Cues into each narrative.

Phase 2: Unaided practice—Table 1 (bottom panel) shows this phase as involving unaided practice with topic set *z*, the same topics that in subsequent phases are used to elicit the experimental samples. The rationale for practising the experimental samples off *SentenceShaper* is to ensure that the quality of the unaided sample (Phase 3) is not artificially depressed, relative to the aided sample (Phase 4) and the post-SSR unaided sample (Phase 5), by novelty, or lesser practice.

Topic set *z* in the study design included the following ANELT topics:

- *Lost Glove*: "You are in the drugstore and this [examiner presents glove] is lying on the floor. You take it to the counter. What do you say?"
- *Broken Glasses*: "You are at the optician's shop. You brought these in [examiner presents broken glasses]. I am the sales person. What do you say?"

In each session of Phase 2, participants completed each topic once, after hearing the lead-in, without benefit of *SentenceShaper* or any Discourse Cues and without feedback of any kind. DCN, EC, and MO practised *Glove* and *Glasses* four times over the course of four sessions; OT and MAI practised them three times over the course of three sessions. Order was counterbalanced across sessions. Narratives were recorded on audiotape for later transcription.

Phases 3–5: Experimental samples—Collection of the experimental samples began in the session immediately following the last session of Phase 2. It began with the unaided sample (U), which, from the perspective of the participant, simply constituted another trial of unaided practice (the fourth for OT and MAI; the fifth for the others). Collection of the aided sample (SSR) and the post-SSR unaided sample (Post-U) followed in turn. *Glove* and *Glasses* were counterbalanced to avoid order effects within and across participants and to ensure that participants did not produce two unaided responses or two aided responses on the same day. For DCN, EC, and MO, experimental sessions were ordered as shown below. For OT and MAI, Session 1 started instead with *Glasses*, Condition U.

- Session 1: *Glove*, Condition U
- Session 2: *Glasses*, Condition U; *Glove*, Condition SSR
- Session 3: *Glove*, Condition Post-U; *Glasses*, Condition SSR
- Session 4: *Glasses*, Condition Post-U

U and Post-U samples were elicited in the standard manner. In the SSR condition, the examiner read the participant the lead-in, then left the room while s/he generated the response on *SentenceShaper* (Discourse Cues included). Upon returning, the examiner played what the participant created, and, without giving feedback, asked whether s/he wished to change or add anything. All conditions were conducted without examiner feedback. In summary, for each of the five participants, six experimental samples were collected (U, SSR, and Post-U for each topic, *Glove* and *Glasses*). These 30 samples—15 Glove narratives and 15 Glasses narratives—comprised the stimuli for the informativeness judgements.

Preparation of the audio samples

The experimental samples were transferred from audiotapes (U and Post-U conditions) and computer files (SSR condition) onto a Macintosh computer. Each sample was then edited and saved as a 16-bit, mono QuickTime file. During editing, identifying information (name, address, etc.) was replaced with a short tone, and extraneous noises were removed (e.g., hospital loudspeaker). Certain background noises, such as the hum of the computer or the rustling of papers, could not be removed; raters were instructed to ignore any differences in recording quality of the speech samples.

The edited samples were transferred to CDs. For each rater, two CDs were created, organised by topic. Each CD contained all 15 samples for that topic (e.g., all 15 *Glove* samples), plus three duplicate samples, added for the purpose of assessing each rater's reliability with herself (Campbell & Dollaghan, 1992). The duplicate samples were different for each rater, having been selected at random from the set; and the full set of 18 samples (15 experimental, 3 duplicates) was presented in different, randomised orders. Raters were not told about the

identity of the speakers, the presence of duplicate samples, or the fact that participants had used a computer program to create some of the samples.

Rating experiment

The rating experiment was conducted in a quiet computer lab, over a single 2-hour session. Raters were instructed as a group, but listened privately through LT-100 headsets via the "Windows Media Player" program on a Dell OptiPlex GX400 computer. The session began with an example of the DME rating method involving ratings of line lengths (Stevens, 1975). It was then explained to the raters that they would be rating speech samples from persons with aphasia who were attempting to communicate a particular topic. They were shown the text of the ANELT lead-in (e.g., to *Glove*) and were told to imagine themselves as the shopkeeper to whom the person with aphasia was speaking. They were also given written and verbal instructions to judge each speech sample on the dimension of "informativeness". This read as follows:

> Your task is to judge the informativeness of each sample by assigning a number to it. The main ingredients of informativeness are accuracy and completeness. The samples you are about to hear will differ from one another, and from unimpaired speech, in many ways, including rate, prosody, and clarity of speech. For present purposes, these factors are relevant only insofar as they affect accuracy and completeness. We are asking you to make a global judgement of each sample, reflecting how informative it is, that is, how accurate and complete.

The rater then listened to the first sample on her CD and was told to "rate the first sample with any number that seems appropriate to you, keeping in mind that higher numbers are associated with greater informativeness and lower numbers are associated with lower informativeness" (Campbell & Dollaghan, 1992, p. 51). She then listened to the second sample and rated its informativeness in proportion to the first one. After taking questions, the examiner instructed the raters to continue with the remaining samples, "remembering to rate the informativeness of each sample in proportion to the one before". Raters were discouraged from replaying previous tracks. After completing the first CD, raters were given a 30-minute break, after which they judged the samples on the second CD (second topic) following the same instruction process.

Data reduction and analysis—DME requires that raters' scores be converted to a common scale prior to data analysis. In this study, the highest score assigned by any rater was 100, so all scores were converted to a scale of 0–100. The principal data analysis was performed with the SPSS General Linear Model Repeated Measures (RM) program. A separate RM-ANOVA was performed for each aphasic participant on each narrated topic. In these analyses, the sole within-subjects factor was Condition (U, SSR, Post-U); and the dependent variable was standardised scores from 12 raters (scores from one rater were eliminated due to poor reliability; see below). The effect of Condition was further analysed by two planned contrasts: U versus SSR, and U versus Post-U. The criterion for significance in all cases was $p < .05$.

In accordance with standard procedures for determining reliability of DME judgements (Campbell & Dollaghan, 1992; Doyle et al., 1996; Jacobs, 2001), we examined the mean of the absolute difference score for first and second hearing of the duplicate samples ($N = 6$; 3 per CD) and calculated Spearman correlations between ratings on first and second hearings. Based on this analysis of intra-rater reliability, one unreliable rater was excluded from all remaining analyses.

Inter-rater reliability was measured here as well: For the remaining 12 raters, a matrix of bivariate correlations (Spearman Rho) was generated that expressed inter-rater agreement on

the scores assigned to the 30 experimental samples. Criterion for significant agreement was $p < .05$ (one-tailed).

RESULTS

Reliability

Intra-rater reliability—The grand mean of the absolute difference score for samples heard twice was 16.3 on a scale of 100 (16.3%), with standard deviation 9.9. One rater's mean was 45.5, three standard deviations above the grand mean. This was the excluded rater mentioned earlier. The grand mean for the remaining 12 was 13.8 ($SD = 4.7$). Correlation coefficients for the six pairs of duplicate samples had a median value of .80 across raters; and Rho computed on all 72 pairs was .75; $p < .0001$. This is considered acceptable intra-rater reliability in studies of this type (e.g., Campbell & Dollaghan, 1992; Doyle et al., 1996).

Inter-rater reliability—The matrix of bivariate correlations expressing agreement across raters had 66 cells below the diagonal (i.e., 66 unique correlations). All but two were statistically significant. Means of the correlations for each rater with all others ranged from . 38 to .58. To our knowledge inter-rater reliability of DME ratings of language samples has not been measured before, so there is no basis for comparison with other studies. In any case, this moderate level of agreement means that in the main analysis, reported below, power was probably sufficient to detect moderate-sized differences across conditions but perhaps not small differences.

Difference in informativeness across conditions

Table 3 shows the mean ratings by participant, topic, and condition, as well as the results of the statistical analyses for Condition main effect and planned contrasts (rightmost columns). Of the ten RM-ANOVAs (one per row), six yielded a significant Condition effect. Four of five participants (all but DCN) showed the effect for one or both topics. Planned contrasts (last column) revealed that in each of the six cases where there was a Condition effect, SSR differed significantly from U in the predicted direction (SSR >U). Averaged across participants (bottom row), the rating for SSR exceeded U by 28 points (*Glove*) and 20 points (*Glasses*), on a scale of 100. This constitutes strong evidence for the predicted aided effect.

Evidence for topic-specific carryover was weaker. Ratings for Post-U differed significantly from U in the expected direction (Post-U >U) in three of ten analyses: Participant MO showed the effect on both topics; Participant EC showed it on *Glasses* only. Transcripts are shown in Table 4 for two of these three cases. The Post-U samples convey content that was not mentioned in the unaided sample (or in any of the unaided practice trials) but appeared for the first time in the aided sample. Such content, shown underlined in the table, plausibly represents carryover from the aided production.

The samples presented in Table 4 were also significant for aided effects. By comparing the U and SSR samples in the table, readers can gain an intuitive feel for the informational enhancement that raters detected in the aided samples. The Appendix presents transcripts from all participants on all topics, including those gathered in Phase 2 (unaided practice).

DISCUSSION

This study extends the evidence from Linebarger et al. (2000) that spoken productions composed by individuals with aphasia on *SentenceShaper*™ are enhanced, relative to productions generated off the program. The present findings show that the language enhancement is not limited to story-plot narratives, but also occurs in narratives that express

hypothetical everyday situations from a first-person perspective. The findings also show that the enhancement is not demonstrable solely on laboratory measures of utterance length and grammatical structure (Linebarger et al., 2000), since unfamiliar listeners perceived the aided samples to be more informative (more complete and accurate) than comparable unaided samples.

Unaided practice and aided practice

In order to examine aided effects and practice-specific carryover in the same design, it was necessary to elicit the experimental samples in a fixed order, with the unaided sample always preceding the aided sample. The inclusion of Phase 2, involving unaided practice of *Glove* and *Glasses*, ensured that the topics were familiar and practised beforehand. The only way that condition order could have operated to the advantage of the aided sample would be if practice benefits were still accruing at the point in the practice sequence when the unaided sample was produced. Informal review of the samples (see Appendix) indicates that this was not the case; rather, for the most part, the unaided sample, coming after three to four trials of unaided practice, looks similar to the practice trials that precede it, and different from the aided production that follows. A recent study supports the absence of practice gains for topics narrated repeatedly in the unaided mode, using quantitative production measures (Linebarger et al., 2007).

Recall that the study began with practice on *SentenceShaper* of a different set of ANELT topics. Such aided practice could conceivably have given rise to treatment effects of the sort that were discussed in the Introduction; that is, generalised carryover to spontaneous production from prolonged experience generating speech on *SentenceShaper*. This was not the intent of Phase 1b, and the study design does not accommodate an analysis of the treatment effects from Phase 1b (see Table 1, middle panel). On the other hand, the design does ensure that any unintended treatment carryover from Phase 1b to spontaneous speech would either dissipate during the sessions of unaided practice in Phase 2 or, if it persisted into Phase 3 (unaided sample) would work against the predicted aided effect by raising the ratings for the unaided sample.

The study design does, of course, accommodate analysis of topic-specific carryover (i.e., from Phase 4 to Phase 5), which can be viewed as a degraded or limited form of treatment effect. If the spontaneous productions of *Glove* and *Glasses* were enhanced from having been narrated on *SentenceShaper* in Phase 4, ratings would be higher for the Post-U (Phase 5) than the U sample (Phase 3). This was the result for two of five participants, on a total of three topics (EC Glasses: U = 12.6, PU = 41.3; MO Glove: U = 5.4, PU = 48.7; MO Glasses: U = 23.1, PU = 55.3). This result is weak, relative to the aided effect, which was significant for four of five participants (six of ten topics). On the other hand, it raises the possibility that prolonged topic-specific practice on *SentenceShaper* might serve as effective preparation for a subsequent face-to-face communication on that topic.

Informativeness versus grammatical structure

This study did not address whether different indices of the aided effect correlate with one another, in particular whether the aided samples judged to be more informative also have more grammatical structure according to QPA analysis. In theory, two samples of comparable grammatical complexity may differ in their informativeness (accuracy and completeness); conversely, samples may differ in structural complexity but not informativeness. There is some empirical evidence for dissociations along these lines (e.g., Doyle et al., 1987; Jacobs, 2001), but the interpretation is complicated by the likely differences in power and sensitivity across methods used to quantify informativeness and grammatical structure.

Review of the transcripts of DCN, the one participant for whom informativeness ratings did not differ for aided and unaided samples, raised the suspicion that his aided sample contained more grammatical structure than his unaided sample. Blinded scoring of his data by a speech-language pathologist experienced in performing QPA analysis was obtained on written transcripts that were purged of cues potentially distinguishing aided versus unaided productions (i.e., prosodic information, punctuation, filled pauses, and other non-narrative words). This revealed a consistent trend towards higher scores (greater length and structure) in DCN's aided versus unaided samples. For example, in the combined *Glove* and *Glasses* transcripts, proportion of words in sentences went from .67 (U) to .88 (SSR); mean sentence length went from 4.7 to 5.8; and proportion of utterances containing a verb went from .42 to .56. While the statistical significance of these findings is questionable due to low statistical power, they do suggest the possibility that the structural and informational impact of *SentenceShaper* will, upon further study, be shown to dissociate across participants. On the other hand, it is worth noting that participant EC exhibited strong aided effects both in terms of informativeness, as seen in this study, *and* in terms of QPA structural measures (Linebarger et al., 2000). Thus, in at least this one case, the aided effect does not dissociate.

Rater characteristics

Selection of listeners for language-rating studies depends on the specific research question (Campbell & Dollaghan, 1992). In aphasia research, rating studies may be used to discern whether spontaneous or therapy-related recovery is evident to persons who most often communicate with the individual with aphasia. In this case, the appropriate raters would be clinicians, family, or friends familiar with the person with aphasia. On the other hand, when the research question concerns the social validity of gains documented on laboratory measures, standard practice is to use raters who are unfamiliar with the individual with aphasia or the purpose of the study. There is less agreement on whether, in such circumstances, it is better to use listeners with some familiarity with aphasic speech, such as student clinicians (Ballard & Thompson, 1999; Hickey & Rondeau, 2005; Jacobs, 2001; Ross & Wertz, 1999) or truly naïve judges who have minimal exposure to aphasic speech (Campbell & Dollaghan, 1992; Hickey & Rondeau, 2005; Lapointe, Katz, & Braden, 1999). Nor is it clear at this point how expertise and other rater characteristics (sex, race, age) affect the results of rating studies (Hickey & Rondeau, 2005; Kazdin, 1977, cited in Hickey & Rondeau, 2005; Olness et al., 2005).

The research question in this study was whether aided effects and topic-specific carryover would be apparent to those who had no familiarity with the participants, *SentenceShaper*, or the purpose of the study. Communication science graduate students served as raters, rather than truly naïve peers, in the interest of ensuring that all raters would have some familiarity with aphasic speech and that differences in familiarity would be minimal (Schiavetti et al., 1983). Having shown that these quasi-expert listeners were sensitive to differences in informativeness in aided versus unaided functional narratives, it becomes an interesting question for the future whether the same would apply to the types of listener to whom aided or post-unaided narratives might some day be addressed in the real world, namely, members of the service community who have no familiarity or prior interaction with either the participant or any other individual with aphasia.

The nature of aided effects and topic-specific carryover

Examination of the transcripts in Table 4 and the Appendix provides some insight into the nature of the aided effect obtained in this study. Compared with the unaided samples, those produced on *SentenceShaper* included more information about the nature of the problem and the desired solution. The availability of the Discourse Cues undoubtedly contributed to this. The aided samples included the cued lexical content more often than did the unaided samples; for example, in Table 4, the SSR transcript from EC contains her only use of the cued content,

"I got a problem", and "I want you to". While the experience of using these cues in the aided mode (i.e., in Phase 1b) did result in participants occasionally including this content in the unaided narratives of Phase 2 and the experimental unaided samples (e.g., MO in Table 3), such carryover was minimal.

The value of the Discourse Cues probably goes beyond the lexical information they provide. The impression one gets is that when participants played those Side Buttons during aided productions, the content they heard, even if not incorporated into the message, was useful in triggering high-probability completions (Cloze effect). This is a general impact of the Side Buttons that has been reported in other *SentenceShaper* studies (Linebarger & Schwartz, 2005). The Discourse Cues may have provided additional help, in the form of an outline of the narrative's structure (greeting, statement of the problem, etc.).

On the other hand, it is not plausible to attribute the aided effect solely to the Discourse Cues. Consider again EC's transcripts in Table 4: The SSR sample conveys a stream of associations that extends well beyond any obvious Cloze completion (e.g., "how much is it cost fifty dollars fine the American Express"). Such content is better attributed to the properties of *SentenceShaper* that enable themes, ideas, and words to be entertained, and rejected or selected, outside the narrow temporal window of real-time speech. Along these lines, the emergence of topic-specific carryover in some users may indicate that the themes, ideas, and/or words that are retrieved in the aided mode of production can sometimes remain facilitated and available to spontaneous speech for some time afterwards. In Table 4, the underlined elements are candidates for informational units that remained in a retrievable state 3–4 days after having been retrieved, for the first time, in the aided mode.

Towards functional use of *SentenceShaper* for assisted communication

Given the evidence that *SentenceShaper* allows some aphasic individuals to produce more structured and informative spoken utterances than they can produce unaided, it would seem desirable to exploit the program for as wide a range of communication situations as possible. One might think that simply installing *SentenceShaper* on a handheld, portable computer would sufficiently extend its range as an effective AAC aid, but this is not the case. As noted above, *SentenceShaper*'s core functionality can be described as that of a word-processing program for spoken language. Paradoxically, the same design elements of *SentenceShaper* that allow it to "turn off the clock" and ameliorate processing limitations also set limits on its use as a functional communication aid. Face-to-face social encounters impose considerable pressure to respond in a timely fashion, whereas *SentenceShaper* is designed to minimise such pressure and the performance limitations associated with it. To date, the approach has been to use the program to prepare for off-line social interactions such as speeches (Fried, 2002: pp. 150, 262) and e-mail or web postings (Linebarger, Schwartz, Kantner, & McCall, 2002; Schwartz et al., 2005). However, face-to-face social encounters represent the core task of functional communication, and so our long-term goal is to develop both the technology and the methodology for integrating *SentenceShaper* into encounters of this sort.

A possible strategy incorporates the offline use of *SentenceShaper* to create utterances appropriate to *anticipated* social situations. Because the user can create these messages at his/her leisure, they can be specific to particular occasions rather than generic high-frequency utterances. These SSR productions could then be played back and recorded onto a portable AAC aid of the type that allows new sound files to be added and stored on the device (e.g., *MessageMate*™, *Touchspeak*, *Dynamo*®, *DynaVox MiniMo*™, or *Lingraphica*®; see Appendix). This option seems desirable for individuals who derive benefit from these existing AAC devices, whether because of their store of generic, high-frequency messages or because they employ an organisational scheme for stored messages that the user has learned to navigate. For some higher-level individuals, however, it may be that a handheld device dedicated to

replay of SSR productions would be more effective. *SentencePartner*™, under development at Psycholinguistic Technologies, Inc., is a software suite that allows the user to download selected utterances from a desktop computer running *SentenceShaper* onto a handheld computer. The authors are currently testing the effectiveness of a prototype of this software.

Individuals who do not derive benefit from using *SentenceShaper* in the therapeutic mode may nevertheless be able to use it effectively in the assistive mode. Yet even in this mode, *SentenceShaper* is not appropriate for all individuals with aphasia. Those who are unable to produce even single words or short phrases are unlikely to use the program effectively. Other significant barriers include severely impaired language comprehension, strong tendency to perseverate in speech and/or motor actions, and executive impairments that impede the allocation of attention to the dual (linguistic and motoric) requirements of program use. Moreover, even for those aphasic individuals who do show strong aided effects, fully independent use of the program may be unlikely; some reminders (e.g., to replay their own productions, to use the Side Buttons, or to move icons from one staging area to another) may be required. Further research is required to identify more precisely the criteria for successful use of the program. But for those individuals who are able to produce more informative spoken language with the support of the device, the study reported here moves us closer to the goal of generalising this support to a wider range of communicative situations.

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APPENDIX: COMPLETE TRANSCRIPTS FOR ALL FIVE PARTICIPANTS

EC (Lost Glove Scenario)

Unaided Practice #1

somebody/h-/has lost a glove lost a glove so no uh on on the uh uh on the um uh uh uh the drugstore no no this one drugstore no no no uh mm the drugstore yeah mm-hmm

Unaided Practice #2

whose glove whose glove um whose glove nobody's on the floor on the floor so whose glove uh uh um (whispered – whose glove uh) the uh uh the counter uh Strawbridges okay whose glove (whispered – I don't oh okay) on the floor on the floor okay whose glove take it in the uh uh ooh I can't explain it wow okay next

Unaided Practice #3

um drop the glove I drop the glove and I don't know no no no no the cashier drop the glove and I the/k-/uh uh drop the glove so drop the glove oh

Unaided Practice #4

oh uh oh uh somebody has picked up the the glove. Uh the cashier take it take it now take it now okay take it now and uh no

Unaided Sample (corresponds to Practice #5)

uh um somebody is dropped the glove dropped the glove and uh I don't know the store I don't know the store pick it up okay

Aided (SSR) Sample

hello the problem is someone lost the glove I want you to take this to the store manager please thank you

Post-SSR Unaided Sample

um who dropped the glove um on the floor on the/t-/table uh and the the uh the store clerk the store clerk the store clerk found the glove found the glove um the store clerk found the glove and uh take it to the department store thank you

EC (Broken Glasses Scenario)

Unaided Practice #1

um uh mm mm mm I don't know where it is and I lost it I don't know or um oh I don't know what it is last year I lost it too I don't know what it is you know what I'm saying but now another pair another pair another pair uh eyeglasses another pair I don't want it no more

Unaided Practice #2

listen, um I lost the uh the eyeglasses uh I going to fix them going to fix them I don't know uh where it is the eyeglasses but I don't know I don't know I lost it I don't know what it is I lost it

Unaided Practice #3

uh I broke my glasses and uh I don't know where it is but another pair another pair so um prescription prescription another pair uh and the uh uh uh oh yeah yeah but I I know them/p-/

uh prescription you know I know him okay I know him you know I I I know well I don't know where it is

Unaided Practice #4

I lost the the uh the glass I don't know where it is I don't know where it is uh um you fix it now later I lost it okay

Unaided Sample (corresponds to Practice #5)

I lost the I lost the I don't know where it is I don't know where it is uh the uh the eyeglasses I lost it

Aided (SSR) Sample

hello I got a problem I lost the eyeglasses I can't find them I want you to fix it I will pick it up later today how much is it cost fifty dollars fine the American Express so long

Post-SSR Unaided

I lost the the uh I lost the uh I can't find it the the I lost it I lost it and uh um another pair or uh another pair or fix it uh how much is it how much is it um oh okay alright then I uh come back later come back later in the in the evening and I get the money now I get the money now and how how much is it cost okay the check write a check yeah write a check

MAI (Lost Glove Scenario)

Unaided Practice #1

um the glove is one glove I want to return it that's not mine um please um do something about it please

Unaided Practice #2

um excuse me um the glove is not mine and it's I somebody is um somebody is lost the glove and I want to it's not mine but um I want to um ex- who do you who um it's fix it

Unaided Practice #3

um how are you um I want to um exchan-/i-/no the glove is/n-/not mine um please um uh something uh please um do something about it um um I'm returning it to you but um customer service um or something I don't know but it's not mine

Unaided Sample (corresponds to Practice #4)

uh it's not mine I wanna return it um oh I um/g-/good morning um I wanna speak to the manager it's um the glove is not mine please um I wanna return uh this

Aided (SSR) Sample

hello the problem is the glove it's not mine I want you to return the glove I will leave it to you goodbye

Post-SSR Unaided Sample

it's not uh hello I um how are you I want to um exchange the um the glove it's not mine and um I wanna return the glove and um and please I I don't know what's um involved but um uh please do something about it please

DCN (Lost Glove Scenario)

Unaided Practice #1

uh eh hi how are you uh I (whispered – have) I found the glove uh the glove uh I don't know if uh/i-/if you can uh ask uh people uh and goodbye

Unaided Practice #2

I uh uh found uh this glove uh okay uh and and uh okay uh you're welcome

Unaided Practice #3

hi uh I found a glove one glove uh okay and uh and okay find out find out and people but/ korne-/oh what find out and people people with mm no

MAI (Broken Glasses Scenario)

Unaided Practice #1

um I broke it and I want to fix it um please help me uh hello how are you um eh this is um I'm sorry but um I'm the glasses is broke and I want to fix it give me um um I don't care what the price um I don't/w-/care what the price is um anything to fix it the glasses

Unaided Practice #2

hello um I how are you um I want to the glasses is is not working and I I know it's hard but it's very important I I wait I wait um uh no problem at all I'm not doing anything because uh I can't see thank you

Unaided Practice #3

hello um how are you I want to um it's broken it's an all/str-/um I want to get it fixed please um help me um I can't see please help me sure thank you I would no problem

Unaided Sample (corresponds to Practice #4)

hello I want to um discuss the glasses it it's broke and I want to fix it please um fix it it's important I can't see

Aided (SSR) Sample

hello I want to speak to the manager the problem is the glasses it's broke I want you to fix it I have another pair of glasses I will return tomorrow goodbye

Post-SSR Unaided Sample

hello I want to um get the glasses fixed um how much time um uh uh how much time uh I need it right away this is a uh only glasses thank you very much I really appreciate it the cost um no problem I um I got money

DCN (Broken Glasses Scenario)

Unaided Practice #1

uh hi how are you uh I need to fix my glasses uh/ma-/my glasses uh (whispered – my glasses) uh the glass/fe-/fell on on please uh please can you fix it uh thank you uh goodbye

Unaided Practice #2

yeah hi how are you my glasses broke uh and I want to I want you to fix my glasses please uh mm uh and um and what time what day you finish with my glasses okay a week okay thank you goodbye

Unaided Practice #3

hi how are you um my glasses uh broke I want you to fix it please uh how much okay and how long um I wait okay and my address is (mumbles) and my/tel-/my telephone is (mumbles) okay and thank you goodbye

Unaided Practice #4

um hi how are you yeah I found the one glove uh okay and mmm and um um thank you and goodbye

Unaided Sample (corresponds to Practice #5)

hi how are you yeah I found one glove uh and and you find you find the owner okay uh anybody I don't know uh okay okay uh see you and goodbye

Aided (SSR) Sample

hi how are you the problem is I found one glove I want you to ask people please and goodbye

Post-SSR Unaided Sample

hi uh ah ah/f-/uh hi how are you I found this no I found one glove find the find the owner in ah in if ah if you can't uh find the person throw it away thank you

MO (Lost Glove Scenario)

Unaided Practice #1

Um uh um 'scuse me uh I I/hæ-//s-/'scuse me I/hæ-//hæ-/I have a/gʌv/(glove) it's not I have a glove but I don't/k-//s-//bus/to well I don't and then it's um well we have a uh uh this uh it's I'm tryin' to see um there's a a/goz/or/t-//bu-//bI-//bIp/or what is that I/u-/uh well uh he says um I 'scuse me/aIkɛn/(again) I have/æn-//n-/'nother/gʌv/(glove) and says no I don't think so well I'm goin' to put it in the and then I can't/prəstraIb/(describe) it uh it's it's um um it will no that's not it is …

Unaided Practice #2

Um/n a-/I that's the problem I was um/θ-//tu-/I'm/taIən/(trying) to I know what to say but I I that's one yeah one word oh my god I'll/s-/I'm I'm okay okay and you go okay and says/m-/hello/pədən/(pardon) me I think/ ats//ðɛt/I don't uh/f-//sp-//pʌdən/(pardon) me I can't I think you have some um/dʌ/(the)/gʌv/(glove) uh he says no that's not uh well I/h-//h-//hæ-/I don't have it well I'm goin' to and I thinks it/stʌ-//strəwb/he has uh uh the the/gʌ-/he has a/grov/(glove) and um um a/skʌmbʌdər/or a toys or what

Unaided Practice #4

hi how are you good good I need you/f-/to fix my glasses uh they are broken and and you have oh no no uh I have um Keystone Mercy yes okay uh/h-/how long are you going to give me my glasses eh okay one week okay eh my uh address is (mumbles) and my telephone is (mumbles) and and goodbye and see you Wednesday

Unaided Sample (corresponds to Practice #5)

hi how are you uh uh I/wa-/I want I want I want you I want I want to give you my glasses because my glasses are broken uh and how much and how long one week okay yeah uh thank you and oh wait and my ag- uh my address is uh (mumbles) and my cell phone is (mumbles) thank you and goodbye

Aided (SSR) Sample

hi good morning how are you good good yeah uh the problem is my glasses broke I want you to fix my glasses please my address is (gives full address here) my telephone is (gives telephone number) okay uh I will pick my glasses up in one week okay thank you and goodbye

Post-SSR Unaided Sample

hi how are you uh I need to give you my glasses because uh my glas- my glasses broke and and uh and the address is (gives address) and my telephone is (gives telephone number here) and what um um and um the glasses uh pick uh no no I pick my glasses when one week okay uh thank you and goodbye

MO (Broken Glasses Scenario)

Unaided Practice #1

Eh/sɛh//ɛs-//ɛstuz/(excuse) me but I/h-//hæ-/a/pwəbwəm/(problem) I had the/bɛs-/I have a/dIs/(this) is uh/bokən/(broken) would you/fo/help me and says um I I/dun//h-/I I don’t know what it is but I/trəp/(dropped)/θ^m/(them)

Unaided Practice #2

Um/hɛdo/(hello) how you doin’ um I have a/pwbləm/(problem) I have my broken I’ve/gɛn/I think I’ve/hɛæd/(had) a/pw abləm/(problem) because um the the the um the I had um/pob^m/(problem) and I it’s/stɛdət/and uh will you/t-/can you see/sI-/because one/plis/(piece)/^/(of)/græs/(glass) is/bok/(broke) and um I’m I’m um/ki/(he) has/t-/he has a all/f-//f-//faIvz/(sides) but um/s-/I I I’d um I think I’ll have to the the the um I’m going to/sfIks/(fix) ‘em/piz/(please).

Unaided Practice #3

Okay um/m-/well um I’m I think I has to the/glov/(glove) and uh I and I/h-/I I don’t know what it is/i-/um but we/gɛn/(can) to the um now oh boy um/drɛʃtʃr//næts/(that’s) not word the word what word but he can No I I there’s a word I can’t/rIscraIb/(describe) it yeah

Unaided Practice #4

Um/stuz/(excuse) me I have a um/pobəm/(problem) I got/t-/some/du/but I don’t know/wIt/(what)/θI-/(this) is okay um I don’t/n-//n-//bu//s-//s-//t-//bIn/I don’t know/dIs/(this) is um um I don’t know it is/bəIn//t-/I believe I don’t know it is/diləŋz/(belongs) to okay well/ɛt/(let) me see well you know/dIs/(this) you can you/tʃ-/can and that’s/ju/word uh/kændər/that’s not no/kændər/is um uh mm let me see here uh yeah sorry

Unaided Sample (corresponds to Practice #5)

Um/stuz/(excuse) me um uh we have uh uh/pw^bw^m/(problem)/wæs/uh uh um/s awi/(sorry) we uh I/h-/um um uh I uh/s awi/(sorry) but um I/pIŋk/(think) you/h-/eh/b^-//hæn/uh I’m I’m I’m sorry/bæt//b a//i-/got I/g-/I can’t the words

Aided (SSR) Sample

/duz/(excuse) me the/gov/(glove) sitting on the/for/(floor) I don't know who belongs to I'll will/fɔs/(lost) and found I don't know but maybe/du/(you) can/pfaIn//dIt/(find it) goodbye

Post-SSR Unaided Sample

okay 'scuse me um I have a/gr^v/(glove) is/fəndəd/on the/for/(floor) I don't know what it's/stuz/to but you can/wɔst/(lost) and find I guess okay I are you but nobody know this/tuz/to is the the/fənt-/I don't know this this the/fɔs/to ah man well I'll/wɔst/(lost) and found okay I'll see you

OT (Lost Glove Scenario)

Unaided Practice #1

here miss uh uh no it's uh okay miss uh glove is missing see about it okay see about it okay girl says oh okay okay/b-/uh sorry bye see you soon

Unaided Practice #2

here your glove is here but the woman is around the store or someplace okay here okay here

Unaided Practice #3

Um hello I think I have some glasses because it's/bukən/(broken) and um I think/wɔd/this um this one/plis/(piece) but/ji-/(you or he) have to but/i-/have to um this/to/this one/t-//pit/(piece) um I think/gɛn/(can)/d ʒun/(you)/b^n/(can)/vu/(you) fix it please

Unaided Practice #4

Um hello how you doin' uh look I have a/pw ɑbwəm/(problem) my/bok/is/tu/I/bok/(broke)/ðI-/this I/kwok/(broke) the/dɛspIz/(glasses) this is/jus/um and I have uh/kIn/(can) you/fsIks/(fix) 'em this/dIz/(is) and then the/jɛd^/uh/θIŋk/(thank) you some this uh eh all/wovər/(over) that's that's okay okay/fɛ/(can)/d ʒu/(you)/drIks/(fix) 'em

Unaided Sample (corresponds to Practice #5)

Uh hello I got a/pobəm/(problem) I/wuz/(was) uh I/k-/I got a my/bok/and/s-/um I/k ɑt/(got) the/bok//dIspIz/(glasses) um and I think have/gɛn/(can)/sIks/(fix) it/piz/(please) I don't know how you could/w^n/it because uh/b ɑt/by is is/bok/(broke) can you/piz/(please)/wI/me um/piz/(please)

Aided (SSR) Sample

Hello/bə/(the)/p ɑbəm/(problem) is/rə/(the)/dæsəz/(glasses) I want you to fix 'um please I don't know but it is but I think I new glasses this is/əm^rsənsi/(emergency) I will/p^m/(come) by/θ^rzdi/(Thursday) afternoon I will see you later okay

Post-SSR Unaided Sample

/suz/(excuse) me I/gət/(got) my/dæsəz/(glasses) and/nɛs/(this) it's/grok/(broke) and I think I have a new/dæsəz/(glasses) because I I know have uh that's the/pen/or what can you/sIks/(fix) 'em/pɔ/(for) me

OT (Broken Glasses Scenario)

Unaided Practice #1

salesperson uh I have eh uh bad news see this uh/aI-/no glasses is broken here fix it for me

Unaided Practice #2

hi I think it is broken okay I no fix it so you fix it for me

Unaided Practice #3

my name is (gives full name) and your name is okay the/gl-/uh glove is fallen off the uh floor here uh here you uh uh you have the glove now thank you okay

Unaided Sample (corresponds to Practice #4)

miss my/a-/name is (gives full name) and your name is the glove is uh in the floor but I don't know who it is please hel- uh uh you take responsibility for it okay but uh afterwards uh (unintelligible utterance) for me please

Aided (SSR) Sample

hi my name is (gives full name) what's your name oh okay the problem is I found the one glove in the drugstore I want you to put it uh in the lost and found okay

Post-SSR Unaided Sample

my name is (gives full name) your name is okay the glove is in the/f-/floor and find it there my I think so and afterwards uh I hand you the glove for purpose of ah what's the name okay uh find the glove and afterwards ah a woman or man comes in for the glove okay um okay thank you bye see you soon

Unaided Practice #3

hi my name is (gives full name) and your name is uh I have a problem okay the glasses I is fed up with this okay I the glasses are uh broken fix it for me please sure okay sure okay (Unintelligible utterance) one hour max okay whatever or maybe one two three four five five minutes

Unaided Sample (corresponds to Practice #4)

hi my name is (gives full name) and your name is okay I think I broke it somewhere 'round the block okay and see this uh is gone okay fix it for me please okay and afterwards I have a present for you okay thank you bye

Aided (SSR) Sample

hello I name is (gives full name) and your name the problem is the glass was broken fix the problem for me and afterwards I have candy for you in the purse I will wait here for the glasses oh what's two hours two hours then okay okay see ya

Post-SSR Unaided Sample

hi what's your name again my/n-/uh no my name is (gives full name) um the glasses are broken so fix 'em please now for me okay and afterwards um you are I have cash for you okay then uh but fix it first and afterwards the cash for me okay okay

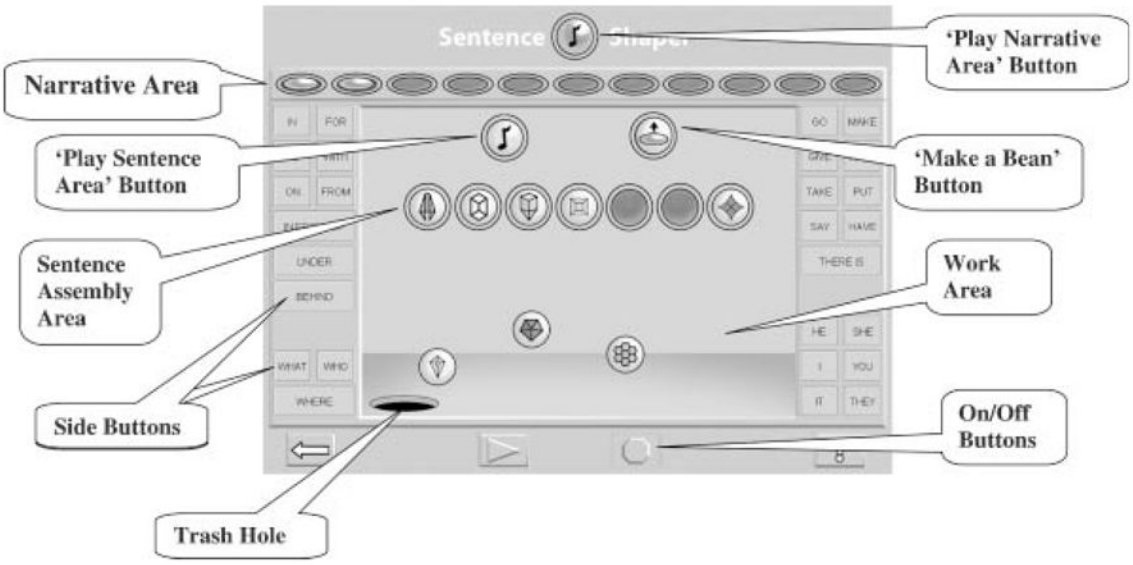

Figure 1.
SentenceShaper screen.

TABLE 1

Designs for investigating three types of outcome of *SentenceShaper* use

Aided Effects Design			
Phase 1	*SentenceShaper* training, topic set *x*		
Phase 2.	**Unaided sample, topic set *z***	} counter balanced	
	Aided sample, topic set *z*		
Treatment Effects Design			
Phase 1	**Unaided sample, topic set *z***		
Phase 2	*SentenceShaper* treatment, topic sets *x* & *y*		
Phase 3	**Unaided sample, topic set *z***		
Current Design			
Phase 1	*SentenceShaper* training, topic set *x*		
Phase 2	Unaided practice, topic set *z*		
Phase 3	**Unaided sample, topic set *z***	] 3 vs 4 Aided Effects	} 3 vs 5 Topic-specific Carryover
Phase 4	**Aided sample, topic set *z***		
Phase 5	**Post-SSR Unaided sample, topic set *z***		

Key comparisons are shown in bold. Numbers designate the sequence of phases in each design. Letter indices are used to indicate whether the same or different topics are narrated across phases; Topic set $x \neq y \neq z$.

TABLE 2

Profiles of the five participants

Participant	Gender	Age	Educ.	MPO	WAB AQ	Classification
EC	F	57	18	201	68.2	Broca's
MAI	F	53	20	59	67.4	Broca's
DCN	M	32	12	43	79.8	Anomic
MO	M	62	14	162	70.0	Broca's
OT	F	54	16	64	75.8	Anomic
Mn		51.6	16	105.8	72.2	
SD		11.5	3.2	70.9	5.4	

Mn, mean; SD, standard deviation; M, male; F, female; MPO, months post onset; WAB, Western Aphasia Battery (Kertesz, 1982); AQ, Aphasia quotient from the WAB. Results of testing performed 13 to 30 months prior to the experiment.

TABLE 3

Summary statistics for the standardized Direct Magnitude Estimation judgments of 12 raters, organised by participant (Pt.)

		Unaided (U)			Aided (SSR)			Post-Unaided			Repeated Measures ANOVA		
											Condition Main Effect		
Pt.	**Scenario**	**Mn**	**SD**	**SE**	**Mn**	**SD**	**SE**	**Mn**	**SD**	**SE**	**F**	**p**	**Contrasts**
EC	Glove	42.6	19.9	5.7	82.1	19.4	5.6	32.1	14.6	4.2	34.4	<.0001	SSR >U
	Glasses	12.6	12.6	3.6	52.7	25.1	7.2	41.3	23.6	6.8	11.5	<.001	SSR >U; PU >U
MAI	Glove	55.7	26.4	7.6	69.2	19.6	5.7	46.9	25.8	7.5	3.2	n.s	n.s
	Glasses	73.8	18.7	5.4	91.6	11.6	3.3	69.4	21.0	6.1	6.9	<.01	SSR >U
DCN	Glove	51.6	21.6	6.2	48.4	21.8	6.3	45.3	15.8	4.6	0.3	n.s	n.s.
	Glasses	82.5	20.0	5.8	80.5	21.1	6.1	71.0	25.0	7.2	1.4	n.s	n.s.
MO	Glove	5.4	5.4	1.6	64.4	26.1	7.5	48.7	29.2	8.4	32.1	< 0001	SSR >U; PU >U
	Glasses	23.1	15.3	4.4	62.8	19.9	5.7	55.3	19.2	5.6	17.5	< 0001	SSR >U; PU >U
OT	Glove	62.1	18.9	5.5	95.4	5.8	1.7	54.5	23.6	6.8	25.5	<.0001	SSR >U
	Glasses	63.8	20.9	6.0	75.6	18.1	5.2	68.0	21.5	6.2	2.7	n.s	n.s.
Grnd Mn	Glove	43.5			71.9			45.5					
	Glasses	51.2			72.6			61.0					

Scenario (Glove, Glasses), and Condition (Unaided (U), Aided (SSR), Post-SSR Unaided (Post-U)).

TABLE 4

Two of the three cases in which listener ratings were significant for topic-specific carryover (Post-U >U), as well as an aided effect (SSR >U)

EC (Broken Glasses)
Lead-in: You are at the optician's shop. You brought these in (present broken glasses). I am the sales person. What do you say?"
U (Mn rating 12.6): I lost the I lost the I don't know where it is I don't know where it is uh the uh the eyeglasses I lost it
SSR (Mn rating 52.7): hello I got a problem I lost the eyeglasses I can't find them I lost them I want you to fix it I will pick it up later today how much is it cost fifty dollars fine the American Express so long
Post-U (Mn rating 41.3): I lost the the uh I lost the uh I can't find it the the I lost it I lost it and uh um another pair or uh another pair or fix it fix it uh how much is it how much is it um oh okay alright then I uh come back later come back later in the in the evening and I get the money now I get the money now and how how much is it cost okay the check write a check yeah write a check
MO (Lost Glove)
Lead-in: You are in the drugstore and this (present glove) is lying on the floor. You take it to the counter. What do you say?
U (Mn rating 5.4): Um/stuz/[excuse] me um uh we have uh uh/pwʌbwʌm/[problem]/wæs/uh uh um/s awi/[sorry] we uh I/h-/um um uh I uh/s awi/[sorry] but um I/pIŋk/you/h-/eh/bʌ-//hæn/uh I'm I'm I'm sorry/bæt//b a//i/got I/g-/I can't the words
SSR (Mn rating 64.4):/duz/[excuse] me the/gov/[glove] sitting on the/for/[floor] I don't know who belongs to I'll will/fɔs/[lost] and found I don't know but maybe/du/[you] can/pfaIn//dIt/[find it] goodbye
Post-U (Mn rating 48.7): okay 'scuse me um I have a/grʌv/[glove] is/fɔndəd/on the/for/[floor] I don'tknow what it's/stuz/to but you can/w st/[lost] and find I guess okay I are you but nobody know this is/tuz/to is the the/fɔnt-/I don't know this this the/fɔs/to ah man well I'll/wɔst/[lost] and found okay I'll see you

U, Unaided; SSR, created on the SentenceShaper; Post-U, Post-SSR Unaided. The transcripts are presented here in full and unpunctuated. Bracketed text shows authors' gloss of apraxic utterances. Underlined text conveys themes and content in the Post-U sample that suggest carryover from the aided production.