

Assistive, rehabilitative, and investigative use of a “processing prosthesis” for aphasia

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CONFLICT OF INTEREST DISCLOSURE

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 the program as a commercial product. A conflict of interest arises because Dr. Linebarger serves as Director of Psycholinguistic Technologies. Therefore, she has not participated in testing or in scoring of raw data in the studies described here. **No one else involved in the research has any commercial interest in the software.**

Background: Why create a processing prosthesis?

Performance factors such as slow activation and rapid decay of words and structures play an important role in aphasia (e.g., Kolk, 1995).

Fragmented, ill-formed utterances may reflect failure to activate sentence elements simultaneously long enough to integrate them. For example:

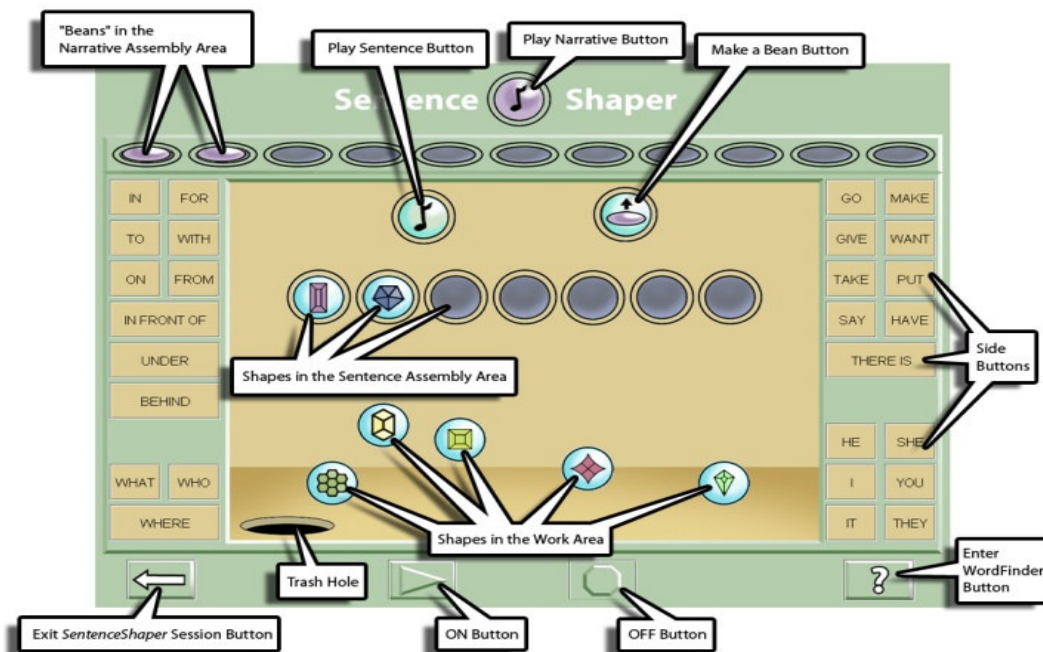
- A subject noun phrase, “the girl” is produced
- Speaker struggles to produce a verb such as “hit”
- But now the subject phrase has decayed from working memory
- By the time “the girl” has been re-retrieved, the memory of “hit” is lost



Hypothesis

A “processing prosthesis” allowing the speaker to refresh the memory traces of words and phrases long enough to combine them may facilitate language production in aphasia.

SentenceShaper® (termed “CS” in earlier studies)



- (1) User records a spoken word or phrase in her own voice by clicking the **On and Off Buttons**.
- (2) Arbitrary crystal **Shape** now appears in the **Work Area**. Clicking this shape replays the recorded speech fragment, helping the user to keep it in memory.
- (3) Shapes are dragged to the **Sentence Assembly Area** and ordered left to right to combine their associated “sound bites” into sentences.
- (4) Clicking the **Play Sentence Button** plays the entire sequence of shapes, which can be re-ordered or deleted.
- (5) Clicking the **Make a Bean Button** moves the sequence to the **Narrative Assembly Area**, where it is represented by a single “**purple bean**” and combined with other beans to form a narrative.
- (6) Optional word-finding support (**Side Buttons, WordFinder**). Clicking a printed word plays its pronunciation; user records the word in his own voice to include it in a production. Word-finding tools can be customized for different users or languages; reading ability not required

“Aided effects”

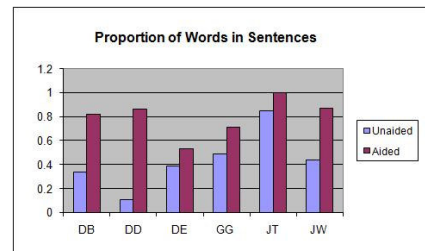
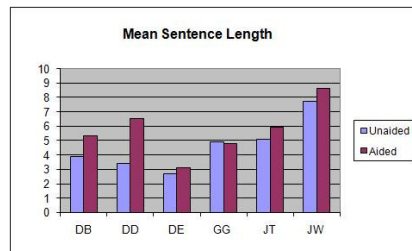
Linebarger, Schwartz, Romania, Kohn, & Stephens (2000) compared spoken narratives on the same topics in two conditions:

- Aided (with SentenceShaper)
- Unaided (without Sentence Shaper)

Please see published paper for details of methods and statistical analyses.

Aided narratives, created with the help of the program, were significantly longer and more structured than the corresponding unaided, spontaneous narratives. Because SentenceShaper’s word-finding tools were disabled, these aided effects demonstrate the impact of “pure” processing support, and reveal preserved linguistic abilities in many people with aphasia.

Shown below: Samples from two participants who showed particularly strong aided effects: (each pair of contrasting aided and unaided samples describes the same event in one of the test videos)



	Unaided (without use of SentenceShaper)	Aided (using SentenceShaper)
DB	The, the maid, the maid, the maid, uh, uh, upstairs and she, uh, the maid upstairs and 'scuse me' and um ... go around but now uh the the policeman, she she?, no, the man, two men, and the uh, oh, she, uh, her, she...knock them out, knock them out, um hum, knock them out, two men.	The man goes around them. She did not do it. The nurse goes around the baby carriage. The policeman, she fights the, the two men.
DD	“Ooh! A fish! Ah, water” and....uh mmm and attendant, “here,” and bumped his head. “Oh boy, oh my hand, my hand, my hand.”	The boy and the fishmonger is taking the fish. The boy hit his hand.

SentenceShaper aided effects in other studies

Subsequent studies (Albright, 2006; Bartlett, Fink, Schwartz, & Linebarger, 2007; Linebarger, McCall, & Berndt, 2004; McCall, Linebarger, & Berndt, in press) report superiority of aided productions in laboratory measures of grammatical structure (QPA; Saffran, Berndt, & Schwartz, 1989), laboratory measures of informativeness (CIU; Nicholas & Brookshire, 1993), and/or listener ratings of informativeness.

What do aided effects tell us about language processing in aphasia?

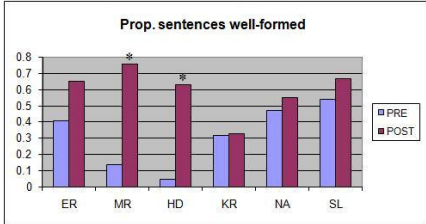
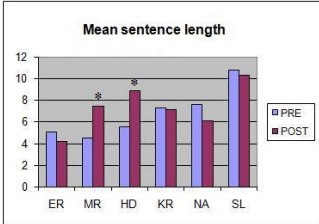
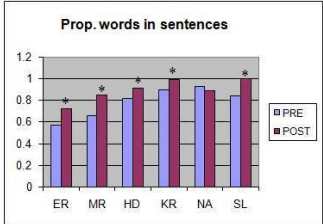
- Striking confirmation of the role of processing limitations in aphasic language production: because the system’s word-finding tools were disabled, the superiority of aided productions reflects impact of “pure” processing support
- Artificially enlarged working memory may reveal aspects of language processing that are obscured by impaired memory/attention or other performance factors.

TREATMENT EFFECTS

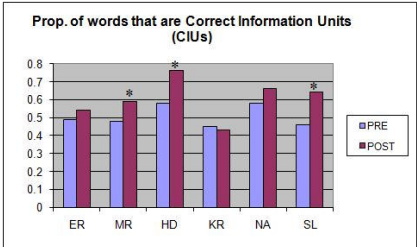
- Use of assistive devices, notably C-VIC/Lingraphica, has been shown to impact spontaneous speech (Aftonomos, Steele, Appelbaum, & Harris, 2001; Weinrich, McCall, Weber, Thomas, & Thornburg, 1995).
- A number of studies have reported positive changes in connected speech following periods of largely independent SentenceShaper use.

Representative SentenceShaper treatment study
(Linebarger, McCall, Virata, & Berndt (2007))

Please see published paper for details of methods and statistical analyses.



- Six participants with chronic (> 1 yr post) non-fluent aphasia used SentenceShaper at home (11 to 23 weeks), with weekly lab visits
- Narratives administered at baseline (n=8) showed no structural or content gains until SentenceShaper treatment commenced.
- Results: 5 of 6 participants made significant gains in at least one measure of structure or content; effects range from minimal to marked. Shown here are the results for a “withheld” narrative administered pre/post, comparable to those for the repeated narratives.



Shown below: **First five utterances** produced in unaided narrative pre and post by two participants who showed the strongest effects

Participant HD	
Pre (unaided)	Post-SentenceShaper use (unaided)
1. he rolled up and snowman	1. the snowman and the boy was out building the snowman
2. body and face	2. this boy comes in the house
3. he went inside to show mother	3. this boy comes in the house and sits down
4. mother and child heat	4. the mother shows him some soup
5. back outside	5. this boy comes out and builds the snowman
Participant MR	
Pre (unaided)	Post-SentenceShaper use (unaided)
1. boy is making a snowman	1. the kid going to make a stoman while the parents are in the house
2. he rest	2. the snowman and the kid goes in the house to play with the toys
3. he went downstairs	3. he cat screams at the stoman
4. snowman was light it up	4. the snowman and the kid goes out to play with the other stoman
5. he brought snowman inside house	5. he flies with the kid over the neighborhood and flies to the other snowman at lights

Other SentenceShaper treatment studies:
Albright (2006), Linebarger, McCall, & Berndt (2004); Linebarger, Schwartz, & Kohn (2001); Linebarger & Schwartz (2005); McCall, Virata, Linebarger, & Berndt (submitted).

TOWARD ASSISTIVE USE: Strengths and weaknesses

WEAKNESSES

1) Lengthy message creation time restricts use to messages that can be anticipated in advance, such as:

- Offline uses (eliminate time pressure)
 - Email: Linebarger, Schwartz, Kantner, & McCall (2002) reported successful piloting of an email interface within earlier version of SentenceShaper; current version of program does not include this interface, but creates mp3s of all user narratives
 - Speeches (e.g., Fried, 2002: pp. 150, 262)
 - Web postings (Schwartz, Linebarger, Brooks, & Bartlett, in preparation)
 - Electronic scrapbooks or Visual Scene Displays (Blackstone, 2004): SentenceShaper messages can be incorporated into any electronic aids that pair photographs with digitized speech
- Real-time encounters requiring short monologues that can be prepared in advance (shopping, doctor visits, transportation, advice, reminiscences)

2) Even those who are able to create novel messages on the system may require ongoing support with effective system use and idea generation.

3) The longer and more complex messages facilitated by SentenceShaper may be more difficult to integrate into real life than simpler, more concrete messages.

STRENGTHS

1) Ability to create messages in the speaker's own voice:

- May allay fears that use of AAC requires bypassing own speech (cf. Hux, Manasse, Weiss, & Beukelman, 2001)
- May confirm to listeners that the user authored the message (cf. Lasker, 1999)
- Superiority of aided productions may help to lift the “cloak of incompetence”

2) Processing support allows some individuals to create novel and complex messages that would be extremely difficult for caregivers to anticipate, or for a user with aphasia to build up by selecting visual icons. For example, consider this aided utterance by a participant in Linebarger et al. (2000):

“I need verbalizing, I need it bad. The therapy’s working, it’s working.
I enjoy therapy. I need it. I need the computer [to] record the message I want e
very day. I can’t stand my stroke. I need drilling.”

Words such as “working” and “drilling” might be difficult to locate by searching visual icons, given their more abstract use here.

3) Potential for treatment effects from sustained use

TECHNOLOGY UNDER DEVELOPMENT

SentenceShaper Scrapbook

The pairing of personal images with spoken narratives created on SentenceShaper can be implemented on web pages or on any device that combines images with digitized sound files.

A version of SentenceShaper that displays images (under development) is shown on the right.



SentenceShaper To Go™ (Linebarger & Romania, submitted)

- The person with aphasia composes a message on SentenceShaper and downloads it to a handheld device from within the SentenceShaper screen.
- Each “purple bean” is dragged to a slot in a mockup of the handheld screen
- This links the bean to a button on the handheld device which plays that bean



Most appropriate for situations which:

- Can be anticipated
- Require “specificity, clarity, or efficiency” (Garrett & Beukelman, 1998)
- Require a “monologue” on the part of the speaker
 - Storytelling and advice to family and friends (cf. Davidson, Worrall, and Hickson, 2003; Hine, Arnott, & Smith, 2003; Stuart, Lasker, & Beukelman, 2000)
 - Service encounters (doctors, household repair personnel, shopping, etc.)

Handheld device can be used in two ways:

- Self-cueing (cf. Mollica, 1999): user plays stored utterances to herself like a teleprompter, then delivers the message with live speech
- Direct playback: user replays the stored productions directly to the listener.

Preliminary data from an ongoing study at Moss Rehabilitation Research Institute:

- Handheld-aided messages more informative than unaided counterparts (Bartlett, Schwartz, Fink, Lowery, & Linebarger, in press; Linebarger & Romania, submitted)
- Participants express preference for self-cued live speech over direct replay

TOPICS FOR FURTHER RESEARCH

- 1) The effectiveness of the word association strategies emphasized in SentenceShaper studies has not been studied systematically.
 - Cloze response: Replaying the first part of a sentence (“I brush”...) may help the user to complete the sentence (“my teeth”)
 - “Preposition bootstrapping”: in a narrative about Thanksgiving, playing the word “on” may trigger “on the table”, playing “with” may trigger “with gravy”, etc. (Linebarger & Schwartz, 2005)
- 2) What is the functional utility of enhancing connected speech (aided or unaided)?
 - Does it increase opportunities to engage in storytelling? (cf. Davidson, Worrall, and Hickson, 2003; Hine, Arnott, & Smith, 2003; Stuart, Lasker, & Beukelman, 2000)
- 3) What are the characteristics of effective SentenceShaper users?
 - Successful outcomes in studies to date: non-fluent aphasia, some residual speech, good single word comprehension, some ability to judge grammaticality, absence of severe working memory impairment
- 4) How to characterize user independence with a processing prosthesis?
 - Does processing support create different patterns of user independence than other AAC aids? Effective SentenceShaper users are often both generative and partner-dependent in the taxonomy of Lasker, Garrett, & Fox, 2007)
- 5) Willingness/ability of individuals with aphasia to create messages in advance for functional situations
- 6) Self-cueing versus direct replay of messages stored on handheld device: early results from Moss study (Bartlett et al., in press; Linebarger & Romania, submitted) suggest a preference for the former.
- 7) Can processing support lead to improvements in narrative structure (e.g., main concepts)?
- 8) What has caused the treatment effects reported from sustained use of the prosthesis? Possibilities include:
 - Increased self-monitoring after sustained use of the program (e.g., Linebarger et al., 2007). If this is the case, then the increase in self-monitoring should be experimentally demonstrable (cf. Oomen, Postma, & Kolk, 2001).
 - A two-stage approach to SentenceShaper treatment (drilling on specific structures through single picture descriptions followed by a period of SentenceShaper use in which the structure is incorporated into multiple narratives on a variety of topics) has been shown to be effective in two small studies (Linebarger, Schwartz, & Kohn, 2001; McCall, Virata, Linebarger, & Berndt, submitted).
 - This suggests that integration of a structure into a variety of conceptual contexts may be more effective than restricting practice to single pictures designed to elicit the structure, although this may be required initially to activate the structure
 - Processing support may simply allow the user to assemble (and thereby practice) structures which s/he would otherwise be unable to create in real time.

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