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

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Abstract

Technology designed to aid language production may serve three interconnected goals: assistive, rehabilitative, and investigative. If a program or device facilitates the creation of language that is superior (e.g., in lexical content, grammatical structure, informativeness, fluency, or clarity) to the individual’s spontaneous, unaided productions, then it may be useful not only to facilitate communication with others (the assistive goal) but also for rehabilitation, since this superiority may carry over into unaided speech after a period of use. Assistive technology may also play an important role in the investigation of aphasic language disorders, allowing us to test different theories of language processing in aphasia and to examine language processing in artificially supportive environments. These interconnected goals are explored in the context of SentenceShaper™, a computer program which supports spoken language production in aphasia by easing performance limitations such as the slow activation and rapid decay of linguistic information.

Introduction

Augmentative and alternative communication (AAC) technology designed for individuals with aphasia may serve three interconnected goals: to help the person with aphasia express his needs and thoughts (the assistive goal), to support language practice (the rehabilitative goal), and to study the underlying disorders (the investigative goal).

We may also distinguish two general approaches to addressing these goals. AAC aids whose primary function is to provide linguistic information may be said to provide direct support for language production, by making available the raw materials for sentence construction. C-VIC (Computer-based VISual Communication; Steele, Weinrich, Wertz, Kleczewska, & Carlson, 1989) and other icon-based systems, for example, can provide words, phrases, and complete messages. This approach is well-motivated by the frequency and severity of word-finding problems in aphasia. A somewhat different approach to communication assistance is to provide

indirect support for language production; that is, to help the user to exploit his preserved abilities more effectively.

An example of the indirect approach is SentenceShaper™ (Linebarger, Schwartz, Romania, Kohn, & Stephens, 2000), a computer program designed to facilitate – rather than replace – spoken language. It is motivated by the “performance hypothesis” (Kolk, 1995) that processing limitations (e.g., slow activation/rapid decay of linguistic information) play a major role in aphasic language production disorders. On this account, sentence planning is disrupted by the inability to hold sentence elements in memory long enough to integrate them into larger structures. SentenceShaper serves as a “processing prosthesis,” allowing the user to record sentences a word or phrase at a time and to keep these sentence elements activated in memory. Each recorded speech fragment is associated with an arbitrary icon on the computer screen. A fragment can be replayed (thus refreshing the user’s memory of its stored “sound bite”) by clicking on its associated icon, and fragments can be grouped into larger structures by assembling their icons in sentence and narrative staging areas on the screen.

This paper reviews previous research on SentenceShaper with respect to the assistive, rehabilitative, and investigative goals outlined above.

Aided effects

The term aided effects is used here to refer to the ways in which a program or device facilitates the creation of language that is superior (e.g., in lexical content, grammatical structure, informativeness, fluency, or clarity) to the individual’s spontaneous, unaided productions.

Several studies have reported aided effects for SentenceShaper (termed “CS” in earlier publications). Linebarger et al. (2000) assessed the impact of processing support alone (i.e., with no word-finding support) on spoken language production. Six participants with agrammatism learned to use the program and practiced independently at home for 15 hours. Aided effects were then assessed by eliciting aided and unaided spoken retellings of two silent videos. Transcripts were analyzed in accordance with the Quantitative Production Analysis methodology (QPA; Saffran, Berndt, & Schwartz, 1989). Aided effects were significant for the group, in the right direction for five of the six participants, and quite marked for two participants (DD, DB). For example, both participants’ aided narratives were superior in the proportion of words in that occurred in sentences (.11 in DD’s unaided transcripts versus .86 in the aided counterparts; .34 unaided versus .82 aided for DB); in mean sentence length (3.4 unaided versus 6.5 aided for DD, 3.9 unaided versus 5.3 aided for DB); and in median length of utterance (2 unaided versus 4 aided for DD, 2 unaided versus 5 aided for DB).

Subsequent studies (Albright, 2006; Bartlett, Fink, Schwartz, & Linebarger, 2007) have replicated and extended these aided effects, employing additional methodologies such as the Correct Information Unit (CIU) analysis of Nicholas and Brookshire (1993), and informativeness ratings by unfamiliar listeners. Note that the aided effects in these later studies reflect the

combined impact of lexical and processing support, because of the inclusion into the program of two optional word-finding tools (Side Buttons, WordFinder).

Implications for the investigative goal

SentenceShaper's aided effects in the absence of any word-finding support (Linebarger et al., 2000) provided quite striking evidence for the performance hypothesis. In addition, AAC aids may serve as heuristic tools, allowing us to examine language processing in artificially manipulated environments. For example, individuals who show strong SentenceShaper aided effects often rely heavily on the replay of their stored utterances, evoking contextual associations/Cloze responses to complete their sentences. Some users also benefit from a similar strategy of playing preposition words available on the Side Buttons of the SentenceShaper workscreen in order to evoke content words associated with these prepositions in a particular context (Linebarger & Schwartz, 2005). The effectiveness of both strategies is most evident in the artificially supportive SentenceShaper environment, which helps the user to retain words in memory long enough to use them on this way.

Implications for the assistive goal

The reported aided effects provide no guarantee that SentenceShaper can be used functionally. SentenceShaper works by "stopping the clock," giving the user time to replay words or phrases before they decay from memory. But message creation may be a lengthy process. Previous studies have reported effective use of SentenceShaper for offline situations such as email (Linebarger, Schwartz, Kantner, & McCall, 2002) and web postings (Schwartz, Linebarger, Brooks, & Bartlett, 2005). For use in more interactive encounters, the program is likely to be most effective when the user can anticipate conversational needs and create messages on the system ahead of time. A version of the program which allows the user to download messages onto a portable handheld device from within the SentenceShaper screen has been developed (Linebarger & Romania, 2007) and is currently under testing.

Treatment Effects

Improvements in participants' spontaneous, unaided spoken narratives have been reported following semi-independent use of SentenceShaper (Albright, 2006; Linebarger, McCall, & Berndt, 2004; Linebarger, McCall, Virata, & Berndt, 2007; Linebarger, Schwartz, & Kohn, 2001; Linebarger & Schwartz, 2005; Virata, McCall, Linebarger, & Berndt, 2007). These effects have ranged from minimal to quite marked. It is highly encouraging to observe gains in spoken narratives, because a consistent finding in the aphasia treatment literature has been the failure of gains from treatment interventions to generalize to comparable improvements in the production of multi-sentence narratives (Fink, Schwartz, Rochon, Myers, Socolof & Bluestone, 1995; Mitchum & Berndt, 2001; Weinrich, Shelton, McCall & Cox, 1997).

Conclusions

The studies reviewed above illustrate the interconnectedness of the assistive, rehabilitative, and investigative roles of AAC technology. SentenceShaper's design was motivated by the performance hypothesis, and the system's aided effects have provided strong confirmatory evidence for that theory. By providing an artificially enlarged language production workspace, the program may also provide a window on users' preserved abilities and reveal effective strategies (e.g., heavy reliance on Cloze completion and prepositional "bootstrapping") that may carry over to spontaneous speech. The reported treatment effects are quite encouraging, but the generalization of these gains beyond the impairment level, or to narrative production outside the laboratory, has not been systematically tested or observed (see especially Albright, 2006); such generalization will most likely require the integration of SentenceShaper with real-life activities in order to foster more intense practice in more naturalistic environments. Thus the assistive and rehabilitative goals are also tightly linked: generalization of treatment effects may depend upon functional use of the program, and the desire to extend treatment gains in spontaneous speech may help to motivate this functional use.

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