Phonological Working Memory in Aphasia

Introduction

Current literature supports linguistic-specific working memory (WM) subsystems, which are devoted to the processing of distinct types of linguistic information (Caplan & Waters, 1999; Caspari et al., 1998; Friedmann & Gvion, 2003; Stowe et al., 2002). For example, Friedmann and Gvion (2003) investigated how WM deficits manifested themselves in participants with conduction aphasia and agrammatic aphasia. They used tasks that required either phonological reactivation or syntactic/semantic reactivation. From their results, they concluded that "…the type of reactivation required by the sentence, as well as, the type of memory overload is crucial in determining the effect of WM limitation on sentence comprehension" (p. 23).

Wright and colleagues (2007) developed several n-back tasks to tap specialized WM capacities by manipulating the stimulus type. One version of the n-back, the PhonoBack, was constructed to measure phonological WM; other versions included the SemBack, to measure semantic WM, and the SynBack, to measure syntactic WM. They found that participants who performed poorly on the SynBack also had more difficulty comprehending syntactically complex sentence structures. They suggested that future studies should include sentence comprehension tasks that require different types of processing, as well as, the WM tasks for different types of linguistic information to further evaluate the relationship between WM and language comprehension. In the current study, performance by PWA on the PhonoBack was compared to their auditory comprehension performance on sentences that were phonologically overloaded. More specifically, the participants' ability to comprehend phonologically taxing sentences was assessed using Garden Path (GP) sentences incorporated in an auditory, self-paced, moving window paradigm.

The goal of the current study was to investigate the relationship between phonological WM and auditory comprehension of phonologically demanding sentences in participants with conduction aphasia. We hypothesized that decreased performance on the PhonoBack would be associated with decreased performance on comprehension questions following the sentences as well as with increased Listening Times (LT).

Individuals with conduction aphasia are included because it is well established in the literature that they often exhibit phonological output deficits and may be susceptible to deficits in phonological WM (Friedmann & Gvion, 2007; Hough et al., 1994; Saffran & Marin, 1975). Further, this study will provide additional data on whether PWA present with type-specific WM deficits that contribute to their clinical profile.

Methods

Participants

Reported are results from two PWA. Data collection is ongoing; we anticipate having a total of 12 PWA. Inclusion criteria for study participation are as follows: (1) monolingual, English speakers; (2) at least 6 months post onset of stroke; (3) single, left-hemisphere cerebrovascular accident (CVA), and (4) sufficient hearing and visual acuity as indicated by passing hearing and vision screenings.

Tasks

N-back task

The n-back task requires participants to decide whether each stimulus in a sequence matches the one that appeared *n* items ago. It requires temporary storage and manipulation of information while at the same time constantly updating the contents in WM. The version of n-back we used is PhonoBack (Wright et al., 2007) which was designed to tap phonological WM. It consists of 25 CVC words, with five ending in each of five frames: -at, -it, -in, -ill, and –ig. Two levels of the PhonoBack were used to determine performance: a 1-back and a 2-back level. Also, two additional levels of processing were tested: identity - participants identified words that were identical, *n* back, and depth - participants identified words that rhymed, *n* back. Stimuli were digitally recorded by a native speaker of English. For all *n*-back tasks, stimulus onset asynchrony (SOA) was 4000ms.

Garden Path Task

For this task, a lexical ambiguity is presented in a strongly biased context, which initially favors a specific interpretation. However, as the sentence unfolds, and the listener reaches the disambiguation position, it becomes evident that it is an alternative interpretation that satisfies the overall meaning of the sentence. At that point, the participant is required to re-analyze the ambiguous word. Friedmann and colleagues (2003, 2007) argued that the re-analysis is based on the reactivation of the phonological form of the word. Moreover, by manipulating the distance between the ambiguous word and the disambiguation position where the re-analysis takes place, it is possible to increase the difficulty of the GP sentence (Christianson et al., 2001; Ferreira & Henderson, 1991; Friedmann & Gvion, 2007). An example sentence is as follows:

"The bat my brother gave me before he went out was born in the attic."

Thirty neurologically-intact adults, all native speakers of English, were used during a three step validation procedure to ensure the experimental sentences met the requirements of a lexical ambiguity that was resolved later in the sentence.

To perform the task, participants used the spacebar to advance to the next part of the sentence. Listening times (LT) were recorded. At the end of each sentence, the participant answered a question that pertained to the sentence; response accuracy was recorded.

Procedures

Participants attended two sessions, each lasting no more than two hours in a sound-insulated room. Stimuli were played through computer speakers at a sound level comfortable for each participant. E-Prime was used to record LT in milliseconds and response accuracy. Presentation order was randomized across participants.

PhonoBack. Following two sets of 10-12 training items, each list contained 20 target items embedded among 60 and 76 total items for the 1- and 2-back, respectively. "Hits" were scored when participants pressed the button to "targets." LTs and response accuracy were recorded. All four conditions (1-back, 2-back, Identity, and Depth) of the task were presented in a single session. 1-back and Identity conditions always preceded 2-back and Depth conditions.

GP task. The task consists of 80 sentences, 40 experimental sentences and 40 control sentences. They are presented in two blocks of 40. Practice items preceded each block. Experimental sentences included two conditions: short (four words between ambiguous word and disambiguation position) and long (8 words). Control sentences were matched for word length to the experimental sentences. The two blocks were presented in separate sessions, no less than two weeks apart.

Results

Results are based on preliminary data from two participants. Therefore, no statistical analyses were performed; however, several characteristics of the data are notable. Participants scored more hits on the 1-back tasks than their corresponding 2-back, for both conditions (Depth and Identity). The 2-back Depth task elicited the least number of hits and appeared to be the most demanding of the n-back conditions. On the GP task, the mean LTs at the disambiguation position for the experimental sentences were longer compared to the mean LTs at the same position for the control sentences. Moreover, participants scored considerably lower on comprehension questions related to the ambiguous sentences compared to the control sentences.

Conclusions and Clinical Implications

Despite the small sample size, it appears that PhonoBack is able to detect phonological WM deficits in individuals with aphasia. Such a finding has theoretical as well as clinical implications. First, it provides additional support for a theoretical model that includes linguistic-specific WM deficits and consequently, it can shape future research trends and eventually lead to modifications of current classification types of aphasia. Moreover, it could become an essential clinical tool in the professional's armory to describe with greater accuracy the clinical profile of people with aphasia.

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