Effort Invested in Cognitive Tasks by Adults with Aphasia: A Pilot Study

Introduction

Impaired performance by individuals with aphasia (IWA) on language tasks may be partially due to an impaired ability to allocate cognitive resources to the tasks (McNeil, 1981, McNeil et al., 1991). Others have explained this deficit as an impaired ability to match effort with task demands (e.g. Clark & Robin, 1991). The terms "effort" and "resources" are frequently used interchangeably (Kahneman, 1973). Kahneman (1973) states that effort refers to mental energy or attentional resources allocated to a task. According to Brehm's theory (Brehm & Self, 1989) effort expenditure is directly dependent on task difficulty.

Clark and Robin (1991) found that their IWA, compared to control participants, had no change in sense of effort on a lexical decision (LD) task that increased in difficulty. Murray and colleagues (1997) assessed IWA's ratings of task difficulty. They also compared participants' performance on a LD task to performance on the LD task when combined with a semantic distractor task. Although performance declined in the dual task condition, IWA's ratings of task difficulty did not change. Findings from these studies suggest that IWA do not invest effort appropriately because they inadequately perceive the task demands. If language performance by IWA is affected by effort allocated, this could have important clinical implications.

To date, only subjective ratings of effort and task difficulty have been investigated. A direct, physiological measure of effort is needed to explore this disconnect between performance and IWA's ratings of perceived effort and task difficulty. A well-studied measure of effort allocated to cognitively demanding tasks is heart rate variability (HRV). HRV is the amount of fluctuation around the mean heart rate. It has been shown to reflect the mental workload required during cognitive tasks (e.g., Hansen et al., 2003) and is a commonly used measure of effort (e.g., Aasman et al., 1987). Cognitively challenging tasks elicit a stress response measured as a drop in HRV from baseline to task conditions (Kalsbeek, 1971). The resulting decrease in HRV provides an objective physiological measure of the effort allocated to the tasks and should provide insight into the effort allocated by IWA on verbal and spatial working memory (WM) tasks. We have adopted the operational definition of effort as the difference in HRV (.07- .14 Hz range) measured during the WM tasks from HRV measured during a resting state.

The objective of this study was to quantify cognitive effort IWA and control participants dedicate to verbal compared with spatial working memory tasks using HRV. Researchers have found that non-brain injured adults' physiological stress response is not affected by task type (Callister, Suwarno, & Seals, 1992), but by task difficulty (Fairclough & Houston, 2004; Gendolla & Richter, 2006; Iani, et al., 2004; Ryu & Myung, 2005). Assuming IWA have an impaired ability to allocate effort to the tasks, it was predicted that they would demonstrate no change in HRV from baseline to task for either verbal or spatial tasks. Further, a significant positive relationship between change in HRV and task performance was predicted for control participants, but none was expected for IWA.

Method

Participants

Participants included 13 IWA and 21 age- and education-matched control participants. All participants demonstrated normal hearing and vision and no depression at the time of testing. Additional inclusion criteria for IWA included a history of unilateral left hemisphere stroke and presence of aphasia as indicated by performance on the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2006).

Tasks

The experimental tasks included verbal and spatial n-back tasks that varied in processing load. 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, continuously updating the contents in WM (Jonides, et al., 1997).

All participants completed three n-back tasks – a 0-back, 1-back, and 2-back for verbal and spatial stimuli. The verbal stimuli consisted of eight letters presented one at a time in the center of the screen. Participants responded as quickly as possible by pressing the spacebar when the letter was the same as the letter *n* back.

The spatial stimuli included black circles presented on a white background in eight different locations spaced in an octagon fashion around a central fixation point. One dot appeared on the screen at a time. Participants respond to the spatial tasks by pressing the spacebar when the dot was in the same location as the one *n* back.

Stimulus onset asynchronies (SOA) of 3500 ms, shown to be effective for use with IWA (Wright, et al., 2007), were used in all n-back tasks. Each n-back contained a practice block. The experimental conditions included 33 targets presented in a single block containing 100 stimuli. Task difficulty order was counterbalanced, and stimuli type was counterbalanced within difficulty levels. Each n-back was preceded and followed by a 5-minute baseline rest period for baseline HRV data recording.

Procedures

Participants were instructed to avoid smoking, caffeine, alcohol, and strenuous exercising on the testing day, and also completed a brief questionnaire describing any possible deviations. Prior to testing, 3 surface electrodes were placed on the torso to record ECG activity. ECG activity was recorded continuously using BIOPAC Student Labs (BSL) PRO MP35 recording unit with BSLPro software (500 samples/second, Filter .05 - .35 Hz). Participants sat in a comfortable, high back chair during recording.

During pre- and post-task baseline conditions, participants rested quietly with their eyes open. The start and end of experimental and rest conditions were marked using the BSLPro software.

<u>Results and Conclusions</u>

One-way repeated measures ANOVAs were conducted for each group to determine whether the .07 - .14 HRV frequency range was sensitive to differences between baseline and task conditions. The .07 - .14 Hz range was significant for both the control, F (1, 112) = 121.06, $p < .001$, partial eta squared = .52, and aphasia groups, F (1, 55) = 19.51, $p < .001$, partial eta squared = .26. HRV significantly decreased from baseline to task conditions indicating both groups allocated effort to the tasks.

Correlation analyses were conducted to determine the relationship between task difficulty and change in HRV in the .07-.14 frequency range. Correlations were non-significant for both groups for verbal and spatial tasks.

Both participant groups allocated effort to the verbal and experimental tasks as demonstrated by a drop in HRV from baseline to task. However, HRV was not sensitive to differences in task demands. Because HRV is determined by the dynamic relationship among two disparate branches of the autonomic nervous system (sympathetic and parasympathetic), it is important to consider factors not related to the experiment that may affect HRV. Medications with anticholinergic properties can affect parasympathetic activity, and beta-blockers decrease the sympathetic input to the heart. Both types of medications are common in older adults; and, particularly individuals who have had strokes. All of the IWA were taking either anticholinergic medications or beta-blockers. Further, more than half of the control participants (14 of 21) were taking medications with anticholinergic effects or beta-blockers. Possibly, the effects of the medications on HRV mask potential significant findings related to task difficulty. Results will be discussed within a theoretical framework of WM and clinical implications will be considered.

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