Neuropsychologia 66 (2015) 204–212

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Between-session intra-individual variability in sustained, selective, and integrational non-linguistic attention in aphasia

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ARTICLE INFO

Article history:
Received 4 June 2014
Received in revised form
20 November 2014
Accepted 21 November 2014
Available online 23 November 2014

Keywords:
Aphasia
Attention
Non-linguistic
Domain-general
Intra-individual variability

ABSTRACT

A number of studies have identified impairments in one or more types/aspects of attention processing in patients with aphasia (PWA) relative to healthy controls; person-to-person variability in performance on attention tasks within the PWA group has also been noted. Studies using non-linguistic stimuli have found evidence that attention is impaired in this population even in the absence of language processing demands. An underlying impairment in non-linguistic, or *domain-general*, attention processing could have implications for the ability of PWA to attend during therapy sessions, which in turn could impact long-term treatment outcomes. With this in mind, this study aimed to systematically examine the effect of task complexity on reaction time (RT) during a non-linguistic attention task, in both PWA and controls. Additional goals were to assess the effect of task complexity on between-session intra-individual variability (BS-IIV) in RT and to examine *inter*-individual differences in BS-IIV. Eighteen PWA and five age-matched neurologically healthy controls each completed a novel computerized non-linguistic attention task measuring five types of attention on each of four different non-consecutive days. A significant effect of task complexity on both RT and BS-IIV in RT was found for the PWA group, whereas the control group showed a significant effect of task complexity on RT but not on BS-IIV in RT. Finally, in addition to these group-level findings, it was noted that different patients exhibited different patterns of BS-IIV, indicating the existence of inter-individual variability in BS-IIV within the PWA group. Results may have implications for session-to-session fluctuations in attention during language testing and therapy for PWA.

1. Introduction

Although aphasia is typically considered to be a disorder in language processing, the cognitive abilities of patients with aphasia (PWA) have come under increasing investigation over the course of the past several decades. Cognition in aphasia is an inherently important line of research, given the existence of a number of theoretical and developmental cognitive-psycholinguistic models positing a strong interconnectedness and functional overlap between language and cognition in healthy individuals (e.g. Vygotsky, 1962; Luria and Yudovich, 1971). Gaining a better understanding of cognition in PWA will enable researchers and clinicians to develop, modify, and implement rehabilitative language treatments that take cognitive abilities into account, thereby maximizing individual patients' long-term potential for improvement.

Among the areas of cognition that have been examined in PWA, *attention* is a skill worth particular consideration. To begin with, attention – arguably the most basic of the cognitive processes – has been found to be impaired in PWA relative to healthy controls (Robin and Rizzo, 1989; Tseng et al., 1993; Erickson et al., 1996; Murray et al., 1997; Murray, 2000, 2012; Hunting-Pompon et al., 2011). Additionally, it has been compellingly argued that language knowledge is largely preserved in aphasia and that the observed language deficit is a result of impaired attentional processes (Hula and McNeil, 2008), a theory which underscores the importance of investigating this particular cognitive skill in PWA. Finally, and on a somewhat different note, attention may play an important role in language rehabilitation. Not only has attention been shown to be predictive of long-term functional recovery after stroke (Mysiw et al., 1989; Robertson et al., 1997), evidence from the aphasia literature has also suggested that cognitive abilities such as attention may successfully predict language therapy outcomes (Lambon Ralph et al., 2010). Our primary motivation for the current study is that an underlying impairment in attention may negatively impact a wide variety of skills and situations (see Fig. 1).

Most models frame attention as a *domain-general* resource that may be drawn on for a variety of tasks, both linguistic and non-

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http://dx.doi.org/10.1016/j.neuropsychologia.2014.11.026
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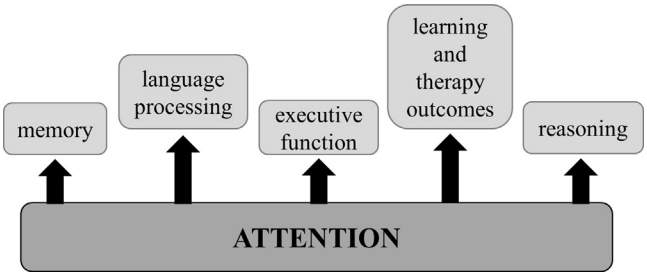

Fig. 1. Theoretical schematic illustrating support provided by domain-general attention to other cognitive/linguistic processes.

linguistic (e.g. Posner and Petersen, 1990; Mirsky et al., 1991; Petersen and Posner, 2012; Cohen, 2014). The most direct way of measuring attention in language-impaired individuals, therefore, is to bypass the language system through the use of non-linguistic tasks. Studies using non-linguistic tasks to investigate attention in aphasia have consistently found evidence of attentional deficits in PWA. Robin and Rizzo (1989) used simple arrows, dots, and auditory pulses and found a significantly impaired ability to orient attention in PWA relative to controls. In a later study, Erickson et al. (1996) investigated the effect of a dual-task condition on primary task performance in PWA, using non-linguistic sound identification as the primary task and the Wisconsin Card Sort Task (also non-linguistic) as the secondary task. Results showed that not only did PWA perform more poorly during the dual-task condition than the single-task condition, they also performed consistently poorer than control subjects. Additionally, Laures et al. (2003) examined arousal and vigilance in PWA and controls and found evidence of impaired performance by the PWA group in both linguistic and non-linguistic contexts, suggesting that attention is similarly impaired in linguistic and non-linguistic tasks in this population. Results like these point to the existence of a basic, domain-general attentional impairment in PWA, one that could have negative implications for many other skills.

With this in mind, the goal of the current study is to gain a fuller understanding of the nature of this impairment by systematically investigating several different types of non-linguistic attention. Though a number of attentional models have been proposed, we will refer here to Sohlberg and Mateer's (2001) clinical model, which is based on the highly predictable stages of recovery from brain injury and is widely referenced in the aphasia literature. One of its central features is a hierarchical complexity in which less complex types of attention are prerequisites for more complex types. The most basic type of attention in this model is *focused attention* (responding discretely to specific stimuli), followed by the more complex *sustained attention* (sustaining consistent responses to stimuli during continuous activity). Next is *selective attention* (maintaining a cognitive set in the face of distracting stimuli), followed by *alternating attention* (shifting between tasks or features), and finally, the most complex type, *divided attention* (simultaneously responding to multiple attentional demands). The experimental task used in the current study is rooted in this model, particularly in its framing of sustained and selective attention.

An additional and central dimension of the current project is its focus on intra-individual variability (IIV); that is, the degree of fluctuation in a single individual's performance over time. Increased IIV on cognitive tasks relative to healthy controls has been identified in a wide variety of clinical populations, including traumatic brain injury (Stuss et al., 1994; Bleiberg et al., 1997) and dementia (e.g. Hultsch et al., 2000; Murtha et al., 2002), as well as both Alzheimer's Disease and Parkinson's Disease (Burton et al., 2006). However, little is known about IIV in cognitive task performance in aphasia, despite the fact that substantial IIV in performance on language tasks has been reported in this population (Ryalls, 1986; Glosser et al., 1988; Freed et al., 1996). The current study examines, for the first time, IIV in non-linguistic attention processing in aphasia. More specifically, we examine day-to-day fluctuations in task performance, or *between-session intra-individual variability* (BS-IIV). We suggest that BS-IIV could play a critical role in therapy outcomes, as language therapy is typically delivered over the course of many sessions spanning several weeks or months and presumably requires consistent attention from session to session.

To summarize, the overarching framework of the current study is that the successful execution of domain-general sustained attention is a prerequisite for domain-general selective attention, that the successful execution of both of these is required for more complex attentional processes, and that fluctuations in attention across sessions may substantially influence any or all of these processes. The goal of the current study was to use non-linguistic tasks as a means to systematically examine the nature of domain-general attention processing in aphasia, with a particular focus on intra-individual variability. We propose that understanding domain-general attention in PWA is of critical importance, as this basic skill may underlie a variety of other tasks and situations. The aims of the current study were as follows:

1. To examine the effect of task complexity on reaction time (RT) in non-linguistic attention in PWA, as well as in a small group of age-matched healthy control participants. We hypothesized that both PWA and age-matched controls would show relatively longer RTs as task complexity was increased.
2. To examine the effect of task complexity on BS-IIV in RT during a non-linguistic attention task. We expected that PWA would, in general, show a greater degree of BS-IIV than controls. We also expected that PWA would show a higher degree of BS-IIV as task complexity was increased.
3. To look at patient-to-patient, or *inter*-individual, variability in BS-IIV in non-linguistic attention. We expected to find evidence of substantial *inter*-individual variability in BS-IIV within the PWA group.

2. Methods

2.1. Participants

Eighteen patients with stroke aphasia (PWA, 12 male, mean age=60.3, SD=8.25) and five age-matched neurologically unimpaired control participants (controls, 2 male, mean age=63.4, SD=7.50) participated in the study (see Table 1). Participants were recruited through advertising and word of mouth. PWA completed several standardized assessments measuring language/cognitive abilities: the Western Aphasia Battery (WAB, Kertesz, 1982), the Cognitive-Linguistic Quick Test (CLQT, Helm-Estabrooks, 2001), and the Boston Naming Test (BNT, Kaplan et al., 2001). The mean Aphasia Quotient (AQ) for PWA was 77.3 out of 100, with a range of 21.2–98.9. The mean CLQT composite score was 80% with a range of 10–100%, and the mean Attention sub-score on the CLQT was 75%, with a range of 18–97%. The mean BNT percent correct was 37.5% with a range of 1–100%. No participants who had been diagnosed with either dementia or Parkinson's Disease were enrolled. This study was approved by the Institutional Review Board at Boston University.

2.2. Stimuli

The computerized experimental task included visual and auditory stimuli. Visual stimuli consisted of a large black dot which