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Assessment of linguistic and verbal short-term memory components of language abilities in aphasia

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A B S T R A C T

Some current models of aphasia emphasize a role of short-term memory in the processing of language and propose that the language impairment in aphasia involves impairment to cognitive processes that activate and maintain representations of words over the time-period needed to support single word and multiple word tasks, including verbal span tasks. This paper reports normative data from 39 people with aphasia and 16 age-matched neurotypical controls on a test battery for aphasia that assesses effects of increased short-term/working memory load on word and sentence processing as well as effects of linguistic variations on verbal short-term memory abilities. Two concepts are discussed that capture the unique potential of this test battery for research and clinical practice: specificity of diagnosis and sensitivity to all degrees of aphasia severity, including mild aphasia. An analysis is included that shows how the performance of individuals with mild aphasia who achieve normal level of performance on the Western Aphasia Battery (Kertesz, 2006) shows a decline in a temporal delay condition that is greater than performance of control participants. We also report preliminary data showing differential effects of adding a time interval before a response or between items to be compared: reduced accuracy for some individuals with aphasia and improved accuracy for others. The theoretical and clinical importance of this finding is discussed, as well as the overall potential for this test battery to be used in research and as a clinical tool. Finally, we discuss the relevance of this test battery to investigate functional communication abilities in aphasia.

1. Introduction

Approaches to assessment of language impairment in aphasia have evolved in accordance with changing views of the nature of aphasia and the level of description used to diagnose a language impairment. Neuroanatomical models motivated classification of aphasia impairments in terms of symptom complexes associated with the regions of neurological impairment, with the symptoms described at the 'task' level (e.g., naming, repetition or comprehension). Psycholinguistic models provided a more microscopic perspective with their description of language impairments in aphasia in terms of the linguistic representations (e.g., semantics) and processes (access, retrieval) involved in carrying out language tasks. For example, in this type of model, a naming impairment could be attributed to poor access of word representations from semantics or poor phonological encoding of words. These models reflected an emerging view of aphasia as a disorder that affects processing of language representations (e.g., McNeil, 1982; McNeil & Pratt, 2001), not the loss of linguistic representations. As this characterization of the nature of aphasia has increased in prominence, research has focused more on identifying the component operations of language processing, including mechanisms of accessing and

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retrieving words (e.g., Dell & O'Seaghdha, 1992; Dell, Schwartz, Martin, Saffran, & Gagnon, 1997) and the temporal aspects of processing (e.g., Martin & Gupta, 2004; Martin, Saffran, & Dell, 1996; R. Martin, Shelton, & Yaffee, 1994). In this paper, we introduce a test battery for aphasia, the Temple Assessment of Language and Short-term Memory in Aphasia (TALSA), which builds on this research, specifying processes that support access and retrieval of language representations and adding a unique focus on the short-term memory (STM)/temporal component of that processing.

Language processing involves timely access to and retrieval of language representations. These operations are supported by cognitive abilities such as STM, working memory (WM) and executive functions. The hypothesized role of executive processes is to 'control' access to and retrieval of language representations via fundamental functions such as attention and inhibition (Conway & Engle, 1994; Engle, 2002; Hula & McNeil, 2008; Kane & Engle, 2003; McNeil, Odell, & Tseng, 1991; Wright & Fergadiotis, 2012). In contrast, STM's role is thought to be more integral to the processing of word representations, serving to maintain activation of semantic, lexical and phonological representations over the time course of processing single and multiple word utterances (Martin & Saffran, 1992, 1997; Martin et al., 1996).

STM is related to WM and sometimes the two abilities are not sufficiently distinguished from each other. Cowan (2008) describes their relationship as follows: (1) STM is a mental ability that maintains a limited amount of information in a temporarily accessible state and (2) WM includes STM along with other cognitive mechanisms (e.g., attention) that "make use of short-term memory" (p. 325). We agree that verbal WM tasks are supported by a STM capacity (measured minimally by a forward digit or word span), but WM and STM demands also vary in the degree of "work" entailed based on the linguistic (e.g., abstract words are harder to recall than concrete words, e.g., Walker & Hulme, 1999) and/or attentional and executive requirements of the task.

Evidence shows that individuals with aphasia almost ubiquitously exhibit reduced verbal STM capacity as measured on verbal span tasks. How does STM support language processing and how is it implicated in aphasia? The interactive activation model of word processing (Dell & O'Seaghdha, 1992), which has been used to account for word production impairments in aphasia (e.g., Dell et al., 1997; Schwartz, Dell, Martin, Gahl, & Sobel, 2006), holds that access to and retrieval of words depend on stable activation of those representations. That stability depends on two processing parameters, connection strength (strength of activation spread) and decay rate (how quickly activation dissipates). Both parameters contribute to the likelihood that a representation will be able to compete with other semantically and phonologically related word representations that are primed by spreading activation. Connection strength needs to be sufficiently strong for the target word's activation level to be greater than competing representations that are primed by spreading activation. At the same time, activation decay rate needs to be slow enough to ensure that the activation level will remain competitive relative to other words in the lexicon until the word is comprehended or retrieved for production or repetition. The latter function, sustaining a strong activation level of the target word that will be uttered, can be viewed as a form of verbal STM that supports access to and retrieval of words in single and multiple word processing tasks, including verbal span tasks used as measures of verbal STM capacity.

1.1. The temple assessment of language and (verbal) short-term memory in aphasia (TALSA): purpose and aims of this study

The TALSA test battery is designed to assess language and verbal STM abilities in aphasia. Information gained from the TALSA battery can be used to identify the following:

(1) The linguistic characteristics (semantic, phonological) of language/STM impairment in aphasia at all levels of severity.
(2) The processing nature of the language/STM impairment (weak activation or too-rapid decay of activated semantic and phonological representations),
(3) The ability to activate and maintain activation of language representations in the contexts of delayed response time, increased memory load and/or verbal interference.

The TALSA includes three groups of subtests:

(1) Language tasks with filled and unfilled intervals between a) two stimuli to be compared in some way or b) stimulus and response.
(2) Judgments of semantic and phonological similarity that vary working memory load (comparing meanings or sounds of two vs. three words).
(3) Verbal span tasks that vary characteristics of stimuli in the span to probe semantic or phonological levels of word processing.

In what follows, we provide the theoretical and clinical motivation for development of this test, as well as empirical support for its assumptions and content. Second, we provide details of the tasks in the test battery, their rationale, normative data from individuals with aphasia as well as age-matched controls, and reliability and validity measures. Third, we present data from the TALSA that demonstrate the positive or negative effects of an increase in response time or WM load on language performance. In the discussion, we focus on some research and clinical applications of the test battery and its value in providing an assessment of aphasia that is highly specific in its detail of linguistic and processing impairments and highly sensitive to all levels of impairment severity. We also discuss the relevance of the data from this test battery to functional communication in aphasia.

1.1.1. Theoretical motivation for developing the TALSA battery

Definitions of aphasia quite naturally focus on the linguistic characteristics of the impairment, but, as noted above, more recent models acknowledge the involvement of STM and other cognitive processes (Darley, 1982; McNeil & Pratt, 2001; McNeil, 1982;