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Working memory and discourse production in people with aphasia

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ABSTRACT

This study explored the relationship between Working Memory (WM) and discourse production in people with aphasia, based on data from the AphasiaBank. The dataset comprised the children's story "Cinderella" and basic WM measures of span, collected from 45 participants (15 people with nonfluent Broca's aphasia, 15 people with anomic aphasia, 15 people with fluent Wernicke's aphasia). Discourse samples were coded for and analyzed in terms of content, micro- (words and sentences) and macro- (groups of sentences) linguistic components, known to demonstrate multi-level discourse ability. Comparisons were made among the different participant groups to identify differences and/or commonalities in performance. Results showed that WM, as measured by reduced word and sentential span, influences macrolinguistic narrative components and may be sensitive to aphasia type. Findings were interpreted in terms of a potential deficit to Baddeley's episodic buffer, affecting sequential and hierarchical narrative information processing.

1. Introduction

Discourse is the communicative foundation upon which humans typically manage their day-to-day tasks (Davidson, Worrall, & Hickson, 2003). It is commonly defined in terms of linguistic units that extend beyond a simple clause, expressed for a specific communicative function (Armstrong, 2000; Halliday & Christian, 2004). Although many Persons with Aphasia (PWA) retain the ability to communicate basic wants and needs, most seek to expand their discourse repertoire to capture a greater range of communicative purposes (Worrall et al. 2011). Indeed, clinical research has attempted to address this priority, with a noticeable increase in the study of discourse patterns among PWA (Armstrong, Ferguson, & Simmons-Mackie, 2013), especially over the past 40 years (Bryant, Ferguson, & Spencer, 2016). However, a clear characterization of discourse problems that PWA exhibit remains a challenge, largely due to methodological differences among studies, such as participant demographics and medical history, sample size, methods of discourse elicitation, and absence of normative data against which evaluation of discourse samples can be done (Whitworth, Claessen, Leitao, & Webster, 2015).

Most studies of discourse production in aphasia have focused on the analysis of the linguistic features underpinning narratives produced by people with aphasia (Bryant et al., 2016). Based on a review of 165 studies, Bryant et al. (2016) identified 536 different discourse measures, which they divided into three broad groupings: (i) language productivity (sample length, lexical diversity, speech fluency, word finding), (ii) information content (efficiency, cohesion, lexical, semantic/conceptual, schema-related), and (iii) grammatical complexity (morphological, word class, syntactic). This division suggests that a comprehensive analysis of narrative discourse in aphasia should involve multiple discourse levels (Ellis, Henderson, Wright, & Rogalski, 2016; Linnik, Bastiaanse, & Höhle, 2016; Sherratt, 2007).

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Armstrong (2000) proposed a useful theoretical framework to capture the multi-level nature of discourse production patterns in aphasia. In this framework, discourse problems PWA experience can be represented from three main perspectives:

- (i) *Structuralist*, which is focused primarily on microstructural discourse components, such as lexical items, morpho-syntactic structures, word classes, word-finding problems, grammatical complexity, grammatical errors
- (ii) *Functionalist*, which is focused primarily on macro-structural discourse components, such as overall text structure (e.g., story grammar), conversational components (e.g., turn-taking), communicative effectiveness/success
- (iii) *Macro-micro*, which combines (i) and (ii) and considers components such as content units, correct information units, main concepts

Evidence suggests that PWA have the greatest challenges with microstructural discourse components, as reflected in omission of obligatory arguments (e.g., Byng & Black, 1989; Whitworth, 2010), problems with discourse cohesion (Glosser & Deser, 1991), and difficulties using referential devices such as pronouns (e.g., Armstrong, 2000; Nicholas, Obler, Albert, & Helm-Estabrooks, 1985). Reports have been mixed, though, with some studies noting deficits (Ulatowska, North, & Macaluso-Haynes, 1981), and others not (Bloom, Borod, Santschi-Haywood, Pick, & Obler, 1996; Glosser & Deser, 1991). Difficulties with the production of micro-level discourse components manifest differently, based on aphasia type (Code, 2010). For example, in a recent study of narratives produced by 22 aphasic participants, Manning and Franklin (2016) found that fluent participants had more pronoun errors and produced qualitatively different articles than their nonfluent counterparts. The nonfluent participants, on the other hand, had a higher number of omissions than fluent ones.

PWA have a somewhat easier time with macro-structural discourse components (Armstrong et al., 2013; Lemme, Hedberg, & Bottenberg, 1984; Lock & Armstrong, 1997), although some studies have found that PWA produce impoverished information (Doyle et al., 2000), show reduced relevance and accuracy (Nicholas & Brookshire, 1993), and have trouble with story grammar (Whitworth, 2010). Distinctions between aphasia types are less evident in such analyses, as PWA appear to be more impaired than adults without aphasia but oftentimes show no statistical difference between aphasia groups (e.g., Manning & Franklin, 2016).

The differentiation between production of micro-vs. macro-level discourse components among PWA is not clear-cut, however, recent studies demonstrate an interdependency between the two (for a detailed description of discourse measures in people with neurogenic disorders, see Kong, 2016). Andreetta, Cantagallo, and Marini (2012), examined the effect of lexical deficits in people with anomic aphasia on their production of macro-linguistic narrative components. In comparison to people without aphasia, discourse impairments among PWA manifested as slower speech rate, shortened Mean Length of Utterance, fewer grammatical sentences, greater semantic paraphasic errors, as well as greater cohesion and global coherence errors, and lesser lexical information units. The authors found that cohesion errors and sentence completeness were strongly correlated, as were global coherence errors and production of lexical information units, and concluded that certain aspects of lexical retrieval possibly affect production of macrolinguistic components in narratives of PWA. They proposed that impaired utterance production among people with anomia adversely affects sentence completeness and inter-utterance cohesion. They further argued that to handle lexical deficits, patients produce lexical fillers and repetitions that impede level of global coherence.

Despite the gains in understanding discourse production in aphasia, characterization of the discourse impairments in this population remains a challenge. Findings suggest that there is considerable interindividual variability among PWA, in terms of the amount of content they provide in their narratives vis-à-vis the intactness of the linguistic structures they produce to express that information. That is, a PWA may demonstrate mild linguistic impairment but, at the same time, show limited expression of discourse content, and vice versa (Pritchard, Hilari, Cocks, & Dipper, 2017). To account for such variability, it might be useful to consider the potential contribution of nonlinguistic cognitive factors to performance, such as those associated with working memory, which are known to be part and parcel of linguistic behaviors observed in aphasia (for a comprehensive review, see Cahana-Amitay & Albert, 2015). Examination of the production of discourse in aphasia through such a lens captures the idea that discourse embodies cognitive-linguistic interlinks that make up the unfolding of natural language in a communicative context (Fergadiotis & Wright, 2011; Manning & Franklin, 2016).

Working memory (WM) has been conceptualized as a limited capacity system, designed to maintain, process, and manipulate information over short spans of time (Baddeley, 2003). In this multicomponent model, a central executive system allots attention resources to three slave components: (1) a phonological loop, which governs the rehearsal and maintenance of verbal information; (2) a visuospatial sketchpad, which stores visual and spatial information; and (3) an episodic buffer, which integrates information from the phonological loop, the visuospatial sketchpad, and long-term memory. In such a system, WM could be considered the workspace in which information is stored and manipulated, while the central executive system would be responsible for the ability to organize WM representations to enhance efficiency of information processing (e.g., Carpenter, Just, & Reichle, 2000; Connor, MacKay, & White, 2000).

Baddeley's WM model is assumed to interact with language performance, suggesting that the integrity of WM capacity can impact a person's ability to carry out language tasks (Baddeley, 2003; Carpenter & Just, 1989; Murray, 2012). Indeed, there is ample evidence that many PWA have difficulties with tests of WM and that these impairments adversely affect their language performance (e.g., Baldo & Dronkers, 2006; Beeson, Bayles, Rubens, & Kaszniak, 1993; Caplan & Waters, 1999; Caspari, Parkinson, LaPointe, & Katz, 1998; Christensen & Wright, 2010; Friedmann & Gvion, 2003; Gvion & Friedmann, 2012; Laures-Gore, Marshall, & Verner, 2011; Rönnberg et al., 1996; Sung et al., 2009; Ween, Verfaellie, & Alexander, 1996; Wright, Downey, Gravier, Love, & Shapiro, 2007). Most reports, describe WM deficits influencing tasks involving phonological, semantic, phrasal, and sentential elements (for a review, see Cahana-Amitay & Albert, 2015), with little to no mention of effects on discourse-level components. This gap is important

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