Exploring the Relationship between Attention Allocation and Working Memory Processes in Persons with and without Aphasia

INTRODUCTION

Aphasia has been associated with working memory deficits (Caplan, & Waters, 1999; Caspari, Parkinson, LaPointe, & Katz,1998; Ivanova & Hallowell, 2010; 2012; Wright & Fergadiotos, 2012,) and attention allocation deficits (Heuer & Hallowell, 2014, Hula & McNeil, 2008; LaPointe & Erickson, 1991; McNeil et al., 2004;2005; Murray, 1999, 2012; Murray, Holland, & Beeson, 1997; Robin & Rizzo, 1988). Some authors suggest that WM and attention deficits are not only concomitant with the language deficits of people with aphasia but that they actually contribute directly to linguistic deficits in aphasia (Kurland, 2011; Hula & McNeil, 2008; McNeil & Pratt, 2001).

While results from empirical studies of individuals with neurological, cognitive or language impairments have confirmed a relationship between attention and WM functions (Conway, Moore, & Kane, 2009; Cowan, 1999; Engle, Tuholski, et al., 1999; Kane, Bleckley, Conway, & Engle, 2001; Kane & Engle, 2000; Turner & Engle, 1989), it remains unclear how working memory deficits and attention deficits relate to aphasia. It is unclear whether they are separate cognitive deficits, or if they are manifestations of a singular cognitive impairment. It is also not well understood how deficits in storage and processing of information, and in allocating attention, are related to aphasia severity and how they contribute to language deficits.

Ivanova & Hallowell (2014) developed working memory measures to assess working memory storage and processing capacity in individuals with and without aphasia, including a traditional modified listening task (MLS). Heuer and Hallowell (2014) developed an eye-tracking method to assess attention allocation, using a dual-task paradigm, comparing performance on a visual search task and a comprehension task under single- and dual-task conditions. Data on all measures were collected with the same group of individuals with aphasia and control participants. Ivanova, Heuer and Hallowell (2011) explored the relationship between working memory storage capacity and visual attention allocation measures. Results indicated significant relationships between MLS storage capacity and visual attention allocation during the single task only for control participants, and for the dual task for both groups in the MLS condition with short and simple sentences.

PURPOSE

The relationship between working memory storage and processing indexed through a modified listening span task and attention allocation measures indexed through an eye-tracking-based method were explored by comparing working memory storage and processing measures with attention allocation measures during single- and dual-task conditions entailing a comprehension task.

To explore how deficits in storage and processing of information and in attention allocation are related to language deficits and aphasia severity, a comparison of all measures to the WAB AQ and auditory comprehension score (AC) in individuals with aphasia was conducted.

METHODS

Twenty-three adults with aphasia participated. Detailed participant characteristics will be summarized in the presentation. Aphasia was assessed using the Western Aphasia Battery-

Revised (WAB-R, Kertesz, 2007). Thirty individuals without language, cognitive, or neurological deficits and who passed a mental status screening (Mini Mental Status Examination; Folstein, Folstein, & McHugh, 1975) served as controls. All participants passed vision and hearing screenings.

Procedures:

Modified Listening Span (MLS) task (Ivanova & Hallowell, 2014). Participants were asked to match sentences of varying length (short and long) and complexity (active and complex) to pictures, and also to remember a separate set of words for subsequent recognition. See Figure 1 for an example.

Eyetracking-based attention allocation task (AA) (Heuer & Hallowell, 2014). Eye fixations were monitored during a listening comprehension task in single- and dual-task conditions. Sentence stimuli were either simple or complex. In the single-task condition a verbal stimulus was presented followed by a corresponding image display, in which one image corresponded to the verbal stimulus. In the dual-task condition, participants were presented simultaneously with a visual search task and the verbal stimulus for the listening comprehension task, followed by a multiple-choice image display with one image corresponding to the verbal stimulus. (See Figures 2 and 3 for examples). Performance was indexed via participants' eye fixations, monitored and recorded at 60 Hz using a remote pupil center/corneal reflection system. A fixation was defined as a stable eye position for a minimum of 100ms within a range of 6 degrees of visual angle horizontally and 4 degrees vertically.

Pearson Correlation Coefficients were calculated for the MLS storage and processing measures, the comprehension single-and dual-task eye-movement measures, and WAB-R AQ and AC in individuals with aphasia. Based on Ivanova, Heuer and Hallowell (2011), significant correlations between WM and AA measures were hypothesized for the dual task in participants with aphasia, and single and dual task for control participants.

RESULTS

Statistical results are provided in Table 1 through 3.

Control participants.

MLS overall processing correlates with the linguistic AA single-and dual task, with the exception of the complex stimulus conditions in single and dual task. *MLS short and simple processing* were not correlated significantly with AA measures, because control participants performed at ceiling level. Thus, the variable was a constant, precluding a valid correlation analysis (See Table 1).

The storage measures *MLS overall storage* and *MLS short and simple storage* were not correlated significantly with the linguistic AA task, with the exception of the simple comprehension task during the single-task condition (See Table 2).

Participants with aphasia.

MLS overall processing was only correlated significantly with the simple single AA task. *MLS short and simple processing* was correlated significantly with all linguistic AA measures (See Table 1). Similar to control participants, MLS storage measures were not significantly correlated with the linguistic AA task (See Table 2). Correlations with the WAB-R AQ and AC score indicated that only the processing scores and the AA measures were significantly correlated with WAB-AQ and AC score.

DISCUSSION

Based on the correlations between the linguistic AA tasks and processing components, and lack of correlations of the AA task and storage component of the modified MLS task, it is suggested that the two processes, storage and processing, rely differently on the recruitment of attention resources and linguistic processing. The correlations between MLS processing measures and AA single and dual tasks are not surprising, given that in both tasks participants were required to listen to a verbal stimulus and choose a corresponding image from a multiple-choice display. Thus, similar processes were assessed during both tasks. The lack of correlation between MLS storage, linguistic AA task, and the WAB AC and AQ, suggests that storage requires different cognitive processes, and is possibility less linguistically mediated. It is possible that other aspects of attention, such focused attention or attention switching, are more strongly linked to working memory capacity. Based on the current data, deficits in attention allocation and working memory do not seem to represent a singular impairment.

In the future, analyses should be considered that allow the exploration of the relationship between aphasia severity, comprehension deficits and measures of working memory and attention allocation, such as regression analyses modeling the complexity of the relationship and the differential influence of each of these variables more appropriately.

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TABLES and FIGURES

Table 1

Correlations between Working Memory Processing Scores and Proportion of Fixation Duration on the Target Image (PFDT) in Language Comprehension Task in the Single and Dual task for Participants With and Without Aphasia.

		Participants without aphasia		Participants with aphasia	
		MLS processing (overall)	MLS processing – short and simple	MLS processing	MLS processing – short and simple
PFDT AA single	overall	.501*	n/a*	.379	.601**
	simple stimuli	.488*	n/a	.512*	.653**
	complex stimuli	.303	n/a	.147	.475*
PFDT AA dual	overall	.506**	n/a	.266	.544**
	simple stimuli	.494**	n/a	.351	.649**
	medium stimuli	.622**	n/a	.094	.516*
	complex stimuli	.331	n/a	.155	.369

*Note. MLS= Modified listening span task; p < .05, ** p < .01.*n/a = no correlation because all control participants performed at ceiling level*

Table 2

Correlations between Working Memory Storage Scores and Proportion of Fixation Duration on the Target Image (PFDT) in Language Comprehension Task in the Single and Dual task for Participants With and Without Aphasia

		Participants without aphasia		Participants with aphasia	
		MLS storage score (overall)	MLS storage score – short and simple	MLS storage score	MLS storage score – short and simple
PFDT AA single	overall	.218	.330	.130	.227
	simple stimuli	.379	.519**	.142	.129
	complex stimuli	.132	.147	.078	.227
PFDT AA Dual	overall	.211	.252	.062	.228
	simple stimuli	.231	.132	.108	.203
	medium stimuli	.135	.313	.245	.280
	complex stimuli	.276	.258	-.263	.030

Note. *MLS= Modified listening span task; PFDT = proportion of fixation duration; AA = attention allocation*
** p < .05, ** p < .01.*

Table 3

Correlations OF Working Memory Storage and Processing Scores and Proportion of Fixation Duration on the Target Image (PFDT) in Language Comprehension Task in the Single and Dual Task with the Aphasia Quotient and the Comprehension Score of the WAB-R.

Condition		WAB-R AQ Score	WAB-R AC Score
		r	*r*
Single AA	Overall	.60**	.52**
PFDT	simple	.70**	.63**
	Complex	.38	.28
Dual AA	Overall	.69**	.66**
PFDT	Simple	.66**	.64**
	Medium	.66**	.64**
	Complex	.68**	.63**
MLS overall storage		.29	.28
MLS overall processing		.64**	.73**
MLS short and simple storage		.29	.31
MLS short and simple processing		.68**	.67**

Note. WAB-R AQ Score = Western Aphasia Battery Aphasia Quotient; WAB-R AC Score = Western Aphasia Battery Auditory Verbal Comprehension Score. *p < .05. ** p <.01

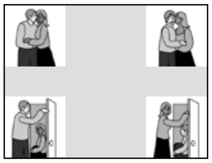
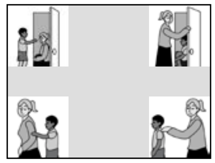
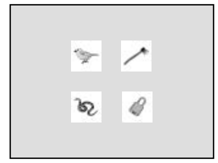
Verbal stimuli	The woman is kissing the man.	*Bird*	The boy is finding the woman.	*Lock*	(recognition display)
Visual stimuli		Blank screen		Blank screen	
Duration of presentation	Until participant gives a response (points to a picture)	2 sec.	Until participant gives a response (points to a picture)	2 sec.	Until participant gives a response (points to images)

Figure 1. Example of a set from the modified listening span task (set size two, short and simple condition).

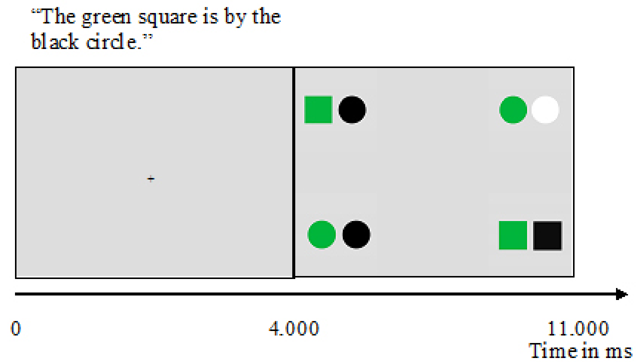


Figure 2. Procedure for the single-task condition during the comprehension task.

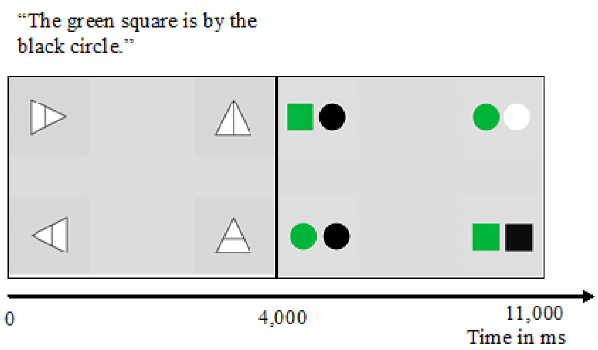


Figure 3. Procedure for the dual task condition during the comprehension task.