INTRODUCTION

Several authors have reported that individuals with aphasia have greater difficulty allocating attention according to task demands than people without neurological disorders (Hula & McNeil, 2008; LaPointe & Erickson, 1991; McNeil et al., 2004; McNeil et al., 2005; Murray, Holland, & Beeson, 1997; Robin & Rizzo, 1988). Studying how attention deficits contribute to neurogenic language deficits is important for clinical practice and research. However, existing methods for indexing attention allocation in people with aphasia pose serious methodological challenges, including demands on comprehension abilities for understanding of dual-task instructions prior to an experiment, and response requirements that may impact participants' performance. Eyetracking methods have great potential to address such challenges. Such methods do not require a) understanding of complex instructions; b) responding verbally, in writing, or with gestures; or c) manipulating devices, such as a computer mouse or joystick (Hallowell, Wertz, & Kruse, 2002). These features reduce critical response confounds and improve the validity of assessment tools for indexing attention allocation (Heuer & Hallowell, 2013).

Heuer and Hallowell (2013) developed an eyetracking method to assess attention allocation using a dual-task paradigm in individuals with and without aphasia. The dual-task method included a visual search task, in which participants were trained to find a visual target in a display that included one target and three nontarget foils, and an auditory linguistic processing task, in which sentences were presented auditorally. Attention demands were manipulated by varying the complexity of each of the two tasks. Changes in attention demands were indexed through performance on the visual search task using eyetracking measures. Results indicated that the method is sensitive to differences between people with and without aphasia, and that it captures response variations associated with task demands and stimulus complexity. While those results were valuable in establishing the construct validity of the novel eyetracking-based measures, no conclusions could be drawn about the concurrent validity of the method because no previously validated measure of attention allocation had been administered.

PURPOSE

The purpose of this study was to test the concurrent validity of the novel eyetracking method developed by Heuer and Hallowell (2013) by comparing the performance on single and dual tasks to scores from a standardized traditional attention assessment-the Test of Everyday Attention (TEA, Ridgeway, Robertson, Ward, & Nimmo-Smith, 1994). Participants without neurological impairment were studied to ensure confidence that TEA task performance was not confounded by language or cognitive impairments. It was also important to replicate the findings for individuals free of neurogenic deficits reported in the previous study to ensure that the construct validity of the method was maintained.

METHOD

Participants. Forty individuals without neurological impairment, who passed a mental status screening (Mini Mental Status Examination; MMSE; Folstein, Folstein, & McHugh, 1975), and vision and hearing screenings, participated. None had participated in previous eyetracking experiments.

Eyetracking tasks. The eyetracking single and dual tasks are described in detail by Heuer and Hallowell (2013). See Figure 1 for an example of a single visual search task, and Figure 2 for an example of the dual task.

Test of Everyday Attention (TEA, Ridgeway, Robertson, Ward, & Nimmo-Smith, 1994). The TEA assesses a variety of different functions of attention, including focused, divided and sustained attention in visual and auditory modality. The subtests *Telephone Search* and *Telephone Search while counting* were administered because these construct targeted by these subtests best mirrors the construct of attention allocation targeted through the novel eyetracking method. In the Telephone Search subtest, participants search for key symbols while ignoring irrelevant symbols in a simulated classified telephone directory. In the Telephone Search with Counting subtest, participants again complete the telephone search, this time in conjunction with a counting task of prerecorded tones. Test stimuli include mock pages from a telephone directory. Auditory stimuli in the counting condition are prerecorded strings of tones.

Analysis. Eye movements were recorded using an LC Technologies EyeFollower system with a sampling rate of 120 Hz. The proportion of fixation duration on target stimuli (PFDT) served as the dependent measure (Heuer & Hallowell, 2013). PFDT was defined as the total duration of fixations on the target image, divided by the total of fixation durations on all images in the display. A value close to 1 indicates that the viewer fixated mostly the target, indexing low processing demands; a value close to zero indicates that the viewer distributed fixations equally across targets and foils, not identifying the target, indexing high processing demands. A repeated measures ANOVA and follow-up t-tests comparing single and dual -task performance, and performance during simple and complex stimulus conditions for the eyetracking tasks were conducted. Pearson correlation coefficients for eyetracking measures and TEA scores were also computed.

RESULTS

Replication of eyetracking-based attention allocation measures

- The sample mean of -.04 (SD = .06) was significantly different from 0, $t(38) = -3.34$, $p = .002$, (two-tailed), $d = .53$, indicating a significant decrement in PFDT from single–to-dual task processing.
- The mean PFDT for simple stimuli of .71 (SD = .08) was significantly higher than the mean PFDT for visually complex stimuli of .62 (SD = .10) during the single visual search task, as indicated by a significant paired-samples t-test, $t(38) = 11.55$, $p > .001$, $d = .90$.
- PFDT significantly decreased with an increase in stimulus complexity as indexed by a significant main effect, $F(2, 76) = 62.18$, $p < .001$ (see means and standard deviations for simple, medium, and complex stimulus conditions in Table 1, and pair-wise comparisons incorporating a Holm p-value correction in Table 2).

Validation of attention allocation task with the Test of Everyday Attention

Pearson Correlation Coefficients were computed for eyetracking measures of visual search single and dual task and the raw and scaled scores for the TEA single (telephone search), and dual task (telephone search while counting). See Table 3 for descriptive data on the performance of individuals on the Telephone search and Table 4 for statistical results. TEA scores correlated significantly with the eyetracking measures, indicating high validity of the novel attention allocation task. Only the correlation between the difference scores for eyetracking versus TEA measures did not achieve significance.

DISCUSSION

Results replicated the findings for control participants in the original Heuer and Hallowell (2013) study. With an increase in task demands associated with an increase in stimulus complexity and also with changes from single-to dual-task processing, decreases in the dependent eyetracking measure PFDT were observed. These findings are important because they support the construct validity of the eyetracking method and ensure that the eyetracking method being examined for concurrent validity with an established measure (the TEA) indexes attention allocation as originally purported.

Concurrent validation of the novel eyetracking task and associated measures was achieved for single- and dual-task processing. TEA single-task scores correlated significantly with eyetracking measures for the visual search single and dual tasks. Similarly, TEA dual task scores correlated highly with the eyetracking measures for the visual search single and the dual tasks.

SUMMARY

The concurrent validity of the novel eyetracking method for capturing attention allocation was established. Results are encouraging in terms of the future feasibility of using the new eyetracking-based method as a clinical and research tool to assess attention allocation in individuals with neurogenic deficits that are difficult to assess with traditional assessment tools.

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Table 1

Means and Standard Deviations for Single, Medium and Complex Stimuli during the Dual-task Condition of the Visual Search Task.

Stimulus Complexity	*Mean*	*Standard Deviation*	*N*
Simple	.70	.12	39
Medium	.61	.13	39
Complex	.57	.13	39

Table 2

Comparisons of Simple, Medium, and Complex Stimulus Conditions in the Dual-task Condition During the Visual Search Task

Pairs	*t*	*df*	*p*
simple – medium	7.15	38	<.001
simple - complex	11.57	38	<.001
Medium – complex	3.41	38	.002

Table 3

Mean, Standard Deviation and Number of Participants for the TEA Raw Scores of Single and Dual-task Processing.

TEA	***M***	***SD***	**Minimum**	**Maximum**	***N***
Single	3.28	.79	2.00	5.30	37
Dual	3.85	1.38	1.80	7.80	36

Table 4

Pearson Correlation Coefficients for the Raw TEA Data, the Dual-task decrement (DTD) and the Scaled Score Equivalent of the DTD (SSE) of Single and Dual-task and PFDT of the Visual Search Single and Dual Task.

PFDT	**TEA**											
	Single		N	Dual		N	DTD		N	SSE		N
VS	*r*	*p*		*r*	*p*		*r*	*p*		*r*	*p*	
Single	.72**	<.001	37	.65**	<.001	36	-.37*	.03	35	.21	.23	35
Dual	.63**	<.001	37	.65**	<.001	36	-.46**	.006	35	.29	.10	35
Diff. score	-.20	.24	37	-.29	.09	36	-.30	.08	35	.22	.21	35

Note VS = Visual search, DTD = Dual-task decrement, SSE = Scaled Score Equivalent,

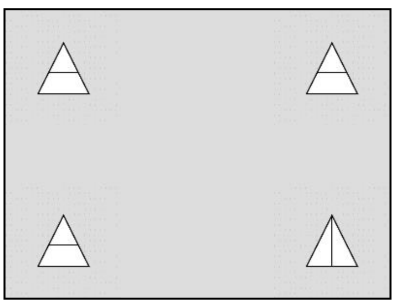

Figure 1. The display is an example of a simple visual search. Participants were instructed to find the different image."

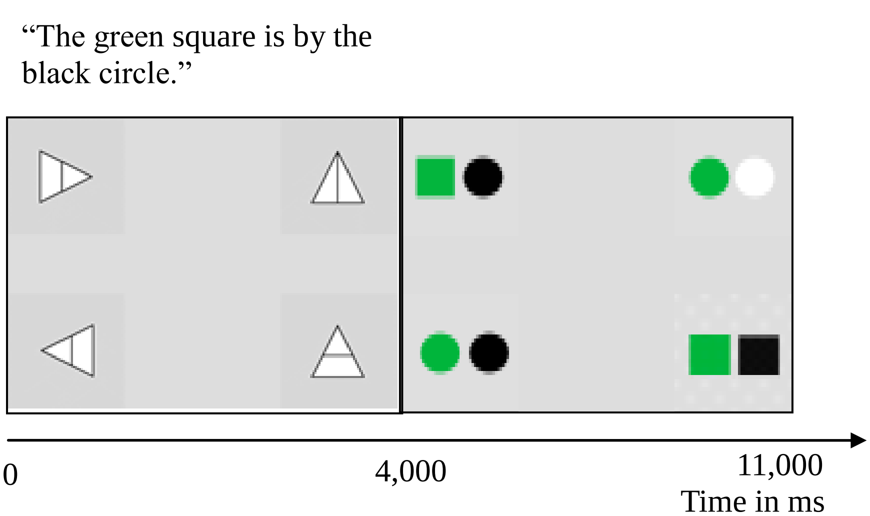

Figure 2. During the dual task, the visual search display on the left and a verbal stimulus are presented simultaneously, followed by the comprehension display on the right side.