Currently, there is increasing empirical and clinical interest in the integrity of nonlinguistic, cognitive processes (e.g., attention, working memory) in aphasia (Kalbe et al., 2005; Lesniak, 2008; Zinn et al., 2007), and the relationship between these processes and aphasic symptoms, prognosis, and response to language treatment (Fillingham et al., 2006; Seniow et al., 2009a; Yeung & Law, 2010). Indeed, some conceptualizations of aphasia specify that deficits in cognitive functions other than language may generate or intensify linguistic impairments (Hula & McNeil, 2008; Murray & Kean, 2004).

Although prior aphasia research has identified co-existing cognitive deficits and an association between language and cognitive abilities (Caspari et al., 1998; Fridricksson et al., 2006; Yeung & Law, 2010), several methodology limitations highlight the need for further investigation. For example, when dual-task paradigms have been used to explore the impact of increased attention demands on language performance in aphasia (e.g., Murray, 2000), formal cognitive measures have rarely been included to assist with interpreting the basis of dual-task decrements. Investigations that have included formal tests have yet to yield a consistent pattern of deficits or a reliable association between cognitive status and severity of aphasic symptoms (e.g., Helm-Estabrooks, 2002 vs. Petry et al., 1994), and have primarily focused on relations between language and executive functions or memory (Jee et al., 2009; Seniow et al., 2009a,b). In fact few aphasia studies have utilized formal attention tests or evaluated a range of attention functions or modalities, even though attention deficits have been reported as the most frequent and persistent post-stroke symptom (Lesniak et al., 2008). Finally, the validity and reliability of some findings are limited due to small sample sizes (e.g., Friedmann & Gvion, 2007), weak study designs (e.g., Frankel et al., 2007), and instrument issues such as using single versus multiple measures of a cognitive function (e.g., Petry et al., 1994; Seniow et al., 2009b) or relying on experimental protocols that lack established psychometric properties (e.g., Wright et al., 2007).

Accordingly, this study was designed to further elucidate the relationship between cognition and aphasia with a focus on attention abilities. Individuals with (IWA) and without aphasia (CON) completed formal measures of attention and other cognitive functions to examine the following hypotheses: (a) compared to the CON group, IWA would score significantly lower on measures of attention as well as measures of other cognitive functions; and, (b) for IWA, there would be significant correlations between their language and communication status and their performance of attention and other cognitive tests.

Methods

Subjects. Participants included 39 adults with and 39 adults without aphasia (Table 1). Groups were matched (i.e., $p > .05$) for age and education, and all subjects met inclusionary hearing, vision, and praxis criteria. According to the *Aphasia Diagnostic Profiles* (Helm-Estabrooks, 1992), IWA had mild to moderately severe aphasia and represented a variety of fluent and nonfluent aphasia types; on the ASHA FACS (Frattali et al., 1995), ratings of overall communicative independence for IWA varied from moderately to completely independent. CON participants were given the *Mini Mental State Exam* (Cockrell & Folstein, 1988) and all scored above the cut-off score of 24 indicating that none of them presented with dementia.

Procedures. As part of a larger research project, all participants completed a battery of cognitive tests with battery administration split between one to two 1- to 2-hour sessions to avoid participant fatigue and to accommodate participants' test-taking speed. Test order was randomized across participants to circumvent order effects. The battery included the following attention measures: (a) *Test of Everyday Attention* (Robertson et al., 1994) to assess auditory and visual sustained, focused, and divided attention as well as attention switching (the Lottery subtest was not given because of the extensive administration time of this subtest); IWA were provided with a number line (with numbers from 1 to 25) to aid their expression of numerical values during the Elevator Counting, Elevator Counting with Distraction, Visual Elevator, Elevator Counting with Reversal, and Telephone Search while Counting subtests; (b) *Behavioral Inattention Test* (Wilson et al., 1987) to identify the presence and severity of visual neglect; and, (c) Rating Scale of Attentional Behavior (Ponsford & Kinsella, 1991) to determine caregivers' perceptions of the presence and frequency of behaviors associated with attention deficits. The other cognitive tests administered were (a) forward and backward Visual Memory Span (Wechsler, 1987) to examine nonverbal short term and working memory abilities, respectively, (b) Tompkins et al.'s (1994) auditory-verbal working memory protocol, and, (c) *Ruff Figural Fluency* to assess nonverbal fluency and executive functions such as self-monitoring and flexibility,

Independent *t*-tests were used to compare IWA and CON group performances of the TEA and other cognitive measures. If heterogeneous variances were observed, separate variance rather than pooled variance *t*-tests were used to compare the aphasic and control groups' performances (Keppel, 1991). A conservative $p < .001$ was adopted to help minimize Type 1 error. Bivariate correlations of attention measures ($p < .01$) with other test battery data and demographic variables were calculated to investigate factors associated with IWA's attention test performances.

Results and Discussion

As hypothesized, IWA displayed attention deficits: Compared to the CON group, they performed significantly more poorly on each of the TEA subtests and the BIT, and were rated as displaying significantly more behaviors indicative of attention deficits (Table 2). The IWA group also obtained significantly lower scores than the CON group on the other memory and executive function measures. A review of TEA standard scores (M =10; SD =3) identified that although only 5 CON participants (13%) scored more than 1 SD below the mean on at least one subtest, 33 IWA (85%) did so, with 25 (64%) scoring more than 1 SD below the mean on at least half of the TEA subtests. Among IWA, there were variable patterns of attention impairments ranging from deficits across all attention functions and modalities to more isolated problems (i.e., poor performance on only one subtest).

Correlational findings supported the second hypothesis that for IWA, language measures would be associated with performance of attention and other cognitive tests. Both ADP and ASHA FACS scores were significantly (most *p* values < .0001) related to each of the attention measures (i.e., TEA, rating scale, BIT), although more moderate correlations were observed between ADP and BIT scores. The other cognitive measures were significantly correlated with at least one language score, with working memory measures having the most frequent and strongest correlations with ADP and ASHA FACS scores.

In summary, this study extended the existing literature by examining the integrity of a number of attention functions in both auditory and visual modalities in the same sample of IWA who represented a spectrum of aphasia profiles. Our results accord well with prior aphasia research (e.g., Kalbe et al., 2005; Seniow et al., 2009a,b; Yeung & Law, 2010) identifying (a) attention and other cognitive deficits in most but not all IWA, (b) heterogeneity in the types and severity of cognitive symptoms among those with cognitive impairments, and, (c) potent associations between language and cognitive measures. Clinically, the current study provides empirical support for including comprehensive cognitive testing within assessment protocols for IWA, and underscores the need to evaluate interventions that address the spectrum of cognitive deficits with which IWA may present.

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Table 1. Group Characteristics

Variable		Aphasic (n = 39)	Control (n = 39)
Age	M	60.2	63.3
(years)	SD	12.9	14.0
	Range	32-83	30-84
Education	M	14.7	14.6
(years)	SD	2.1	2.4
	Range	12-22	8-21
Time Post Stroke	M	52.1	
(months)	SD	49.6	
	Range	6-204	
Gender	(Male: Female)	26:13	16:23
Aphasia Diagnostic Profiles (Standard Scores)			
Auditory Comp.	M	12.0	
	SD	2.9	
	Range	8-17	
Lexical Retrieval	M	11.9	
	SD	3.8	
	Range	5-17	
Repetition	M	10.1	
	SD	2.8	
	Range	5-14	
Aphasia	M	111.0	
Severity	SD	16.2	
	Range	88-135	
ASHA FACS (rating score with max. = 7)			
Overall Comm.	M	6.1	
Independence	SD	0.9	
	Range	3.9-7	
MMSE	M		28.3
(Tot. Raw Score)	SD		1.7
	Range		25-30

Table 2. Test Battery Data

Cognitive Test		Aphasic (n = 39)	Control (n = 39)
Test of Everyday Attention (standard scores)[1]			
Map Search 1	M	6.4	11.2
	SD	3.2	2.9
	Range	1-12	6-17
Map Search 2	M	6.6	11.1
	SD	2.7	2.7
	Range	2-13	7-17
Elevator Counting	M	6.2	7.0
	SD	1.0	0.2
	Range	4-7	6-7
Elevator Counting With Distraction	M	7.1	11.5
	SD	3.1	1.7
	Range	2-13	7-13
Visual Elevator	M	5.9	11.4
	SD	3.7	2.4
	Range	0-15	6-15
Elevator Counting With Reversal	M	7.5	12.5
	SD	3.6	2.9
	Range	0-15	7-18
Telephone Search	M	5.7	10.7
	SD	2.7	2.4
	Range	0-14	7-17
Telephone Search With Counting	M	5.3	11.7
	SD	3.9	3.1
	Range	0-15	6-19
Rating Scale of Attentional Behavior (Total Score)[2]			
	M	19.1	1.6
	SD	11.5	3.0
	Range	0-42	0-10
Behavioral Inattention Test[3]			
	M	137.1	143.5
	SD	10.2	2.1
	Range	90-146	139-146
Auditory-Verbal Working Memory (# recall errors)	M	24.9	7.9
	SD	11.5	5.3
	Range	6-42	0-18

WMS-R Visual Memory Span (%iles)			
Forwards	M	42.0	63.5
	SD	31.6	22.1
	Range	2-98	30-99
Backwards	M	46.6	63.6
	SD	29.1	23.1
	Range	2-96	24-99
Ruff Figural Fluency Test (%ile for # unique designs)	M	21.7	60.7
	SD	26.8	19.1
	Range	1-100	28-99

[1]Scaled has *M* = 10, *SD* = 3 based on a sample of 154 non-brain-damaged adults.

[2]Based on summing the ratings of 14 items, each of which is rated on a scale from 0 (attentional behavioral problem does not occur at all) to 4 (attentional behavioral problem always occurs).

[3]BIT cut-off score of 129 is indicative of visual neglect; 5 IWA scored below 129.