Cognitive impairments in the domains of attention, memory, and executive functioning (EF) are common concomitant symptoms, although not ubiquitous, in aphasia (Martin et al., 2012; Murray, 2012). Recent research suggests that identifying co-exiting EF problems may be particularly important given that such problems (a) correlate with language performance in a number of areas (e.g., sentence processing, word retrieval; Baldo et al., 2005; Martin & Allen, 2008), and (b) negatively affect survival, response to language treatment, generalization and maintenance of treatment effects, and thus prognosis (Oksala et al., 2009; Seniow et al., 2009; Yeung & Law, 2010). To date, however, EF in aphasia has been examined with a restricted set of measures, with the vast majority of studies using *Raven's Matrices* or tests similar to that (e.g., *TONI*), and/or the *Wisconsin Card Sorting Test* (WCST), to evaluate nonverbal problem solving/reasoning and inhibition, respectively (e.g., Baldo et al., 2010; Fillingham et al., 2006; Hinckley & Nash, 2007; Oksala et al., 2009; Seniow et al., 2009; Yeung & Law, 2010). Whereas debate persists pertaining to theoretically or operationally defining EF, there is agreement that it represents a multidimensional cognitive construct (Godefroy et al., 2010; Varney & Stewart, 2004). Establishing the integrity of EF abilities with an array of tasks or tests is therefore necessary to not only identify the breadth of EF abilities commonly compromised in aphasia, but also determine which EF deficits influence aphasic symptoms and recovery.

Accordingly, this study was designed to further elucidate the integrity of EF as well as the relationship between EF and language performances in individuals with aphasia (LHD). Given that right hemisphere brain damage (RHD) may compromise EF and that these deficits may contribute to RHD-related language difficulties (Ferre et al., 2011; Godefroy et al., 2010), a comparison group of adults with RHD was included to determine the distinctiveness of the LHD group's performance pattern. The *Ruff Figural Fluency Test* (RUFF; Ruff, 1996) was selected because it has nominal language demands, a quick administration time (i.e., < 10 min), and acceptable psychometric properties (Berning et al., 1998; Kraybill & Suchy, 2008; Lezak et al., 2004), and evaluates planning, self-monitoring, and cognitive flexibility, EFs that have been infrequently examined in prior aphasia research. Whereas the RUFF or shorter but similar Design Fluency Test have been previously used with neurogenic patients, these studies either excluded aphasic patients, failed to specify the presence and/or severity of aphasia in their subject samples, or were case studies (Baldo et al., 2001; Frankel et al., 2007; Varney & Stewart, 2004). Additionally, these prior studies have focused on total achievement (i.e., number of unique designs and errors) versus qualitative scores (e.g., number of design patterns), even though the latter have been associated with greater diagnostic specificity (Possin et al., 2012).

The following hypotheses were examined: (a) RUFF scores of LHD and RHD groups would be significantly lower than those of adults with no brain damage (CON); (b) LHD and RHD groups would perform similarly on RUFF achievement but not qualitative scores (Baldo et al., 2001; Possin et al., 2012); and, (c) RUFF scores of the patient groups would be related to their language abilities, as well as their performance of other executive measures.

Methods

Subjects. The study involved 35 CON, 35 LHD, and 15 RHD participants (Table 1). Groups were matched (i.e., $p > .05$) for age and education, and all subjects met inclusionary hearing, vision, and praxis criteria. LHD participants had mild to moderately severe aphasia and represented a variety of aphasia types. RHD subjects varied from mild to severe levels of cognitive-communicative impairment. All CON participants scored above the cut-off of 24 on the *MMSE* indicating that none of them presented with dementia.

Procedures. The RUFF consists of 5 sheets of paper, each containing 40 squares with 5 dots in each square; for each page, examinees must generate as many different figures as possible (in 60 s) by connecting at least two dots and only using straight lines. RUFF performance is traditionally quantified in terms of the number of unique designs and an error ratio (i.e., number of repeated designs divided by number of unique designs), the latter of which is considered an index of planning efficiency (Ruff, 1996). Qualitative analyses involved tallying the number of orderly patterns (akin to strategy use or semantic clusters; Lezak et al., 2004; Lanting et al., 2009) and examining design complexity (e.g., designs involving 1 vs. 2 lines) and the number and types of non-repetition errors (e.g., drawing lines to dots in different squares). In addition to language and functional communication measures (Table 1), subtests from the WMS-R and *Test of Everyday Attention* were given to evaluate other executive skills (Goldstein & Naglieri, 2014). A subset of participants also completed an experimental verbal fluency task (Table 3), which required naming as many items as possible for a target category given 2 minutes. Acceptable inter- and intra-rater agreement were achieved for all quantitative and qualitative variables.

Results and Discussion

As hypothesized, the patient groups displayed EF deficits: Compared to the CON group, they performed significantly more poorly ($p < .001$) on standard RUFF scores (i.e., unique designs and error ratio; Table 2). The LHD and RHD groups did not, however, significantly differ ($p > .8$) on these RUFF scores. A review of individual participants' performances identified that although all CON participants scored, according to the test manual, within or above average for these RUFF scores, only 6 LHD (17%) and 3 RHD (20%) did so.

Qualitative analyses yielded a different pattern of group differences (Table 2). For example, LHD and CON groups performed similarly in terms of the average number of orderly patterns produced and the maximum number of designs in a pattern, but with a smaller proportion of aphasia participants generating orderly patterns. In contrast, the RHD group used fewer patterns than the other groups and shorter patterns than the CON group. RHD participants more frequently utilized less complex, 1-line designs compared to controls.

Correlational findings supported the hypothesis that RUFF scores would be associated with language and other executive measures, albeit differences in the number and nature of these associations were observed for aphasic versus RHD participants. For instance, for the LHD group, only the number of unique designs was related to their verbal fluency performance (i.e., total number of correct exemplars) whereas for the RHD group, the number of unique designs and design complexity scores were closely tied to the number of verbal exemplars and semantic clusters they produced.

In summary, the current results indicate that individuals with aphasia may experience difficulties on planning and self-monitoring tasks, even when language demands are nominal. The results accord well with prior research identifying EF deficits in most but not all aphasic participants and potent associations between language and EF measures (Baldo et al., 2010; Seniow et al., 2009). They are also consistent with studies documenting that these EF deficits and their relation to language performance are not unique to LHD, and may be similarly heterogeneous following RHD (Godefroy et al., 2010; Possin et al., 2012). Theoretical (e.g., domain general vs. specific deficits) and clinical (e.g., importance of comprehensive cognitive testing) implications of these findings for future aphasia and RHD research will be discussed.

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Table 1. Group Characteristics and Test Data

Variable		LHD (n = 35)	RHD (n = 15)	CON (n = 35)
Age (years)	M	60.3	58.6	60.9
	SD	15.0	17.1	15.4
	Range	32-100	31-87	30-82
Education (years)	M	14.6	14.2	14.8
	SD	1.7	1.8	2.1
	Range	12-16	12-16	8-16
Time Post Stroke* (months)	M	47.5	42.5	
	SD	47.3	47.6	
	Range	6-204	6-152	
Gender (Male: Female)		25:10	10:5	22:13
MMSE (Tot. Raw Score)	M		27.6	28.1
	SD		2.3	1.9
	Range		21-30	25-30
Aphasia Diagnostic Profiles (Standard Scores)				
Lexical Ret.	M	11.6	14.6	
	SD	3.9	2.2	
	Range	5-17	10-17	
Aud. Comp.	M	11.8	14.1	
	SD	3.2	1.5	
	Range	6-17	11-17	
Aphasia Severity	M	110.3	127.4	
	SD	17.2	8.8	
	Range	80-135	111-135	
Boston Naming Test	M	36.7	52.1	57.8
	SD	20.2	7.6	2.2
	Range	0-60	29-58	52-60
ASHA FACS (rating score with max. = 7)				
Overall Comm. Independence	M	6.1	6.6	
	SD	0.9	.6	
	Range	3.6-7	4.6-7	

WMS-R Visual Memory Span (%ile)				
Backwards	M	45.0	37.6	64.3
	SD	28.4	32.2	23.2
	Range	2-90	2-80	28-99
Test of Everyday Attention (Standard Scores)				
Visual Elevator	M	5.9	8.5	11.6
	SD	3.6	4.2	2.3
	Range	0-15	3-14	6-15
Telephone Search	M	5.1	7.8	11.4
With Counting	SD	3.4	4.4	3.7
	Range	0-13	2-15	6-19

*As an inclusionary criterion, all aphasic and RHD subjects were required to be at least 6 months post-stroke onset.

Table 2. RUFF Quantitative and Qualitative Data

Variable		LHD	RHD	CON
#Unique Designs	M	53.3	50.4	84.6
(raw score)	SD	21.6	27.3	19.2
	Range	5-102	0-114	51-116
# Unique Designs	M	17.8	21.0	62.9
(%ile)	SD	23.5	28.4	18.4
	Range	1-94	1-99	37-99
# Repetition Errors	M	12.8	14.1	11.6
	SD	17.1	13.4	13.2
	Range	0-83	0-45	2-47
Error Ratio*	M	53.0	53.8	26.9
(%ile)	SD	30.7	29.7	16.4
	Range	7-100	7-99	3-56
Orderly Pattern Use				
# Patterns	M	2.9	0.7	4.1
	SD	3.9	1.3	5.4
	Range	0-13	0-4	0-17
Max. # Items/	M	2.4	1.3	3.2
Pattern	SD	2.3	2.0	2.4
	Range	0-5	0-5	0-6
Participants	Tot. #	19	5	25
Using Pattern(s)	%	54	33	71
Design Complexity (Proportion of Unique Designs)				
1-Line	M	0.23	0.34	.18
	SD	.24	0.36	.11
	Range	0-1.0	0-.96	0-.33
2-Line	M	0.27	0.21	.31
	SD	.11	0.15	.10
	Range	0-.65	0-.51	.19-.48
3-Line	M	0.51	0.45	.52
	SD	.23	0.30	.15
	Range	0-.84	.23-.84	.36-.84

Non-Repetitive Errors (Proportion of Unique Designs)				
Skipped Squares	M	2.3	7.4	2.8
	SD	6.9	17.4	5.09
	Range	0-39	0-69	0-16
Cross-Connected Squares	M	0.8	1.9	0.1
	SD	3.1	2.7	.32
	Range	0-17	0-7	0-1
Failed to Use Straight Lines	M	1.0	0.5	0.0
	SD	2.8	1.0	.0
	Range	0-15	0-3	0-0
Lines to Distractors	M	0.3	0.9	0.1
	SD	.71	1.0	.32
	Range	0-3	0-3	0-1
Lines to Nowhere	M	1.7	0.9	0.8
	SD	5.1	1.8	1.23
	Range	0-30	0-7	0-4
Total Non-Repetitive Errors	M	6.2	11.6	3.8
	SD	11.0	18.6	4.8
	Range	0-51	0-75	0-16

**Reflects total number of design repetitions/perseverative errors divided by total number of unique designs. A higher percentile for this measure indicates a poorer performance.

Table 3. Group Data From the Experimental Verbal Fluency Task

Variable		GROUP LHD (n = 24)	RHD (n = 14)	CON (n = 24)
# Correct Exemplars	M	21.1	21.1	36.1
	SD	11.4	7.8	10.2
	Range	8-50	12-43	22-57
% Correct Exemplars	M	91.7	95.3	95.8
	SD	10.4	4.7	3.6
	Range	70-100	87-100	86-100
# Repetition Errors	M	.67	.71	1.0
	SD	.92	.83	.95
	Range	0-3	0-2	0-3
# Non-Repetition Errors (e.g., unrelated to category)	M	1.0	.36	.46
	SD	1.7	.63	.78
	Range	0-5	0-2	0-2
# Semantic Clusters	M	2.6	1.9	5.4
	SD	2.5	1.7	1.9
	Range	0-8	0-5	3-11
Mean Length of Semantic Clusters	M	3.7	3.7	4.4
	SD	0.8	0.6	0.8
	Range	3-5.5	3-5	3.3-6
Participants Using Semantic Clusters	Tot. #	18	10	24
	%	75	71	100