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Road Sign Recognition during Computer Testing versus Driving Simulator Performance for Stroke and Stroke+Aphasia Groups

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1. Original Project:

Road Sign Recognition during Computer Testing versus Driving Simulator Performance for Stroke and Stroke+Aphasia Groups could not be completed due to the unexpected difficulties older participants experienced with motion sickness during simulator trials. Therefore, the project was revised and the final report are included here.

1a) Revised Project Description:

Recognition and Interpretation of Road Signs in Poststroke Aphasia Effected Older Drivers

ABSTRACT

Driving is essential to maintaining independence. For most Americans preserving personal mobility is a key element to retaining jobs, friends, activities and the basic necessities to maintain a household. This is particularly true for older people. However, as the general age of the US increases, more and more people are becoming at greater risk for neurologic diseases such as stroke. Brain damage from stroke can affect physical mobility, sensorimotor, cognition, communication, visual perception, and visual processing which are all critical processes needed for driving. Currently, there is no consistent way to determine when a person can return to driving poststroke. Most driving studies exclude people with poststroke aphasia (PWA). However, aphasia may result in the inability to recognize and interpret the words, symbols, and gestures on road signs, which will impact safe driving. This paper presents the results of a recent study that tested road sign interpretation tasks among groups of healthy and poststroke older drivers to assess the effects of poststroke aphasia on driving. The results showed that aphasia significantly impacted accuracy and response time of road sign interpretation. More importantly, however, as language and symbol complexity increased on road signs, the aphasia-affected drivers performed with less accuracy and required more time. Although poststroke aphasia has not been taken into account in most stroke-related driving research, these findings suggest further research is warranted and may have implications for the design of road signs and healthcare professionals who make decisions about when a PWA may safely return to driving.

Keywords: Stroke, Aphasia, Return to Driving, Traffic Signs,

INTRODUCTION

The aging population is increasing rapidly. Research shows that eventually, either normal sensory changes that occur with age or health conditions, will impact the ability of older adults' to drive safely and efficiently *(1)*. Since the risk of neurologic disease or degeneration such as stroke or dementia also increase with age, the probability that these conditions will effect drivers with greater frequency in the future is also increasingly likely *(2)*. Strokes result from failures in the cerebrovascular system that result in sudden neurological deficits *(3)*. Stroke is one of the most prevalent disabling diseases in the United States and is the leading cause of adult disability *(4)*. Each year, 795,000 Americans suffer a stroke resulting in $73.7 billion stroke-related healthcare and rehabilitation costs in 2010 *(4)*.

As the number of aging drivers increases, so too does the likelihood that these drivers will experience sensory and health changes that could affect their driving ability. Research has shown that access to transportation has a significant effect on the physical health and emotional well-being of older adults *(5-9)*. In fact, over and above the functional necessities of driving, older adults view the ability to drive as an essential part of their identity *(6)*, equating their ability to drive with feelings of independence and freedom *(5-9)*. Driving cessation due to stroke or other neurologic disorder leads to loss of independence, which may in turn lead to declines in health, and feelings of decreased worth *(8)*.

Aphasia is a language disorder that results from a stroke to a specific area of the brain. Aphasia has been operationally defined as "an acquired selective impairment of language modalities and functions resulting from a focal brain lesion in the language-dominant hemisphere that affects the person's communicative and social functioning, quality of life and the quality of life of his/her relatives and caregivers." (p. xx) *(10)*. The language modalities that may disrupt communicative functioning include listening, verbal expression, reading and writing. Aphasia may co-occur with other cognitive or motor deficits, but it is not caused by them *(11-13)*. The National Aphasia Association (NAA) reports that 25-40 percent of people who survive a stroke have aphasia. In the United States, one million people are currently diagnosed with aphasia and 200,000 additional cases occur every year *(14)*. Recovery from aphasia is long term and full restoration of pre-injury language abilities may not be possible *(14)*.

Reading, one of the language modalities affected by aphasia, includes not only letters, words, gestures, and numbers, but also symbols, such as those used on many road signs. The impairment is called alexia, defined as an *acquired* reading impairment that affects an individual's ability to perceive and/or interpret written information, which leads to the inability to comprehend what is read. Moreover, impairments in other language modalities (listening, expression and writing) may affect reading comprehension because of the brain's interconnectivity *(15-18)*.

Driving requires the accurate perception and interpretation of written material (i.e. road signs) in a timely manner. The words and/or symbols that appear on road signs may create problems for people with aphasia (PWA) because they have to access undamaged areas of the brain which increases the amount of time it takes to interpret and respond to road signs. Some could argue that the traffic signs with pictographs may alternatively or additionally assist the PWA's understanding of the sign.

However, research supports that even when images supplement comprehension, PWA have deficits in symbol interpretation *(19, 20)*.

While the above information is well-known to speech-language pathologists who work with PWA, very little research has examined the effects of poststroke aphasia on driving ability. In fact, the extant literature on poststroke driving performance has dealt with aphasia in one of three ways:

1. included participants with lesions that could have resulted in aphasia but did not address *(21-23)*;
2. excluded PWA (Lundqvist *(24, 25)*; or
3. included PWA but did not address how the language deficits might have affected the results *(26-28)*.

Therefore, while investigators are able to provide recommendations about driving post stroke *(29)*, they are not able to make the same recommendations about driving if a person has poststroke aphasia. This creates a dilemma for healthcare professions often asked to make recommendations about a person's readiness to drive after stroke *(30)*.

Only four studies have examined the effect of aphasia on some aspect of driving performance from 1975 through 2003 *(30-33)*. Two studies used driving simulation or on-road driving to determine the effect of language deficits of driving performance *(31, 33)*. While both studies reported that PWA performed significantly worse than either a control group or other brain injured group, neither study described whether road signs recognition was measured. Two other studies directly measured the impact of aphasia on road sign recognition *(30, 32)*. These two studies are the focus of the following discussion since the methodology and results pertain more directly to the present study.

In the first study the investigators examined road sign recognition in PWA as compared to neurologically normal participants and those with brain lesions but no aphasia *(32)*. The 11 participants (4 with aphasia, 2 without aphasia, and 5 controls) were required to correctly respond to road markings and 20 different traffic signs using a miniature car on a model road. The group with aphasia gave considerably fewer correct answers compared to the other two groups. The investigators then repeated the study using a shorter version of the test and 14 participants with neurologic damage (9 with aphasia, 5 without aphasia). Results indicated again that the PWA had fewer correct answers across a wider range than the group without aphasia *(32)*. This research demonstrated that difficulty interpreting road signs could result from *either receptive or expressive aphasia,* not just receptive, as would be expected for a person with poststroke alexia (reading disorder).

In the most recent finding, investigators compared a group of PWA to a neurologically normal control group matched for age, educational background, and years driving *(30)*. The investigators examined road sign identification through the Road Sign Recognition Test from the *Stroke Driver Screening Assessment* (*SDSA*) *(34)*, which requires the matching of road signs to appropriate situations in which they would be found; auditory comprehension of Highway Code road sign descriptions; and reading comprehension of Highway Code road sign descriptions. Results indicated that the PWA, even those that had returned to driving, were significantly slower and significantly less accurate than the control group. In the Road Sign Recognition Test, PWA took longer—7.61 (*SD* = 3.03) minutes on average compared to 4.94 (*SD* = 2.01) minutes; and were less accurate—identifying 8.11 signs (*SD* = 2.30) out of 12 compared to 10.72 (*SD* = 1.18). The PWA also had significantly lower scores than the control group on the Highway Code road sign descriptions. On the auditory comprehension of road sign descriptions, PWA identified 9.53 signs (*SD* =2.58) out of 12 compared to 11.56 (*SD* = .62) identified by neurological normal control group. On the reading comprehension of road sign descriptions, PWA identified 9.12 signs (*SD* = 2.93) out of 12 compared to 11.61 (*SD* = .62) identified by the control group. These results support the idea that PWA have greater difficulty interpreting the linguistic information necessary to identify road signs.

Mackenzie & Paton's *(30)* study is valuable because it assessed *both* accuracy and timing, both important in on-road driving. Their findings are somewhat limited by the measures used. The Road Sign Recognition Test from the *SDSA* does not assess *understanding* of a road sign's function but rather, requires matching the road sign to the appropriate location in which one would see the sign. The *SDSA* then might be considered an assessment of road sign *memory* not road sign *function.* Additionally, the auditory and reading comprehension road sign tests required matching official, governmental descriptions to the road signs. However, the reading level/complexity of the written descriptions was not addressed, and could have been a factor for PWA, as discussed above. Moreover, many of the descriptions did not include the sign's function. These results led the present investigators to suggest that further study examining the functional interpretation of road signs was warranted.

In summary, the literature supports the premise that PWA could have difficulty interpreting road signs due to processing deficits for words and/or symbols. The few studies that included PWA identified aphasia's negative effect on performance and road sign recognition, but findings were inconsistent. What is missing from the literature is an investigation of the accuracy and timeliness of road sign interpretation by PWA. Both of these variables—accuracy and timeliness—are critical to safe driving. Furthermore, in a short test that provides accuracy and timeliness of road sign interpretation, information could be useful to doctors or other health care workers required to make decisions about when a PWA could return to driving. As an initial step in developing such an assessment, this study investigated whether differences existed between a group of PWA and a neurologically normal control group in accuracy and response time on a road sign interpretation task.

2. Methodological Approach

This study sought to investigate aphasia's effect on road sign interpretation abilities by answering two experimental questions:

- Does presence of aphasia significantly affect road sign interpretation accuracy?
- Does presence of aphasia significantly affect road sign interpretation response time?

Based on the literature it was hypothesized that aphasia would result in decreased accuracy and increased response time of 30 selected road signs.

Test subjects included 20 older people recruited from stroke support groups, the Louisiana State University-Speech, Language, Hearing Clinic, and word of mouth. These 20 participants were separated into two groups. As summarized in Table 1, the pool included 10 community-dwelling people without self-reported history of neurological disorder (the control group CG) and 10 community-dwelling people who had sustained stroke in the left hemisphere and had received a diagnosis of aphasia ≥ 6 months prior to study participation (the aphasia group AG). Participants with aphasia have returned to driving or have stated a desire to return to driving. All participants were between 50-85 years of age, native English speakers with ≥ 8th grade education. Groups were closely matched in mean age (CG *M* = 66.2 *SD* = 4.94 years, AG *M* = 66.1 *SD* = 10.90 years); however, the CG group included 4 women and 6 men while the AG group included 1 woman and 9 men.

Both groups included participants whose education levels ranged from high school completion to completion of advanced degrees. Participants were excluded from the study for any of the following: history of sustained or unresolved drug and alcohol abuse or mental illness; failed aided or unaided hearing screening; legally blind *(35)*, visual field blindness , color blindness *(36)*, left neglect; and motoric deficits that make them unable to use a computer keyboard. In addition, the AG aphasia severity based on *Western Aphasia Battery-Revised* (WAB-R) *(37)* bedside test scores ranged from 61.6 to 80 indicating mild to moderate aphasia severity. Reading comprehension ranged from 2nd grade to 5th grade, based on *Basic Reading Inventory (38)*.

Materials and Procedures

Road sign images were found using Google Image search. Table 2 illustrates the signs used in the study. Road signs were selected by the research team and validated by asking five individuals from southern Louisiana, aged 50-85 years, with no known language or cognitive disorders to answer yes/no to the question "have you previously seen this sign?" Thirty-six road signs were recognized by the majority of the individuals surveyed and were used in the experiment. Three signs were used in the practice portion of the road sign interpretation experiment and 33 signs were used for data collection. Researchers then wrote the possible road sign interpretations for each sign using simple vocabulary and sentence structure that would be understood by the AG.

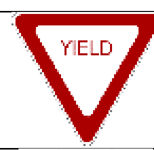
TABLE 1 Participant Demographics

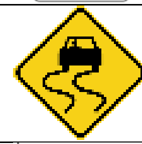
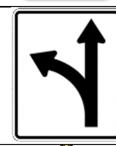
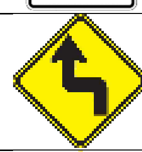
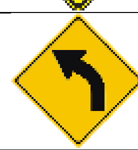
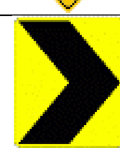
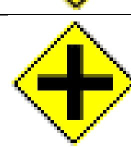
Group	ID #	Age (yrs)	Sex	Education Level	WAB-R Bedside[a]	Aphasia Severity[a]	Reading Comprehension (Grade Level)
Aphasia	301	84	M	College Degree	80.8	Mild	*
	302	77	M	College Degree	70.8	Moderate	*
	303	54	M	Advanced Degree	61.6	Moderate	2nd
	304	66	M	Advanced Degree	78.3	Mild	4th
	305	68	M	Advanced Degree	90	Mild	3rd

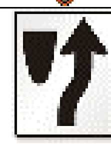
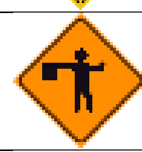
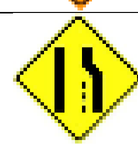
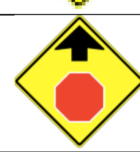
	306	67	M	College Degree	84.2	Mild	5th
	307	70	M	Advanced Degree	69.2	Moderate	5th
	308	50	M	High School	84.5	Mild	2nd
	309	53	M	College Degree	*	*	*
	310	71	F	Some College	*	*	*
		M=66.1 *SD*=10.9	F=1 M=9				
Control	101	60	F	Some College			
	102	74	F	High School			
	103	64	M	Advanced Degree			
	104	70	F	College Degree			
	105	61	M	College Degree			
	106	69	M	Advanced Degree			
	107	64	F	Advanced Degree			
	108	72	M	Some College			
	109	67	M	College Degree			
	110	61	M	Some College			
		M= *SD*=	F=4 M=6				

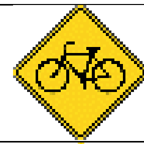
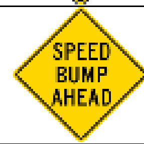
[a] = *Western Aphasia Battery-Revised (37)*; * = missing data

Table 2 Road Sign Stimuli

Sign	Correct Response	
Yield (practice)	Slow down and watch for other cars.	
Stop (practice)	Come to a complete stop.	
Parking (practice)	Park here.	
Traffic Signal Ahead	Prepare for a traffic light ahead.	

One Way	Do not go right.	
Slippery Road	Slow down, the road may be slippery.	
No U-Turn	Do not make a U-turn.	
No Left Turn	Do not turn left.	
No Right Turn	Do not turn right.	
Left Turn Only	Get in this lane to turn left.	
Left Turn Straight Through Shared Lane	Get in this lane to go straight or turn left.	
Road Curves	Curve with the road.	
Curve Left	Curve left.	
Chevron Arrow	Use caution curving.	
Curve Right	Curve right.	
Intersection Ahead	Prepare for a four way intersection ahead.	

Road Closed Ahead	Find a different route.	
Speed Limit	Do not go over 55 miles per hour.	
Railroad Crossing	Watch out for trains.	
Road Work Ahead	Be alert to road worker.	
Stay to the Right	Stay to the right of the median.	
Pedestrian Crossing	Stop for pedestrian.	
Flagman Ahead	Follow the road workers directions.	
Lane Ends - Merge Left	Merge left when lane ends.	
Stop Sign Ahead	Prepare to stop ahead.	
Yield Sign Ahead	Prepare to yield ahead.	
Change in Speed Limit	Prepare to change speed ahead.	
Median (Divided Highway)	Stay on own side of median.	

Watch for Bicyclists	Be cautious of bike riders.	
Speed Bump	Slow down to go over the bump.	
Evacuation Route	Follow the signs to safety.	
No Parking	Do not park here.	
Handicap Parking	Park here if handicap.	
U-Turn	Make a u-turn if needed.	
Do Not Enter	Do not go this way.	
School Zone	Watch for children.	

Each participant was seated at a desk and presented with the road sign interpretation experiment on a laptop computer using in *E-Prime 2.0* software. The experiment was presented on a Dell Latitude E5540 laptop computer with a 16-inch LED screen as shown in Figure 1. The 7, 4, and 1 keys on the number pad of the laptop were marked respectively with red, green and blue colored stickers. The stickers corresponded to the color of the text choices presented on the laptop screen during the experiment.

FIGURE 1 Road sign experimental configuration.

All text was enlarged to Times New Roman font size 18. Directions were presented aloud and in text on the computer screen as shown in Figure 2. Training was completed until the participant demonstrated understanding and ability to complete the task. At that point the experiment was administered.

FIGURE 2 Road sign presentation.

The screen changed to gray after the three choices were read signaling the participant to respond. During the training phase feedback was displayed after the response for correct or incorrect response. For an incorrect response the research assistant would remind the participant of the instructions, and the next practice item was presented. The participant received four opportunities to practice before the experiment began.

The experiment began after successful practice. New instructions appeared on the screen and were read aloud to the participant. They were as follows:

> *"The experiment is going to start now. On each of the following road signs, press the key that matches the color of the correct response. The screen will change to gray when you*

can respond. There will be no feedback between slides and no questions during this part of the session. Do you have any questions or need to use the restroom now? The experiment will take about 20 minutes."

The research assistant allowed for questions and breaks at this time. Once questions or breaks were completed, the research assistant spoke and presented the following text,

"Ready? Remember, answer: "What should a driver do if he sees this sign?" Press any key to start."

The research assistant moved from sitting beside the participant to sitting across from him to reduce anxiety. For each participant the stimuli were randomly presented to reduce fatigue effects. No feedback was presented during the experiment. The research assistant was allowed to encourage the participant to "do your best" or repeat the stem question "What should a driver do if he sees this sign?" When finished, "The End" appeared on the screen.

The software collected the accuracy and response time to each road sign presented for each participant. The experiment closed and the data were saved automatically on a flash drive attached to the laptop computer. Data were subsequently uploaded to the database for analysis.

3. Results/Findings

To quantify the results of the experiments, the mean number of correct answers, the associated response time, and standard deviations were calculated for each group. A between-groups MANOVA was conducted in SPSS v.22 to compare the effect of the presence of aphasia on accuracy and response time in a road sign interpretation experiment. Results were calculated with α = 0.05. Response times that fell outside three standard deviations from the mean response time, i.e. outliers, were trimmed from the data set according to standard procedures.

Between-Group Analysis

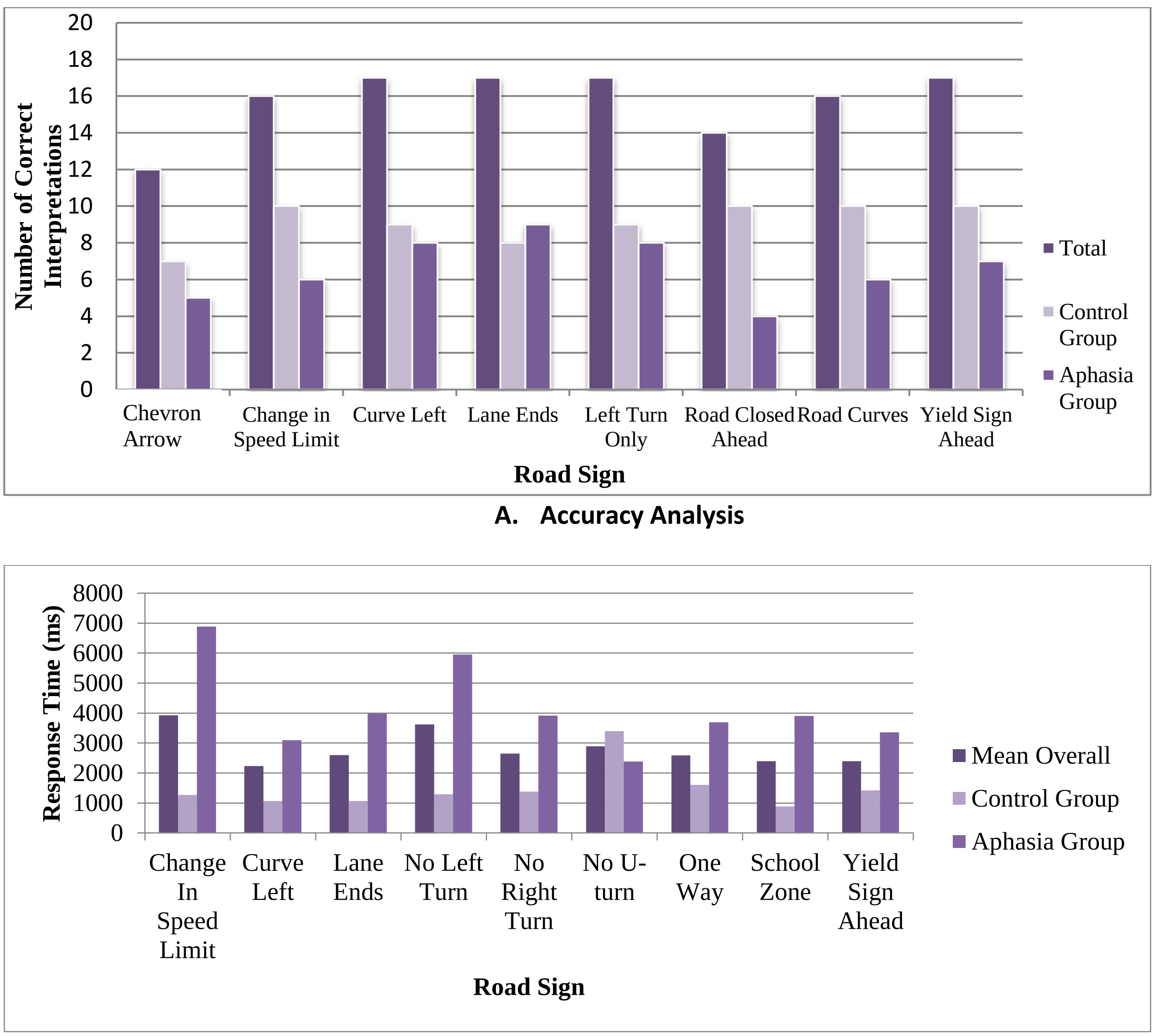
Response time data demonstrated a normal distribution for both groups $\alpha = .05$ [AG ($W = .901$, $p = .225$ and CG ($W = .962$, $p = .808$)]. Accuracy data were mixed [AG ($W = .980$, $p = .967$) and CG ($W = .730$, $p = .002$)]. Therefore, the MANOVA was conducted using the Pillai-Bartlett trace because it is robust to violations of multivariate normality (Bray & Maxwell, 1985).

The MANOVA results showed a significant effect of aphasia for both mean number correct and response time [$V=.493$, $F(2, 17) = 8.446$, $p = .003$]. Two separate univariate ANOVAs were then conducted to determine aphasia's effect on each of the dependent variables ($\alpha = .05$). The presence of aphasia showed a significant effect on *M* number correct, $F(1, 18) = 15.696$, $p = .001$. The AG was less accurate ($M = 28.60$, $SD = 2.76$) than the CG ($M = 28.60$, $SD = 1.06$). The presence of aphasia showed a significant effect on *M* response time, $F(1, 18) = 5.160$, $p =.036$. The AG was slower ($M = 2777.62$ ms, *SD*

= 2144.92 ms) than the CG (M = 1211.58 ms, *SD* = 390.66 ms). A summary of univariate ANOVA results is presented in Table 6.

Analysis of Error and Response Time by Sign
Visual inspection of the raw data was conducted in order to identify patterns of accuracy and response time among the participants in their respective groups and as a whole.

Accuracy. Using the results data in Figure 3A, several patterns emerged during visual inspection. The *Chevron Arrow* sign had the lowest combined accuracy of response at 60 percent. After *Chevron Arrow* the AG most often erred on three signs: *Road Closed Ahead*, *Change in Speed Limit*, and *Road Curves*; while the CG most often erred on *Lane Ends – Merge Left*, *Left Turn Only*, and *Curve Left*. The greatest difference in accuracy of response between the two groups occurred on the following signs: *Road Closed Ahead* (AG = 40%, CG = 100%), *Change in Speed Limit* (AG = 60%, CG = 100%), *Road Curves* (AG = 60%, CG = 100%), and *Yield Sign Ahead* (AG = 70%, CG = 100%).



A. Accuracy Analysis

B. Response Time Analysis
FIGURE 3. Road sign response analysis.

Response Time. As shown in Figure 3B, the signs that had the longest response time for *both groups combined* included *Change in Speed Limit* (*M* = 3924.789 ms), *No U-Turn* (*M* = 2892.55 ms), and *No Right Turn* (*M* = 2644.55 ms). The signs that had the shortest response time overall included *Watch for Bicyclists* (*M* = 1124 ms), *Traffic Signal Ahead* (*M* = 1259.5ms), and *Left turn Straight through Shared Lane* (*M* = 1281.55 ms). However, the AG and CG did not demonstrate similar response times to similar signs. For the AG, the three signs with the longest response time included *Change in Speed Limit Ahead* (*M* = 6881.00 ms), *Lane Ends* (*M* = 3982.40 ms), and *Chevron Arrow* (*M* = 3320.22 ms). For the CG, the three signs with the longest response time included *No U-Turn* (*M* = 3399.60 ms), *Curve Left* (*M* = 1452.30 ms), and *Yield Sign Ahead* (*M* = 1422.40 ms). For the AG, the three signs with the shortest response time (i.e. easiest to interpret) included *Watch for Bicyclists* (*M* = 1399.30 ms), *Left turn Straight through Shared Lane* (M = 1453.80 ms), and *U-Turn* (*M* = 1511.50 ms). For the CG, the three signs with the shortest response time were *Traffic Signal Ahead* (*M* = 655.00 ms), *Watch for Bicyclists* (*M* = 848.7 ms), and *School Zone* (*M* = 883.1 ms). Figure 2B also shows the four signs with the greatest difference in response time between groups: *Change in Speed Limit* (Difference = 5616.8 ms), *No Left Turn* (Difference = 4666.7 ms), *School Zone* (Difference = 3020.70 ms), and *Lane Ends* (Difference = 2914.4 ms).

4. Impacts/Benefits of Implementation (actual, not anticipated)

None to report at this time.

5. Recommendations and Conclusions

This paper summarized the findings of a recent study to assess older drivers with stroke-related disabilities and their ability to comprehend and respond to information conveyed on road signs. The motivation for this work was based on the need to better understand how aphasia effects the perception and interpretation of information related to driving. Although prior research has been conducted to assess how language deficits might affect the ability of stroke-affected persons to drive, there was a limited understanding of how aphasia effects road sign recognition, specifically. And how the accuracy and timeliness of road sign interpretation relates to the ability to drive safely.

In general, the research findings provide preliminary evidence to support the idea that PWA have difficulties accurately and quickly interpreting road signs, both of which are needed for safe driving. While the results support previous findings *(30, 32)* that also showed PWA have poorer road sign *recognition* skills than those without aphasia, it presents *new* evidence that PWA have difficulty with accurate and efficient road sign *interpretation* as road signs become more complex (i.e. use more words and/or more symbols per sign). Considering the prevalence of aphasia and the importance of driving to older adults, these preliminary results support further research in this area. Furthermore, these findings have implications for those who create road signs and healthcare professionals who are asked to make determinations on poststroke return to driving for PWA.

With regard to accuracy, the findings demonstrated that the AG was significantly less accurate than the neurologically normal CG. These findings are consistent with findings showing that PWA performed less accurately on a road sign test than a neurologically normal group (Mackenzie & Patton, 2003). However, the present study designed a different, and possibly more critical aspect of driving by asking participants to indicate what a driver should do when he sees a sign (i.e. interpret sign, select action), compared to the prior study which asked participants to match a sign to a scenario (i.e. recognize sign in context).

The results of this research were similar to the findings of Lebrun et al. (1978) in that the responses of individuals with PWA, regardless of aphasia type (receptive or expressive), were less accurate than those without aphasia*(32)*. Subjects with aphasia characterized by expressive language deficits had difficulties with road sign interpretation and the AG was significantly less accurate than the CG and had greater variability in accuracy scores. In terms of response time, a critical variable associated with safe driving, the study hypothesized that the AG would have significantly longer response times in the road sign experiment than the neurological normal CG. The findings demonstrated that the AG was significantly slower in interpreting road signs than the CG.

However, simple accuracy and response time differences did not tell the whole story about the present study's results. Analysis of responses to individual road signs led to findings that provide *new* evidence to the literature with regard to the language and symbol complexity of road signs. After inspecting individual road signs, trends were found that may support the idea that damaged language and symbolic processing could be responsible for the AG's poorer performance on the road sign interpretation. The accuracy data appears easier to interpret then the response time data, possibly due to a more complex relationship between processing time and road signs.

Overall, *Chevron Arrow* was the most missed sign across both groups. The high incidence of misinterpretation in the CG suggests that this sign might actually be a difficult stimulus to interpret for older adults with and without aphasia. Although the face validity of the sign had been confirmed prior to the experiment using normal older drivers, it often elicited responses such as "I don't know" or "I've never seen it before." However, in retrospect, it may be that seeing the sign by itself rather than in the context of a curve, where there would be multiple *Chevron Arrow* signs, created the problem. In the future, it may be fruitful to conduct an independent study on the face validity of the road signs using a larger and more diverse sample of older adults.

The AG's error pattern provides stronger evidence for the notion that increased complexity of words, symbols, or a combination of words and symbols increased errors. Except for the *Arrow Curve* sign, there was a distinct difference in accuracy responses between the groups. The sign that had the largest difference in accuracy between groups was *Road Closed Ahead*. Notably, this is one of three signs that *only* used words, with no ancillary symbols to provide further information. Two other linguistically dense signs, *Speed Bump Ahead* and *Speed Limit*, had few errors included a word from the sign in the experimental options (Do not go over 55 miles per hour; Slow down to go over the bump.) This issue needs to be studied in more detail. However, the error pattern for *Road Closed Ahead* supports that language processing deficits may be a cause for misinterpretation of road signs.

Change in Speed Limit and *Yield Sign Ahead* were two signs that also resulted in large differences in accuracy between groups. Although *Change in Speed Limit* and *Yield Sign Ahead* are as linguistically dense as *Road Closed Ahead,* these two signs included a combination of words and symbols, which may have increased the complexity of the signs relative to other signs stimuli. This finding goes counter to the theory that pictures and symbols may assist PWA to comprehend words better. On the other hand, it may suggest that road signs comprise a unique "language" system made up of arbitrary symbols that drivers learn, and thus may be prone to damage when a person has a stroke that affects the brain's language centers. This is an area of research that merits further investigation.

While it is difficult to generalize these findings to the general population due to the small sample size, they provide preliminary evidence to indicate that the complexity of words and symbols on road signs may need to be considered by road sign developers; and by those who are asked to make decisions about when a person with poststroke aphasia is ready to safely return to driving. Further study is needed in this area to determine whether these results can be replicated in larger samples of PWA and healthy controls, and even, perhaps with other populations who have reading disorders or are illiterate.

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Deliverables

I. Research Dissemination			**Done**
12/31/14	Donovan, Brown, Savage, & Varnado: *Do People with Aphasia Interpret Road Signs Differently than People without Aphasia?* Paper submitted for Clinical Aphasiology Conference 2015 (rejected – not enough data)		**X**
03/31/15	C. Brown M.A. Thesis Completed: *Do People with Aphasia Interpret Road Signs Differently than People without Aphasia?*		**X**
7/25/15	Donovan, Brown, Savage, Varnado, Parr, & Wolshon: *Recognition and Interpretation of Road Signs in Poststroke Aphasia Effected Older Drivers.* Paper submitted for the 2016 Traffic Research Board Annual Meeting.		**X**
12/31/15	Donovan, Brown, Savage & Varnado: *Linguistic Complexity and Symbol Complexity Affect Accuracy and Response Times Differently on a Road Sign Interpretation Task.* Submit paper to Clinical Aphasiology Conference 2016		
03/31/16	Donovan, Savage, Brown, & Varnado: *Do People with Aphasia Interpret Road Signs Differently than People with Stroke Only and People without Aphasia?* Submit paper to American Speech-Language-Hearing Association 2016 Convention.		
II. Publications (Authorship order will be determined prior to each manuscript using APA *Publication Practices & Responsible Authorship* http://www.apa.org/research/responsible/publication/ accessed August 18, 2014)			
7/25/15	Donovan, Brown, Savage, Varnado, Parr, & Wolshon: *Recognition and Interpretation of Road Signs in Poststroke Aphasia Effected Older Drivers.* Submitted to *Traffic Research Record*		**X**
10/01/15	Donovan, Brown & Savage: *Aphasia Severity Differentially Effected Accuracy and Response time in a Road Sign Interpretation Task.* Target submission to *American Journal of Speech-Language Pathology*		
III. Educational Experiences for Undergraduate and Graduate Students			
LSU			
Fall 2015	Dr. Donovan	COMD 7780 Seminar on Aging & Communication	**X**
	Dr. Donovan	COMD 7387 – Impact of Stroke and Aphasia in Reading Road Signs	**X**
Spring 2015	C. Brown	Thesis Defense (open to all COMD faculty and students): *Do People with Aphasia Interpret Road Signs Differently than People without Aphasia?*	**X**
	C. Brown	COMD Brown Bag Poster Presentation: *Do People with Aphasia Interpret Road Signs Differently than People without Aphasia?*	**X**
	Dr. Donovan	Guest Lecture: COMD 3047 – Introduction to Research Methods Guest Lecture: *Pitfalls and Promises of Interdisciplinary Research*	**X**
Southeastern Louisiana University			

Fall 2014	Dr. Savage	CSD 687 Research – Impact of Reading Road Sign Recognition and Driving Performance	**X**
Spring 2015	Dr. Savage	National Student Speech Language and Hearing Association local chapter	**X**
	Dr. Savage	Research presentation to College of Nursing & Health Sciences Research Consortium	**X**
IV. Community Outreach			
Spring 2015	Donovan, Brown, Savage, & Varnado	LSU Life Course & Aging Center Student Research Symposium & Community Partners Luncheon Poster Presentation	**X**
Ongoing	Dr. Donovan	Stroke Support Group, Baton Rouge Rehabilitation Hospital	**X**
	Dr. Donovan	LSU Speech-Language-Hearing Aphasia Group, Baton Rouge, LA	**X**
	Dr. Savage	Stroke Support at North Oaks Hospital, Hammond, LA	**X**