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Research Report

Gender differences in aphasia outcomes: evidence from the AphasiaBank

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Abstract

Background: Stroke is one of the leading causes of death in the United States. Aphasia is a language impairment which results as a consequence of stroke. Gender differences are reported in underlying mechanisms of stroke, however, gender differences in aphasia type and severity remain unclear.
Aims: To examine gender differences in aphasia impairment based on data from AphasiaBank, a research repository of data obtained from studies of aphasia.
Methods & Procedures: The data were collected from AphasiaBank for 294 persons with aphasia (PWA) (172 men, 122 women). Baseline comparisons by gender groups were completed using independent samples *t*-tests and Pearson Chi square statistics. Univariate comparisons of the total Western Aphasia Battery—Revised (WAB-R) -AQ and -R subtests' scores were compared between the two groups using independent samples *t*-tests. Multivariate comparisons were completed by using multivariate analysis of variance (MANOVA).
Outcomes & Results: Gender differences were observed in the severity of aphasia with men exhibiting more severe aphasia than women. Analyses of WAB-R indicated greater impairment among men based on AQ and greater impairment was observed in individual subtest performance. Men exhibited statistically significantly lower WAB-R AQs than women (67.4 versus 75.6). Lower WAB-R AQs were derived from lower scores among men on individual subtests; information content, fluency, repetition, sentence completion, responsive speech and tests of comprehension (yes/no, auditory word recognition and sequential commands).
Conclusions & Implications: This study offers evidence of gender differences in aphasia severity, global communication impairment and lower scores on individual subtests used to derive the WAB-R AQ. The limitations of the study with suggestions for future directions are presented.

Keywords: aphasia outcomes, gender differences, stroke, persons with aphasia, aphasia severity.

What this paper adds

What is already known on the subject

The underlying causes and mechanisms associated with stroke are different for men and women, which result in different stroke outcomes for both groups. Previous studies have reported that women have worse post-stroke outcomes as compared with men.

What this paper adds to existing knowledge

This study is the first in the United States to report gender disparities in aphasia outcomes using the most common measures of aphasia such as the Western Aphasia Battery—Revised.

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What are the potential or actual clinical implications of this work?
This study helps clinicians understand how underlying stroke mechanisms are related to aphasia outcomes in both genders. Additionally, it also explains how aphasia outcomes differ between men and women.

Background

Gender differences in stroke in the United States

The annual incidence of stroke in the United States is estimated to be approximately 795,000 (Benjamin *et al.* 2018). Although the total number of strokes and stroke deaths has declined in recent decades (Kleindorfer *et al.* 2010), stroke is the fifth leading cause of death (Benjamin *et al.* 2018). Despite stroke being one of the leading causes of death, few studies have examined stroke in women. On average, 55,000 more women have a stroke each year compared with men. The male-to-female ratio of stroke is 1.25 from ages 55–64 years, 1.5 from ages 65–74 years, 1.07 from ages 75–84 years, but 0.76 from age 85+ years (Benjamin *et al.* 2018). Overall, women experiencing strokes tend to be older than their male counterparts (Appelros *et al.* 2009, Roquer *et al.* 2003). Evidence has shown that women experience more severe strokes than men, yet the stroke survival rate is higher among women (Benjamin *et al.* 2018).

Gender difference in causes/mechanisms of stroke

The underlying causes and mechanisms associated with stroke in women differ substantially from those in men. Women experience different vascular risk profiles and distribution of stroke subtypes as compared with men (Roquer *et al.* 2003). Women also possess several unique characteristics such as lactation, menopause, hormone replacement post-menopause and the use of oral contraception, all of which are believed to be associated with stroke risk that are not present in men (Tate and Bushnell 2011). Pregnancy is another stroke-related characteristic unique to women that causes temporary changes that can persist post-partum or accumulate over multiple pregnancies and increase the risk of stroke (Tate and Bushnell 2011). Further, many complications during pregnancy (i.e., preeclampsia) and the post-partum period increase a woman's chance of experiencing a stroke and/or developing poor cerebrovascular health (Vladutiu *et al.* 2017).

Gender differences in stroke outcomes

Regardless of the underlying cause, studies have shown that women have worse post-stroke outcomes than men. For example, women are more likely to have more severe strokes and have greater long-term post-stroke disability relative to men (Tomita *et al.* 2015). Consequently, many women experience worse functional recovery than men and greater post-stroke disability that translates into poorer quality of life (Gall *et al.* 2018).

Aphasia: a common consequence of stroke

Aphasia is an acquired language disorder characterized by deficits in listening comprehension, verbal expression, reading and writing that can result in significant community-based limitations even in its mildest form. Recently, researchers have indicated that about 18% of individuals with a diagnosis of ischemic stroke have aphasia which results in more than 2.5 million Americans currently living with aphasia. A more recent study showed that more than 18% of all stroke survivors discharged from US hospitals have a diagnosis of aphasia (Ellis *et al.* 2017).

In other countries rates of aphasia among stroke patients have also varied. Dickey *et al.* (2010) reported a rate of 60 per 100,000 stroke patients in Canada. Engelter *et al.* (2006) estimated the rate of aphasia to be 43 per 100,000 stroke patients in Switzerland. The Royal Rehab-Rehabilitation and Disability Network (2016) estimates there are 8600 new cases of aphasia in Australia each year (based on figures from the work of Engelter *et al.* 2006). The UK Stroke Association reports more than 350,000 individuals in the UK have aphasia (Stroke Association 2018).

Are there gender disparities in aphasia?

Despite gender differences in the underlying mechanisms associated with stroke and potential gender differences in functional stroke outcomes, it is unclear what potential gender differences exist in aphasia (rates, type, severity), a common consequence of stroke. Understanding potential gender differences in aphasia has been of longstanding interest.

Gender and aphasia rates

An early study by Hier *et al.* (1994), using data from the NINDS Stroke Data Bank, found that aphasia was present in 19.4% of men and 22.5% of women. The study reported that infarcts were the underlying cause of aphasia more frequently in women (37.0%) than men (28.3%). A recent meta-analysis of 25 studies including 48,362 stroke patients found that rates of aphasia are higher in women (29.6%) than men (26%) (Wallentin

2018). Wallentin (2018) also examined data from the Healthcare Cost and Utilization project and found rates of aphasia among women with stroke (33.2%) were higher than men (30.2%).

Gender and Aphasia types

A number of studies from the 1980s generally reported no gender differences in types of aphasia (Code and Rowley 1987, Scarpa *et al.* 1987, Schecter *et al.* 1985). Hier *et al.* (1994), using the NINDS Stroke Data Bank, found Wernicke's, global and anomic aphasias were more common in women than men. Similar to early studies, Yao *et al.* (2015) found no gender differences in type of aphasia and Broca's aphasia was the most common type found in most men and women.

Aphasia severity/outcome

Regarding severity of aphasia impairment, Sarno *et al.* (1985) found no gender differences in severity of aphasia. Similarly, Engelter *et al.* (2006) found no statistically significant differences between females and males with regard to aphasia severity in stroke patients with first ischemic stroke. In contrast, Basso *et al.* (1982) found that women had less severe forms of aphasia than men. Chen and Li (2009) also found that women had less severe aphasia impairment when compared with men. Finally, Yao *et al.* (2015) found that men presented with greater aphasia morbidity than women after stroke and aphasia onset was at younger ages.

Rationale for the study of potential gender disparities in aphasia

There is some evidence that suggests gender differences may exist in individuals with aphasia. The current literature is generally consistent that women have higher rates of aphasia than men. However, the same literature is less clear about gender and types of aphasia as well as gender and severity of aphasia even though women are known to have more severe strokes and stroke is the primary cause of aphasia. Sex differences have been suggested in language lateralization between men and women which may also contribute to gender differences in aphasia outcomes. Since language is traditionally believed to be organized unilaterally in the left hemisphere, any differences may contribute to differences in aphasia outcomes following stroke since aphasia primarily occurs following stroke to the left hemisphere. For example, Kansaku *et al.* (2000) found that women use the right and left hemispheres in a more equal fashion during linguistic processing tasks than men. Similarly, Clements *et al.* (2006) found sex-related lateralization differences with males showing greater left lateralization for phonological tasks but greater bilateral activation during visuospatial tasks. In contrast, women showed greater bilateral activation during phonological tasks and right lateralization during visuospatial tasks.

The purpose of this project, then, was to examine gender differences in aphasia outcomes (type of aphasia and levels of impairment) using data from AphasiaBank (Forbes *et al.* 2012). The rationale for this study is based on the premise that men and women have different underlying causes and mechanisms of stroke and potentially differences in language lateralization, therefore possibly causing different aphasia outcomes. The research questions are as follows:

- Are there gender differences in the type of aphasia experienced by men and women with stroke?
- Are there gender differences in the severity of aphasia as measured by the WAB-R Aphasia Quotient (AQ)?
- Are there gender differences in the individual subtests of the WAB-R AQ?

Materials and method

Data source

Data for this project were obtained from AphasiaBank. This is a shared database that provides a repository for aphasia data from persons with aphasia (PWA) who have been enrolled in research studies. The collection of data in AphasiaBank offers researchers a large database to study aphasia outcomes (Forbes *et al.* 2012). It was created in 2007 with a definitive goal to improve the treatment of aphasia (Holland *et al.* 2009) by comparing PWA and individuals without aphasia, specifically for their communication skills through uniform discourse samples (Forbes *et al.* 2012). Investigators involved in studies of aphasia are able to upload data to AphasiaBank based on a standard 'AphasiaBank' protocol which includes (1) speech samples, (2) picture descriptions, (3) story narratives, (4) discourse samples and (5) standardized test results (WAB-R, etc.). Detailed information about the AphasiaBank and aphasia measures collected in the database is available at http://aphasia.talkbank.org/protocol/list.pdf. The inclusion criteria for the study was: participants whose complete demographic information and WAB AQs were available were included in the study. Thus, 294 participants from the AphasiaBank were included.

Aphasia outcomes

For this study the primary outcome of interest was the AQ from the WAB-R (Kertesz 2007). The WAB-R is a comprehensive assessment of communication function that comprises spontaneous speech, comprehension, repetition and naming subtests which are used to calculate a composite AQ. AQ characterizes the individual's auditory–verbal communication ability and severity of aphasia. These scores range from 0 to 100, with lower scores indicating greater language deficits. Aphasia severity was calculated and WAB-R AQs between 0 and 31.2 were classified as severe aphasia, scores between 31.3 and 62.5 were classified as moderate aphasia, scores between 62.6 and 93.7 were classified as slight (mild) aphasia, and those > 93.8 indicated no aphasia (Pedersen *et al.* 2003). In addition to severity, participants were classified by aphasia types (anomic, Broca's, Wernicke's, global, conduction aphasia, transcortical (motor, sensory, isolation) and other). For this study, all available data were used for gender comparisons even if they obtained WAB-R AQs above the cut-off of 93.8. Recent evidence suggests individuals with WAB-R AQ > 93.8 (no aphasia) frequently present with subtle discourse deficits regardless of their normal WAB-R AQ (Fromm *et al.* 2017).

Analyses

Comparisons of aphasia outcomes between men and women were completed using independent samples *t*-tests for continuous variables and Pearson Chi-square statistics for categorical variables. To evaluate aphasia outcomes, univariate comparisons of the total WAB-AQs and WAB subtests' scores were completed between the two groups using independent samples *t*-tests. Individuals who presented with 'no aphasia' were also included in the analysis. Multivariate comparisons were completed by using multivariate analysis of variance (MANOVA). For all comparisons, gender served as the independent factor and the WAB-R AQs and WAB-R AQ subtest scores as the dependent factors, while controlling for baseline differences in speech and language therapy (SLP) treatment received. All statistical analyses were completed using IBM SPSS Version 22 (IBM SPSS Statistics, 2013; Armonk, NY, USA). Imaging data were not available for all participants; therefore, we were unable to examine carefully the impact of stroke location and size of lesion in this study.

Results

The sample obtained from AphasiaBank contained data for 294 PWA (172 men, 122 women). The mean age of the total sample was 61.9 years; the mean for years of education was 15.4 years; and 90% were right handed. The sample was classified into the following aphasia types: anomic (33%), Broca's (24%), Wernicke's (8%), global (1%) conduction (18%), transcortical motor (3%), transcortical sensory (0.7%), unknown (2%) and no aphasia (10%; based on the WAB-R AQ cut-off of 93.8). The mean duration of aphasia was 5.2 years and the mean years of SLP treatment received was 3.2 years. Gender differences were present in the years of treatment received with men receiving at least one additional year of treatment compared with women (see table 1 for summary of demographic characteristics, aphasia type and severity by gender).

Univariate gender comparisons of aphasia outcomes as measured by performance on the WAB-R AQ and the WAB-R subtests are summarized in table 2. A significant gender difference was observed in the WAB-R AQ with lower mean scores among men compared with women, $t(292) = -3.548$, $p < .001$. A total of 5% of the sample exhibited severe aphasia, 27% moderate aphasia, 59% mild aphasia and 10% no aphasia. Gender differences were observed in the severity of aphasia with more men exhibiting severe aphasia (8% men versus 0% women), but more women than men (15% women versus 6% men; $p = .001$) exhibiting no aphasia. The individuals with 'no aphasia' were included in the analysis as well. Additionally, an analysis excluding individuals with 'no aphasia' was also completed and the removal of those individuals did not change the results of the study. Gender differences were also observed in the following WAB-R subtests: information content, $t(289) = -3.55$, $p < .001$, fluency, $t(289) = -3.079$, $p = .002$, repetition, $t(286) = -3.005$, $p = .003$, sentence completion, $t(286) = -3.153$, $p = .002$, responsive speech, $t(286) = -3.156$, $p = .002$, yes/no comprehension, $t(286) = -3.663$, $p < .001$, auditory word recognition, $t(286) = -3.104$, $p = .002$, and sequential commands, $t(286) = -3.104$, $p = .002$. Men exhibited lower scores than women on all subtests noted above.

Results of the MANOVA of WAB-R AQ and WAB-R subtest scores, controlling for baseline differences in SLP treatment received, indicated statistically significant gender differences. For WAB-R AQ ($F(1, 231) = 9.87$, $p = .002$) and WAB-R subtest scores: information content, $F(1, 231) = 9.69$, $p = .002$, fluency, $F(1, 231) = 8.66$, $p = .004$, repetition, $F(1, 231) = 7.50$, $p = .007$, sentence completion, $F(1, 231) = 6.33$, $p = .013$, responsive speech, $F(1, 231) = 7.50$, $p = .007$, yes/no comprehension, $F(1, 231) = 10.46$, $p = .001$, auditory word recognition, $F(1, 231) = 7.23$, $p = .008$, sequential commands, $F(1, 231) = 6.78$, $p = .01$, except object naming, $F(1, 231) = 2.62$, $p = .107$, word fluency, $F(1, 231) = .94$, $p = .332$, women performed better than men. The estimated marginal means and 95% confidence intervals are reported in table 3.

Discussion

The purpose of this study was to examine the gender differences in post-stroke aphasia outcomes (type of aphasia

Table 1. Total sample demographic characteristics, aphasia type and severity by gender

	Total ($N = 294$)	Men ($N = 172$)	Women ($N = 122$)	*p*-value
Age (years) (mean (SD))	61.9 (12.5)	62.8 (11.5)	60.7 (13.8)	.142
Education (years) (mean (SD))	15.4 (2.8)	15.6 (2.9)	15.2 (2.7)	.133
Handedness (%)				
Right	90.0	90.0	90.4	.750
Left	6.0	6.9	4.8	
Ambidextrous/unknown	4.0	3.1	4.8	
Aphasia type (%)				.057
Anomic	33.3	33.7	32.8	
Broca's	24.3	27.4	19.2	
Wernicke's	8.0	9.1	6.4	
Global	1.3	2.3	0.0	
Conduction	17.7	16.6	19.2	
Transcortical motor	3.3	2.9	4.0	
Transcortical sensory	0.7	0.0	1.6	
Unknown	1.7	1.7	1.6	
No aphasia	9.9	5.8	15.6	
Aphasia duration (years) (mean (SD))	5.2 (4.7)	5.4 (5.0)	4.8 (4.2)	.216
Years of SLP treatment (mean (SD))	3.2 (3.7)	3.7 (4.1)	2.6 (3.1)	.027

Note: SLP, speech and language therapy.

and level of impairment). In gender comparisons of data obtained from the AphasiaBank, we found group differences in the types of aphasia with more men classified as having Broca's and Wernicke's aphasia than women. These differences, however, did not reach statistical significance. The findings do agree with reports from Hier *et al.* (1994), where Broca's aphasia was mostly observed in men. It is also notable that although Yao *et al.* (2015) did not report gender differences in aphasia type, Broca's aphasia was the most common type of aphasia in both men and women. The novel findings of this study were related to levels of impairment. Men exhibited lower WAB-R scores than women indicating greater levels of impairment than women. These results are consistent with the previous reports of gender differences in aphasia impairment with greater impairment in men than in women (Basso *et al.* 1982, Chen and Li 2009, Yao *et al.* 2015). This study also went one step further by examining the specific subtest scores that contribute to the AQ. Women performed better than men on individual WAB-R subtests except for object naming and word fluency. These findings suggest group differences were found across a broad range of language skills critical to effective communication.

Imaging data were not available for all participants; therefore, we were unable to examine the impact of stroke site and size of lesion. However, there is some evidence that offers insights into these group differences. Some suggest these findings can be attributed to gender differences in cerebral hemisphere structure and their impact on behaviour after stroke (Zhang and Wang 2004). Consequently, men may be predisposed to more severe aphasia disorders due to greater unilateral hemisphere involvement for language processing (Kansaku *et al.* 2000, Bitan *et al.* 2010). Along the same line, studies of laterality suggest that women may exhibit greater bilateral language representation resulting in women performing better on the language tasks as compared with men (Bitan *et al.* 2010). It is also possible that bilateral language representation may serve as a buffer for aphasia severity after stroke. If in fact, greater bilateral lateralization may limit the impact of stroke of key language zones that are primarily limited to the left hemisphere. For example, Forkel *et al.* (2014) found that both the right and left hemispheres are critical in language recovery. Similarly, study by Qiu *et al.* (2017) suggests that the right inferior frontal gyrus is critical to aphasia recovery particularly in the subacute stage to increasing other brain areas critical to language performance. This emerging evidence suggests sex differences resulting in greater bilateral involvement during language tasks may be related to better aphasia outcomes which is traditionally related to the left hemisphere. Others suggest gender differences in language

Table 2. Univariate comparisons of WAB-R Aphasia Quotient (AQ) and WAB-R AQ subtest scores by gender

	Total	Men	Women	*p*-value
WAB-R AQ (mean (SD))	70.8 (19.9)	67.4 (21.3)	75.6 (16.6)	<.001
Aphasia severity (%)				.001
Severe aphasia (0–31.2)	4.8	8.1	0.0	
Moderate aphasia (31.3–62.5)	26.5	27.3	25.4	
Mild aphasia (62.6–93.7)	58.8	58.7	59.0	
No aphasia (93.8–100)	9.9	5.8	15.6	
Spontaneous speech (mean (SD))				
Information content	7.7 (2.3)	7.3 (2.5	8.2 (1.8)	<.001
Fluency	6.3 (2.5)	5.9 (2.6)	6.8 (2.3)	.002
Repetition (mean (SD))	65.3 (26.9)	61.28 (28.7)	70.8 (23.3)	<.001
Naming (mean (SD))				
Object naming	44.4 (16.8)	43.0 (17.8)	46.4 (15.2)	.082
Word fluency	7.9 (5.2)	7.6 (5.3)	8.3 (5.0)	.289
Sentence completion	8.0 (2.7)	7.6 (2.9)	8.6 (2.3)	.002
Responsive speech	7.8 (3.1)	7.3 (3.4)	8.5 (2.5)	.002
Comprehension (mean (SD))				
Yes/no	55.7 (5.3)	54.7 (5.9)	57.0 (4.0)	<.001
Auditory word recognition	53.4 (9.5)	52.0 (10.3)	55.4 (7.8)	.002
Sequential commands	53.8 (22.6)	50.2 (23.1)	58.6 (21.0)	.002

Table 3. Estimated marginal means of multivariate comparisons of WAB-R AQ and subtest scores by gender

	Mean (95% confidence interval)		
	Men	Women	*p*-value
WAB-R AQ	66.8 (63.4–70.2)	75.1 (71.2–79.0)	.002
WAB-R info content	7.3 (6.9–7.7)	8.2 (7.8–8.6)	.002
WAB-R fluency	5.7 (5.3–6.2)	6.7 (6.2–7.2)	.004
WAB-R repetition	61.4 (56.9–65.9)	70.9 (65.8–76.1)	.007
WAB-R object naming	42.2 (39.3–45.1)	45.9 (42.5–49.2)	.107
WAB-R word fluency	7.4 (6.5–8.2)	8.0 (7.0–9.0)	.332
WAB-R sentence completion	7.5 (7.1–8.0)	8.4 (7.9–9.0)	.013
WAB-R responsive speech	7.2 (6.7–7.8)	8.4 (7.8–9.0)	.007
WAB-R yes/no	54.5 (53.6–55.3)	56.7 (55.7–57.8)	.001
WAB-R auditory word recognition	51.7 (50.1–53.3)	55.1 (53.2–56.9)	.008
WAB-R sequential commands	49.6 (45.7–53.4)	57.4 (52.9–61.8)	.010

Note: Model controlled for years of SLP treatment.

specific cortical differences may not exist (Wallentin 2009, 2018). A review of the literature by Wallentin (2009) found that studies of regional grey matter is similar between men and women in cortical areas critical to language. In summary, the literature related to this issue is unclear and requires further study. More importantly, the lack of clarity on this issue suggests multiple factors may contribute to differences in aphasia profiles among men and women.

Interestingly, the findings of worse outcomes among men do not agree with previous reports of women being a greater risk for stroke and having a greater likelihood of experiencing worse stroke outcomes than men (Gall *et al.* 2018, Tomita *et al.* 2015). Women have a higher risk than men to develop one or a combination of the three major stroke-related risk factors; hypertension, atrial fibrillation and possible diabetes that worsen stroke outcomes (Roquer *et al.* 2003). How risk of comorbid stroke-related conditions contributes to the underlying mechanisms that cause stroke and aphasia outcomes is less clear. There is also evidence that women are less likely to receive evidenced-based care known to improve stroke outcomes. For example, women are less likely to receive cerebrovascular reperfusion therapies (tPA, intra-arterial therapy, angioplasty, stent or carotid endarterectomy) and cardiac reperfusion therapies after stroke (Eriksson *et al.* 2009, Towfighi *et al.* 2013). Roquer *et al.* (2003) also found that lesions causing aphasia in men were more posteriorly located whereas the lesions were located more anteriorly in women. Despite these differences in therapeutic care critical to stroke outcomes and potentially aphasia outcomes, in this study women ultimately exhibited better post-stroke aphasia outcomes.

Limitations

Although the findings reported here are informative, this study has several limitations that should be carefully considered.

First, the sample of individuals with aphasia available in AphasiaBank have high levels of education which may not be representative of typical patients with aphasia. However, it is important to note that relationship between education and aphasia outcomes is not entirely clear because evidence suggests quality of education is a stronger predictor of years of education (Manly *et al.* 2002). Similarly, education is a weak predictor of aphasia outcomes (Plowman *et al.* 2012).

Second, the data reported here are retrospective and derived for multiple research studies all with different goals and objectives.

Third, gender differences existed in the number of individuals with no aphasia. More women presented with 'no aphasia' condition based on the WAB-R AQ > 93.8. This was given full consideration and a second analysis excluding those individuals with no aphasia was completed and the removal of those individuals did not change the results.

Fourth, the data included in AphasiaBank were not originally designed for the comparisons completed in this study.

Fifth, the individuals included in the AphasiaBank database are in the chronic phase or recovery. Consequently, the results reported here likely are not representative of individuals in the acute phase of recovery.

Sixth, specific lesion location data is inconsistent in the AphasiaBank thereby limiting a clear comparison of that data for definitive conclusions.

Seventh, the number of years of therapy differed between the two groups based on self-report. It is unclear how and why these differences existed and how such differences impacted the observed outcomes.

Last, because the data were derived from the AphasiaBank, they are data derived from individuals who decided to participate in aphasia research. Thus, the data may not be representative of the general aphasia population but more reflective of individuals with aphasia who agree to participate in research. Despite these comparisons, the findings reported here offer critical information regarding gender differences in aphasia outcomes.

Conclusions

The current study provides evidence suggesting that there are gender differences in aphasia impairment with men exhibiting greater deficits. However, more information is required regarding vascular regions likely to cause aphasia and how these regions differ amongst men and women.

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References

Appelros, P., Stegmayr, B. and Terent, A., 2009, Sex differences in stroke epidemiology: A systematic review. *Stroke*, **40**, 1082–1090.

Basso, A., Capitani, D. and Morachini, S, 1982, Sex differences in recovery from aphasia. *Cortex*, **18**, 469–475.

Benjamin, E., Virani, S., Callaway, C., Chamberlain, A., Chang, A., Cheng, S., Chiuve, S., Cushman, M., Delling, F., Deo, R., de Ferranti, S., Ferguson, J., Fornage, M., Gillespie, C., Isasi, C., Jiménez, M., Jordan, L., Judd, S., Lackland, D., Lichtman, J., Lisabeth, L., Liu, S., Longenecker, C., Lutsey, P., Mackey, J., Matchar, D., Matsushita, K., Mussolino, M., Nasir, K., O'Flaherty, M., Palaniappan, L., Pandey, A., Pandey, D., Reeves, M., Ritchey, M., Rodriguez, C., Roth, G., Rosamond, W., Sampson, U., Satou, G., Shah, S., Spartano, N., Tirschwell, D., Tsao, C., Voeks, J., Willey, J., Wilkins, J., Wu, J., Alger, H., Wong, S. and Muntner, P., 2018, Heart disease and stroke statistics—2018 update: a report from the American Heart Association. *Circulation*, **137**(**12**), e67–e492.

Bitan, T., Lifshitz, A., Breznitz, Z. and Booth, J., 2010, Bidirectional connectivity between hemispheres occurs at multiple levels in language processing but depends on sex. *Journal of Neuroscience*, **30**(**35**), 11576–11585.

Chen, Y. and Li, Y., 2009, The effect of gender on the post-stroke aphasia. *Journal of Shanghai Jiaotong University (Medical Science)*, **29**(**8**), 978–981.

Clements, A., Rimrodt, S., Abel, J., Blankner, J., Mostofsky, S., Pekar, J., Denckla, M. and Cutting, L., 2006, Sex differences in cerebral laterality of language and visuospatial processing. *Brain and Language*, **98**(**2**), 150–158.

Code, C. and Rowley, D., 1987, Age and aphasia type: the interaction of sex, time since onset and handedness. *Aphasiology*, **1**, 339–345.

Dickey, L., Kagan, A., Lindsay, M., Fang, J., Rowland, A. and Black, S., 2010, Incidence and profile of inpatient stroke induced aphasia in Ontario, Canada. *Archives of Physical Medicine and Rehabilitation*, **91**(**2**), 196–202.

Ellis, C., Hardy, R., Lindrooth, R. and Peach, R., 2017, Rate of aphasia among stroke patients discharged from hospitals in the United States. *Aphasiology*, **32**(**9**), 1075–1086.

Engelter, S. T., Gostynski, M., Papa, S., Frei, M., Born, C., Ajdacic-Gross, V., Gutzwiller, F., and Lyrer, P. A., 2006, Epidemiology of aphasia attributable to first ischemic stroke: incidence, severity, fluency, etiology, and thrombolysis. *Stroke*, **37**(**6**), 1379–1384.

ERIKSSON, M., GLADER, E., NORRVING, B., TERÉNT, A. and STEGMAYR, B., 2009, Sex differences in stroke care and outcome in the Swedish National Quality Register for Stroke Care. *Stroke*, **40**(**3**), 909–914.

FORBES, M., FROMM, D. and MACWHINNEY, B., 2012, AphasiaBank: a resource for clinicians. *Seminars in Speech and Language*, **33**(**3**), 217–222.

FORKEL, S., THIEBAUT DE SCHOTTEN, M., DELL'ACQUA, F., KALRA, L., MURPHY, D., WILLIAMS, S. and CATANI, M., 2014, Anatomical predictors of aphasia recovery: a tractography study of bilateral perisylvian language networks. *Brain*, **137**(**7**), 2027–2039.

FROMM, D., FORBES, M., HOLLAND, A., DALTON, S., RICHARDSON, J. and MACWHINNEY, B., 2017, Discourse characteristics in aphasia beyond the Western Aphasia Battery cutoff. *American Journal of Speech–Language Pathology*, **26**(**3**), 762–768.

GALL, S., PHAN, H., MADSEN, T., REEVES, M., RIST, P., JIMENEZ, M., LICHTMAN, J., DONG, L. and LISABETH, L., 2018, Focused update of sex differences in patient reported outcome measures after stroke. *Stroke*, **49**(**3**), 531–535.

HIER, D., YOON, W., MOHR, J., PRICE, T. and WOLF, P., 1994, Gender and aphasia in the stroke data bank. *Brain and Language*, **47**(**1**), 155–167.

HOLLAND, A., FORBES, M., MACWHINNEY, B., FROMM, D. and WRIGHT, H., 2009, *AphasiaBank: Preliminary Lexical, Morphosyntactic, and Error Analyses*. Paper presented at Clinical Aphasiology Conference. Keystone, CO. [online] Available: http://aphasiology.pitt.edu/1997/

KANSAKU, K., YAMAURA, A. and KITAZAWA, S., 2000, Sex differences in lateralization revealed in the posterior language areas. *Cerebral Cortex*, **10**(**9**), 866–872.

KERTESZ, A., 2007, *Western Aphasia Battery—Revised*. New York, NY: Grune & Stratton.

KLEINDORFER, D., KHOURY, J., MOOMAW, C., ALWELL, K., WOO, D., FLAHERTY, M., KHATRI, P., ADEOYE, O., FERIOLI, S., BRODERICK, J. and KISSELA, B., 2010, Stroke incidence is decreasing in whites but not in blacks. *Stroke*, **41**(**7**), 1326–1331.

MANLY, J. J., JACOBS, D. M., TOURADJI, P., SMALL, S. A. and STERN, Y., 2002, Reading level attenuates differences in neuropsychological test performance between blacks and white elders. *Journal of the International Neuropsychological Society*, **8**, 341–348.

PEDERSEN, P., VINTER, K. and OLSEN, T., 2003, Aphasia after stroke: type, severity and prognosis. *Cerebrovascular Diseases*, **17**(**1**), 35–43.

PLOWMAN, E., HENTZ, B. and ELLIS, C., 2012, Post-stroke aphasia prognosis: A review of patient-related and stroke-related factors. *Journal of Evaluation in Clinical Practice*, **18**(**3**), 689–694.

QIU, W., LI, K., WU, H., YANG, Q., KANG, Z., CHEN, Z., QIU, G., XIE, C., WAN, G. and CHEN, S., 2017, Evidence of cortical reorganization of language networks after stroke with subacute Broca's aphasia: a blood oxygenation level dependent-functional magnetic resonance imaging study. *Neural Regeneration Research*, **12**(**1**), 109–117.

ROQUER, J., CAMPELLO, A. and GOMIS, M., 2003, Sex differences in first-ever acute stroke. *Stroke*, **34**(**7**), 1581–1585.

ROYAL REHAB-REHABILITATION AND DISABILITY NETWORK, 2016, *Speaking Aphasian* (available at: http://www.royalrehab.com.au/wp-content/uploads/2016/07/Speaking-Aphasian.pdf).

SARNO, M. T., BUONAGURO, A. and LEVITA, E., 1985, Gender and recovery from aphasia after stroke. *Journal of Nervous and Mental Disease*, **173**(**10**), 605–609.

SCARPA, M., COLOMBO, A., SORGATO, P. and DE RENZI, E., 1987, The incidence of aphasia and global aphasia in left brain-damaged patients. *Cortex*, **23**, 331–336.

SCHECTER, I., SHEJTER, J., ABARBANEL, M., KOREN, R., MENDELSON, L., RING, H. and BECKER, E., 1985, Sex and aphasic syndromes. *Scandinavian Journal of Rehabilitation Medicine*, **Suppl. 12**, 64–67.

STROKE ASSOCIATION, 2018, *Aphasia Awareness* (available at: https://www.stroke.org.uk/what-is-aphasia/aphasia-awareness).

TATE, J. and BUSHNELL, C., 2011, Pregnancy and stroke risk in women. *Women's Health (London)*, **7**, 363–374.

TOMITA, H., HAGII, J., METOKI, N., SAITO, S., SHIROTO, H., HITOMI, H., KAMADA, T., SEINO, S., TAKAHASHI, K., BABA, Y., SASAKI, S., UCHIZAWA, T., IWATA, M., MATSUMOTO, S., SHOJI, Y., TANNO, T., OSANAI, T., YASUJIMA, M., and OKUMURA, K., 2015, Impact of sex difference on severity and functional outcome in patients with cardioembolic stroke. *Journal of Stroke and Cerebrovascular Diseases*, **24**(**11**), 2613–2618.

TOWFIGHI, A., MARKOVIC, D. and OVBIAGELE, B., 2013, Sex differences in revascularization interventions after acute ischemic stroke. *Journal of Stroke and Cerebrovascular Diseases*, **22**(**8**), e347–e353.

VLADUTIU, C., MEYER, M., MALEK, A., STUEBE, A., MOSHER, A., AGGARWAL, S., KLEINDORFER, D. and HOWARD, V., 2017, Racial differences in the association between parity and incident stroke: results from the reasons for geographic and racial differences in stroke study. *Journal of Stroke and Cerebrovascular Diseases*, **26**(**4**), 749–755.

WALLENTIN, M., 2009, Putative sex differences in verbal abilities and language cortex: A critical review. *Brain and Language*, **108**, 175–183.

WALLENTIN, M., 2018, Sex differences in post-stroke aphasia rates are caused by age. A meta-analysis and database query. *PLoS ONE*, **13**(**12**), e0209571. https://doi.org/10.1371/journal.pone.0209571

YAO, J., HAN, Z., SONG, Y., LI, L., ZHOU, Y., CHEN, W., DENG, Y., WANG, Y. and ZHANG, Y., 2015, Relationship of post-stroke aphasic types with sex, age and stroke types. *World Journal of Neuroscience*, **5**(**1**), 34–39.

ZHANG, Y. and WANG, Y., 2004, Relevant factors about the types of aphasia. *Chinese Journal of Rehabilitation Theory and Practice*, **10**, 241–242.