Sex, Hand Preference and Brain Asymmetry

Christiana M. Leonard[1], Stephen Towler[1], Suzanne Welcome[2] & Christine Chiarello[2]

University of Florida, Gainesville[1] & University of California, Riverside[2]

Introduction

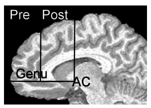
It is frequently claimed that women and left handers have a more bilateral organization for language and reduced brain asymmetry compared to men. Experimental support for these claims has been mixed (Paus et al 1996; Yucel et al 2001; Huster et al (2007). Positive findings are less often seen in large scale studies (Watkins et al 2001; Good et al 2001).

The current study, part of the Biological Substrates for Language Project, affords the opportunity to explore this issue in another large-scale. For the current study, medial frontal and perisylvian structures were measured in 100 men and 100 women whose behavioral asymmetry had been assessed with the split visual field procedure investigation (Chiarello et al (2009). Hand preference was measured with a 5 activity scale (Bryden 1982) . Using the procedure of Christman et al (2007), individuals were classified as consistent handers if they performed all five activities with the same hand. All others (n = 97) were classified as mixed handers. Five of the consistent handers wrote with their left hand, 23 of the mixed handers wrote with their left hand.

A previous study on this sample (Welcome et al 2009) found a significant interaction between consistency of hand preference and sex in the relation between brain structure and behavioral asymmetry. Mixed handed women showed a positive relation between the area of the corpus callosum and visual field asymmetry while consistent handed men showed a negative relationship.

In the present study we used discriminant analysis to compare the ability of brain measures to successfully classify hemispheres as left or right. We asked whether the sensitivity of these measures differed as a function of sex and hand preference.

Method



PARTICIPANTS:

- 100 male, 100 female native English speakers
- 18-34 years of age

GENERAL PROCEDURES:

- Volumetric MRI scans (1.2 mm thick sagittal images) on 1.5 GE Scanner
- Brain tissue extracted, reoriented, and segmented into isometric voxels with FSL software http://www.fmrib.ox.ac.uk/
- Surface and volume measurements made with scripts written in PVWave http://www.vni.com/ (Leonard et al 2008).
- Analyses were conducted with PC-SAS (SAS Institute, Cary NC).

BRAIN MEASURES ENTERED INTO INTIAL DISCRIMINANT ANALYSIS:

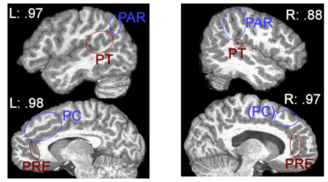
- Total hemispheric gray and white matter volume
- Volumes of pre and post genual cingulate and paracingulate grey matter. Compartments were defined by vertical planes anterior to the genu of the corpus callosum and vertical and horizontal planes through the anterior commissure (AC).
- Average length, planum temporale (PT), planum parietale (PAR) & Heschl's gyrus (HG). PT and PAR were measured on all images that were located between 68 and 81% of the distance to the lateral surface. HG was measured on images that were located between 50 and 68% of this distance.

Results

DISCRIMINANT ANALYSIS IN FULL SAMPLE

Results of discriminant analysis using nine brain measures to classify hemispheres as left or right. Five measures contributed significantly to successful classification ($p < .0001$). 78% of the left hemispheres and 76% of the right hemispheres were successfully classified.

Entire sample of 200 F(9,390) = 22.11, p < .0001			
Brain measure	R^2	F	P <
Planum temporale	.17	81.36	.0001
Heschl's gyrus	.14	64.44	.0001
Planum paraietale	.12	52.15	.0001
Postgenual paracingulate	.06	25.98	.0001
Pregenual cingulate	.05	20.27	.0001
Pregenual paracingulate	.011	4.32	.05
White matter (hemisphere)	.005	1.82	.18
Postgenual cingulate	.001	.32	.57
Grey matter (hemisphere)	.001	.24	.62



Examples of hemispheres with high posterior probabilities of correct classification.

The five measures that contributed significant variance to classification in the full sample are listed below.

PAR: Posterior ascending ramus (parietal planum)
- Left: Relatively short
- Right: Relatively long

PC: Postgenual paracingulate cortex
- Left: Prominent
- Right: Absent (indicated by parentheses)

PRE: Pregenual cingulate cortex
- Left: Thin
- Right: Thick

PT: Planum temporale
- Left: Relatively long
- Right: Relatively short

Heschl's gyrus (measured more medially)
- Left: Relatively large
- Right: Relatively small

EFFECT OF SEX AND HAND PREFERENCE CONSISTENCY

Results of discriminant analysis using five brain measures to classify hemispheres as left or right. All four analyses were significant ($p < 0001$). In mixed handed women, the group that theory would predict to be least lateralized, all five measures discriminated between the hemispheres. By contrast, in men, neither medial frontal measure (paracingulate and cingulate cortex) was sensitive to hemisphere.

Brain measure		R^2 (Bold = $p < .01$)			
Sex		Women		Men	
Hand preference		Consistent	Mixed	Consistent	Mixed
n		59	41	44	56
Planum temporale		**.18**	**.30**	**.21**	**.09**
Planum parietale		**.14**	**.11**	**.08**	**.13**
Heschl's gyrus		**.10**	**.17**	**.17**	**.14**
Postgenual paracingulate		**.14**	**.13**	.01	.05
Pregenual cingulate		.02	**.19**	.03	.04
% hemispheres classified correctly	L	**80**	**83**	**75**	**70**
	R	**73**	**83**	**82**	**71**

Discussion

Women and individuals with mixed hand preference did not exhibit evidence for weak hemisphere lateralization. In fact, women with mixed hand preference were the only group in which both medial frontal measures contributed significantly to successful hemisphere classification. Surprisingly, and in contradiction of a substantial literature, the paracingulate cortex did not show evidence of asymmetry in men. Removing left handers from the analysis did not change the results.

The forces that govern the development of these robust and easily visible cortical asymmetries are not understood. It appears that easily measured dimensions such as sex and handedness (or even extreme behavioral pathology such as schizophrenia (Leonard et al 2008)) cannot explain the diversity of cortical organization found in large samples. Small sample studies that produce associations that appear to support theoretical preconceptions (e.g., weaker female lateralization) are rarely replicated in large sample studies. A multivariate approach, in which the effects of multiple cortical regions are assessed, may yield greater insight into individual differences than continuing to focus on dimensions in isolation or comparisons between behaviorally defined groups.

References

Bryden MP (1982) Laterality: Functional asymmetry in the normal brain. New York Academic Press.
Chiarello C, Welcome SE, Halderman LK, Towler S, Julagay J, Otto R, Leonard CM (2009) Neuropsychology 23: 210-222.
Christman SD, Jasper JD, Sontam V, Cooil B (2007) Brain Cogn 63: 51-58.
Good CD, Johnsrude I, Ashburner J, Henson RN, Friston KJ, Frackowiak RS (2001) Neuroimage 14: 685-700.
Leonard CM, Kuldau JM, Maron L, Ricciuti N, Mahoney B, Bengtson M, DeBose C (2008) Neuropsychology 22: 147-158.
Leonard CM, Towler S, Welcome S, Halderman LK, Otto R, Eckert MA, Chiarello C (2008) Cereb Cortex 18: 2920-2931.
Watkins KE, Paus T, Lerch JP, Zijdenbos A, Collins DL, Neelin P, Taylor J, Worsley KJ, Evans AC (2001) Cereb Cortex 11: 868-877.
Welcome SE, Chiarello C, Towler S, Halderman LK, Julagay J, Otto R, Leonard CM (2009) Neuropsychologia (in review).

ACKNOWLEDGMENTS

This research was supported by NIDCD grant 5R01DC6957. Great thanks are due to Matthew Manry, Natalie Anne Hammond, Caroline Anderson, Dawn Joseph, Michelle Long, Gabrielle Messmer, Stephanie Demian and Kaitlyn Schmutz.