Between-group racial differences in the relation of brain function to intelligence

V. J. Schmithorst[1], and S. K. Holland[1]
[1]Radiology, Children's Hospital Medical Center, Cincinnati, OH, United States

Introduction

Despite continuing debate in recent years over the etiology of between-group racial differences in intelligence [1] there is no published data examining racial differences in the neurobiological correlates of intelligence. We performed a retrospective analysis of fMRI data obtained as part of a study of normal language development in children ages 5-18 to examine the question of whether there is an interaction of brain activation, IQ, and race. This cross-sectional study was conducted between the years 2000 and 2005 in a group of more than 300 typically developing children.

Materials and Methods

Details of the paradigms and study population have been published elsewhere [2] and are summarized here.

fMRI: MRI scanning was performed on a Bruker 3T system using gradient EPI: TR/TE = 3000/38 ms, FOV = 25.6 X 25.6 cm, BW = 125 kHz, matrix = 64 X 64, slice thickness = 4 mm with 25 slices acquired in order to cover the whole brain. Four fMRI tasks were performed as part of the cross-sectional study: Syntactic prosody: Children hear a target sentence, and then several sentences low-pass filtered so that only the prosody (inflection) is audible. They respond via button press when the low-pass filtered sentence matches the target sentence. Silent Verb Generation: Children hear nouns (e.g. "ball") and silently generate verbs which would correspond (e.g. "throw", "kick"). Word-Picture matching: Children see two pictures (line-drawings) on a video monitor and simultaneously hear the object of the one of the pictures spoken. They respond via button press to the picture which matches the spoken word. Narrative Comprehension: Children listen to 30-second short stories spoken by an adult female speaker.

Subjects: For each task, the children who self-identified, or whose parents identified them as, African-American were matched to a group of Caucasian children according to sex, age, Wechsler Full-Scale IQ, and socio-economic status (SES). There were at least 20 African-American children and 20 Caucasian children for each task; age range = 5 – 18 years, IQ range = 75 – 119.

Data Analysis: fMRI data was processed using routines written in IDL (ITT Visual Informations System Inc., Boulder, CO). A cost function was used to classify and discard frames with excessive motion, with a threshold based on analysis from the entire cross-sectional dataset (Altaye et al., manuscript in preparation). Activation maps (T-scores) were computed for each subject, for each task, using the General Linear Model (using only the retained frames). A one-sample T-test was then used to find regions of significant activation or de-activation. A second level analysis was performed, using only the regions that were significant in the previous analysis. The variable of interest was race-X-IQ interaction. Covariates included: sex, age, race, IQ, SES, and the square root of the number of retained frames for each subject. For word-picture matching and syntactic prosody, in-scanner task performance was also included as a covariate.

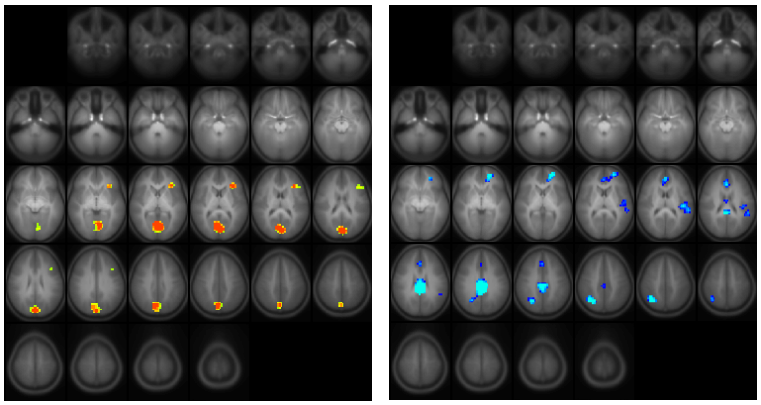

Figure 1. Regions of activation with significant race-X-IQ interactions (cold colors, Caucasian > African-American; hot colors, African-American > Caucasian) on functional activation for the tasks of : word-picture matching (left); narrative comprehension (right). All regions significant with $p < 0.05$ (FWE corrected). Images in radiologic orientation.

Results and Discussion

There was no significant difference in age, IQ, SES, or task performance for word-picture matching or syntactic prosody. For two of the tasks (verb generation and syntactic prosody) we found no regions with significant race-X-IQ interactions. Regions activated during the task: significant race-X-IQ interactions were found for the word-picture matching task (Figure 1, left), in the left inferior frontal gyrus and for the narrative comprehension task (Figure 1, right), in the left superior temporal gyrus. Regions de-activated during the task: significant race-X-IQ interactions were found for the word-picture matching task (Figure 1, left) in the cuneus/precuneus; for the narrative comprehension task (Figure 1, right) in the medial/left inferior frontal gyrus, in the posterior cingulate, and in the right inferior parietal lobule.

These results provide preliminary support of the hypothesis of between-group differences in the relationship between brain activation and intelligence in African-American and Caucasian children. These interactions were found in narrowly circumscribed regions and only in two out of the four fMRI language tasks examined. Thus, our results suggest such differences are subtle and not widespread. Findings suggest that the relation between executive function and intelligence may differ between the groups: a) decreasing de-activation with intelligence in regions in the "default-mode" network (medial frontal and posterior cingulate) during the narrative processing task in Caucasians but not in African-Americans; and b) decreasing activation with intelligence of the dorsal left IFG, associated with selection from competing alternatives [3], for Caucasians but not African-Americans during the word-picture matching task. Other differences may indicate subtly different relationships between intelligence and language lateralization and sensory processing. We have previously found evidence of such differences between Caucasians and Chinese-Americans [4]. Further research should investigate different races beyond African-American and Caucasian, functional and effective connectivity, and relations between brain structure and intelligence (e.g. using diffusion or volumetric techniques).

These results are not evidence for or against a hereditarian or environmental explanation of between-group differences in intelligence. The brain matures greatly between birth and age 5, the youngest age at which participants can tolerate an MRI scanning session without sedation. Differences at age 5 could therefore be due to genetics, or due to different environmental factors, or a combination of both. Moreover, differences in brain function-intelligence relationships are not the same as differences in intelligence itself, and the cohorts included in this study were matched for IQ.

Conclusion

Preliminary fMRI evidence is shown supporting subtle differences in brain activation – intelligence relationships as a function of race. This suggests that sufficiently powered prospective neuroimaging studies could reveal additional findings of relevance to language processing in racial groups during development.

References

[1] JP Rushton and AR Jensen. Psychology, Public Policy, and Law, 11, 235-294, 2005. [2] SK Holland et al. Int J Audiol, 46, 533-51, 2007. [3] VJ Schmithorst et al. Hum Brain Mapp, 28, 1060-74, 2007. [4] A Rajagopal, et al. Soc. for Pediatric Radiology, 52st Meeting, Carlsbad, CA, 2009.