A 'Simple' Re-Executable Publication: IQ in Typically Developing Children

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Introduction:

The relationship between IQ and brain structural volume in typically developing brain is a known confound in virtually all structural neuroimaging studies. A better understanding of this effect is important for ongoing studies. We selected three publications related to IQ and structural volumes in typically developing children from the literature and attempt to prospectively replicate the main observations in current publicly available data in a re-executable and extensible fashion.

(1) **Pietschnig et al.** *"Our results showed significant positive associations of brain volume and IQ (r = .24, R2 = .06) that generalize over age (children vs. adults), IQ domain (full-scale, performance, and verbal IQ), and sex."*

(2) **MacDonald PA, et al.** *"Correlations between the WASI-IQ and the left striatum, composed of the caudate nucleus and putamen, were significant. When these data were analyzed separately for male and female children, positive correlations were significant for the left striatum in male children only."*

(3) **Ganjavi H, et al.** *"After correcting for total brain volume and age, a significant negative correlation was found between total CC midsagittal area and IQ (r=−0.147; p=0.040). Post hoc analyses revealed a significant negative correlation in children (age less than 12) (r=−0.279; p=0.004) but not in adolescents (age≥12) (r=−0.005; p=0.962). Partitioning the subjects by gender revealed a negative correlation in males (r=−0.231; p=0.034) but not in females (r=0.083; p=0.389)."*

These main observations can be turned into new hypotheses (pre-registered at OSF: https://osf.io/yuv52) for replication:

Hypotheses:

PIET-1: Total Brain Volume will positively correlate with IQ (in both sexes across the complete age range).

MAC-1: Left striatum volume (caudate + putamen) will positively correlate with IQ in the total (male + female) child (age < 20) group.

MAC-2: Left striatum volume (caudate + putamen) will positively correlate with IQ in the male children group.

MAC-3: Left striatum volume (caudate + putamen) will not correlate with IQ in the female children group.

MAC-3: Left striatum volume (caudate + putamen) will not correlate with IQ in the female children group.

GANJ-1: Total Corpus Callosum midsagittal area, after correcting for total brain volume, will negatively correlate with IQ.

GANJ-2: Total Corpus Callosum midsagittal area, after correcting for total brain volume, will negatively correlate with IQ in the young (age < 12) group.

GANJ-3: Total Corpus Callosum midsagittal area, after correcting for total brain volume, will not significantly correlate with IQ in the adolescent (age > 12) group.

GANJ-4: Total Corpus Callosum midsagittal area, after correcting for total brain volume, will negatively correlate with IQ in the male (age < 12) group.

GANJ-5: Total Corpus Callosum midsagittal area, after correcting for total brain volume, will not significantly correlate with IQ in the female (age < 12) group.

Methods:

A re-executable publication (aka "ReproPub") requires specification of 5 key elements: 1) the source data, 2) the processing workflow, 3) the computational environment, 4) the complete derived results, and 5) the complete statistical results (4).

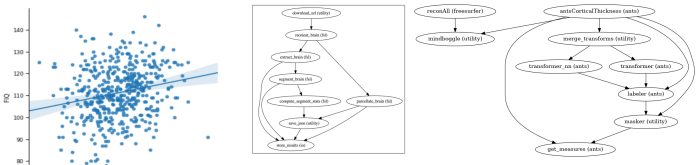
Data: The source data for this analysis comes from the typical subjects included in the ABIDE (5) dataset.

Processing: The analysis was run using a custom Docker container [https://hub.docker.com/r/mgxd/mindboggle/tags (1.4.0-aws)] containing FSL and Mindboggle on AWS Batch. Each T1 image was processed using this container to generate four sets of outputs. The output of the Simple1 workflow (4) using FSL (6), and the outputs from FreeSurfer (7), ANTs (8), and Mindboggle (9) using the mindboggle123 script (10). The outputs were aggregated and mapped into a common namespace using Interlex and combined with the phenotypic clinical and demographic data. For the analyses in this abstract the FreeSurfer outputs are being used. Linear regression for the given structural volume and full-scale IQ (FIQ) was performed (covarying for total brain volume in GANJ-*).

Results:

Results are shown in the table below.

					Our Result				
	Region	Correlation Direction	Age	Sex	r2	p-value	N	t-value	covariates
PIET-1	Total Brain Volume	+	All	Both	0.245	< 10-4	389	4.9	site
MAC-1	Left striatum volume	+	< 20	Both	0.176	< 10-4	343	3.96	site
MAC-2	Left striatum volume	+	< 20	Male	0.3	< 10-4	290	3.75	site
MAC-3	Left striatum volume	N.S.	< 20	Female	0.313	0.046	71	2.03	site
GANJ-1	Corpus Callosum Area	-	All	Both	0.21	0.034	479	-2.12	site
GANJ-2	Corpus Callosum Area	-	< 12	Both	0.35	0.1	144	-1.65	site, TBV
GANJ-3	Corpus Callosum Area	N.S.	> 12	Both	0.125	0.157	335	-1.42	site, TBV
GANJ-4	Corpus Callosum Area	-	< 12	Male	0.358	0.297	116	-1.05	site, TBV
GANJ-5	Corpus Callosum Area	N.S.	< 12	Female	0.472	0.326	28	-1.01	site, TBV



Conclusions:

Six of the nine *a priori* hypotheses regarding IQ and brain structure volumes in typically developing children selected from the literature were confirmed in the FreeSurfer analysis of the ABIDE dataset. Further analysis is ongoing to see if additional findings from these (and other) publications can also be confirmed. Of particular interest is findings in this literature that were not significant (which may be limited in terms of power) to see if newer, higher powered studies do indeed find a significant relationship.

References:

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10.https://github.com/nipy/mindboggle/blob/master/mindboggle/mindboggle123

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