Parasite prevalence and the worldwide distribution of cognitive ability

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Corey Fincher
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Image courtesy of http://www.aquatreat.co.uk/
Global Intelligence

Worldwide variation in intelligence has been a topic of study for some time.

Previous Studies

Barber (2005)

- Education and employment prospects drive IQ
- Education ($r = .71$)
- Job Complexity ($r = 0.70$)
- Infant Mortality ($r = -0.34$)
Previous Studies

- Templer and Arikawa (2006)
- Climate creates selective pressures favoring high IQ
  - Temperature (r = 0.76)
  - Skin Color (r = -0.92)
Previous Studies

Kanazawa (2008)

- Evolutionarily novel environments create selective pressures for higher IQ
- Linear distance from central Africa
  - (0º N, 0ºW): $r = 0.45$
  - South Africa: $r = 0.53$
  - Ethiopia: $r = 0.22$
Previous Studies

Sadat (2008) and Woodley (2009)

- Inbreeding depression reduces phenotypic quality of the brain.

- Consanguineous marriage
  - Sadat: $r = -0.77$
  - Woodley: $r = -0.62$
Current Study

Does infectious disease play a role in the global diversity of intelligence?
The human brain is extremely metabolically expensive to build and maintain.

<table>
<thead>
<tr>
<th>Age</th>
<th>Resting Metabolic Rate (kcal/day)</th>
<th>Cost of the Brain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newborn</td>
<td>161</td>
<td>87%</td>
</tr>
<tr>
<td>3 months</td>
<td>300</td>
<td>64%</td>
</tr>
<tr>
<td>18 months</td>
<td>590</td>
<td>53%</td>
</tr>
<tr>
<td>5 years</td>
<td>830</td>
<td>44%</td>
</tr>
<tr>
<td>10 years</td>
<td>1160</td>
<td>34%</td>
</tr>
<tr>
<td>Adult male</td>
<td>1800</td>
<td>23% (414kcal)</td>
</tr>
<tr>
<td>Adult female</td>
<td>1480</td>
<td>27% (400kcal)</td>
</tr>
</tbody>
</table>

From Holliday (1987)
Parasites may affect the body energetically in four ways.
(1) Some parasites feed directly off of the body’s tissues. These must be replaced at the energetic cost of the host.
- Includes flukes and other worms, and many kinds of bacteria.
(2) Some organisms cause diarrhea or absorb nutrients directly out of the host’s intestines. These limit the body’s access to its own nutrients.

- Diarrheal diseases are the most common kind of infectious disease in the world, and is the top killer of children under 5 years old (WHO, 2004).

Image courtesy of http://faculty.clintoncc.suny.edu/
(3) Viruses use the cellular machinery and biological macromolecules of their host to reproduce, at the energetic expense of the host.

Image courtesy of http://incontiguousbrick.files.wordpress.com/
(4) All forms of parasitic infection result in activation of the immune system, at energetic expense. 
- Includes the production of white blood cells and antibodies.

Image courtesy of http://www.rickmcginnis.com/
If the brain does not have access to sufficient resources while it is growing, its phenotypic quality will suffer.

This effect should be particularly profound during the ages where the brain is most costly.

This has already been shown to occur with other parts of the body, as developmental instability leads to asymmetry (e.g. Thornhill and Møller, 1997).

Intelligence has also been shown to correlate with body symmetry (e.g. Furlow et al., 1997; Prokosch et al., 2005).
Ecological factors include temperature, monthly temperature range and rainfall.

This distribution is similar for human diseases and non-human diseases.

From Guernier et al., 2004
Intelligence and Helminth Infection

- Negative relationship between intelligence and intestinal helminth infection (reviewed in Watkins and Pollitt, 1997).
- No leading hypothesis.
- Not looked at in the greater context of infectious disease.
Predictions

(1) infectious disease will correlate significantly and negatively with average national IQ, and

(2) this correlation will remain robust when other factors are controlled.
Methods
Variables: Average IQ

  - \( n = 113 \)

  - \( n = 192 \)

- Wicherts et al. (2010) Modification (WEAM):
  - \( n = 192 \)
Variables: Infectious Disease

- Disability adjusted life years (DALY) (WHO, 2004)
- 28 representative infectious diseases including malaria, tetanus, hepatitis, and tuberculosis.
- 1 DALY = one healthy year of life lost per 100,000 people.
- Log-transformed
Variables: Temperature

- From Templer and Arikawa (2006)
- Average winter high temperature
Variables: Novelty

β Kanazawa (2008)

β Linear distance from central Africa (EEA)
β (-5°lat, -25°lon)

β Calculated using Pythagorean theorem

β Log-transformed
Variables: Education

● Literacy
  ● From World Bank (2008)
  ● % of population with basic proficiency

● Enrollment in secondary education
  ● From Barrow and Lee (1991)
  ● % of school-age people enrolled

● Completion of secondary education
  ● From Barrow and Lee (1991)
  ● % of adults who have completed secondary Education

● Average years of education (AVED)
  ● From Barrow and Lee (1991)
  ● Average number of years of education
Variables: Wealth

- Gross domestic product per capita (GDP)
- From CIA world factbook (2007)
- Log-transformed
Did not use

β Skin color
β Inbreeding
Results
Zero-Order Correlations

LVCD: $r = -0.82$, $n = 107$, $p < 0.0001$

LVE: $r = -0.82$, $n = 184$, $p < 0.0001$

WEAM: $r = -0.76$, $n = 184$, $p < 0.0001$
Within Murdock’s (1949) areas

<table>
<thead>
<tr>
<th>Region</th>
<th>$r$</th>
<th>$n$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>-0.80</td>
<td>22</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Eastern Eurasia</td>
<td>-0.70</td>
<td>11</td>
<td>0.016</td>
</tr>
<tr>
<td>Insular Pacific</td>
<td>-0.83</td>
<td>12</td>
<td>0.0009</td>
</tr>
<tr>
<td>North America</td>
<td>-0.76</td>
<td>7</td>
<td>0.049</td>
</tr>
<tr>
<td>South America</td>
<td>0.043</td>
<td>16</td>
<td>0.88</td>
</tr>
<tr>
<td>Western Eurasia</td>
<td>-0.73</td>
<td>39</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
Within Murdock’s (1949) areas

<table>
<thead>
<tr>
<th>Region</th>
<th>r</th>
<th>n</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>-0.80</td>
<td>53</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Eastern Eurasia</td>
<td>-0.62</td>
<td>20</td>
<td>0.0033</td>
</tr>
<tr>
<td>Insular Pacific</td>
<td>-0.85</td>
<td>17</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>North America</td>
<td>-0.65</td>
<td>12</td>
<td>0.022</td>
</tr>
<tr>
<td>South America</td>
<td>0.077</td>
<td>23</td>
<td>0.73</td>
</tr>
<tr>
<td>Western Eurasia</td>
<td>-0.65</td>
<td>59</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Within Murdock’s (1949) areas

**WEAM**

S Africa  
\[ r = -0.49 \quad n = 53 \quad p = 0.0002 \]
Hierarchical Linear Model

\[ R^2 = 0.78 \]
\[ n = 184 \]
\[ p < 0.0001 \]

\[ R^2 = 0.77 \]
\[ n = 184 \]
\[ p < 0.0001 \]
Other correlations with IQ (LVE)

- Average winter high temperature: $r = -0.72$
- Distance from central Africa (EEA): $r = 0.48$
- Literacy: $r = 0.61$
- A VED: $r = 0.74$
- $2^0$ school enrollment: $r = 0.64$
- $2^0$ school completion: $r = 0.36$
- GDP: $r = 0.67$
## Multiple Regression (L VE)

<table>
<thead>
<tr>
<th>Term</th>
<th>Estimate</th>
<th>STD Error</th>
<th>STD Beta</th>
<th>VIF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>98.6</td>
<td>5.98</td>
<td></td>
<td></td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Disease</td>
<td>-8.56</td>
<td>0.983</td>
<td>-0.616</td>
<td>3.5</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Distance from EEA</td>
<td>5.05</td>
<td>1.00</td>
<td>0.232</td>
<td>1.41</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Winter High</td>
<td>-0.253</td>
<td>0.0666</td>
<td>-0.224</td>
<td>2.83</td>
<td>0.0007</td>
</tr>
<tr>
<td>A VED</td>
<td>0.0116</td>
<td>0.294</td>
<td>0.00285</td>
<td>3.62</td>
<td>0.97</td>
</tr>
</tbody>
</table>

**Whole Model:**

\( r^2 = 0.889, \ n = 83, \ p < 0.0001 \)
# Multiple Regression (WEAM)

**Whole Model:**

\[ r^2 = 0.796, \ n = 83, \ p < 0.0001 \]

<table>
<thead>
<tr>
<th>Term</th>
<th>Estimate</th>
<th>STD Error</th>
<th>STD Beta</th>
<th>VIF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>94.2</td>
<td>7.45</td>
<td></td>
<td></td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Disease</td>
<td>-6.39</td>
<td>1.22</td>
<td>-0.50</td>
<td>3.5</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Distance from EEA</td>
<td>3.90</td>
<td>1.22</td>
<td>0.195</td>
<td>1.41</td>
<td>0.0019</td>
</tr>
<tr>
<td>Winter High</td>
<td>-0.219</td>
<td>0.0828</td>
<td>-0.228</td>
<td>2.83</td>
<td>0.0099</td>
</tr>
<tr>
<td>A VED</td>
<td>0.377</td>
<td>0.365</td>
<td>0.10</td>
<td>3.62</td>
<td>0.31</td>
</tr>
</tbody>
</table>
Discussion
Predictions

 Prediction 1: does infectious disease predict worldwide variation in IQ?
   Yes

 Prediction 2: is infectious disease a significant predictor when other factors are controlled?
   Yes
Other factors are involved
Two plausible pathways

(1) During periods of infection, energy is temporarily diverted toward immune function and away from building metabolically costly tissues.

(2) The level of exposure to disease one encounters during development will determine the amount of energy that will permanently be invested in immune function.
Implications: the Flynn Effect

As nations develop:
(1) Education improves
(2) Wealth increases
(3) Increased access to medical technology and infrastructure
Implications: nation building

- Those interested in raising average IQ should focus their efforts on reducing infectious disease.
- These efforts should target in particular the times in development when the brain is most sensitive to disruption: early childhood periods.
- Diarrheal diseases, intestinal parasites and malaria should especially be targeted.
Future Directions

- longitudinal study.
- Do the increases in intelligence associated with the Flynn Effect coincide with increases in public health?
- Which diseases are most costly to the proper development of the brain?
- Which, if either, of the two pathways we propose is true.
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