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It's getting bigger all the time: Estimating the Flynn effect from secular brain mass increases in Britain and Germany

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ABSTRACT

Secular increases in brain mass over nearly a century have been noted for both males and females in the UK and Germany. It has been argued that such trends may be associated with the Flynn effect. The IQ gain predicted on the basis of these trends is 0.19 and 0.08 points per decade for UK, and 0.2 and 0.15 points per decade for German males and females respectively, indicating a small contribution to the Fullscale IQ trends in these countries (2.95% of the German decadal gain and 12.73% of the UK gain). There is also a sex difference in the rates of brain mass gain in both countries, favoring males. Temporal correlations between the secular trend in UK brain mass and European Flynn effects on Fullscale IQ, Crystallized, Fluid and Spatial abilities reveal correlations ranging from 0.751 in the case of Fluid ability to 0.761 in the case of Crystallized ability. The brain mass increase may be an imperfect proxy for changes in specific neuroanatomical structures important for IQ gains. Its small contribution to these gains is also consistent with the influence of other contributing factors. Increasing brain mass is predicted by the life history model of the Flynn effect as it suggests increased somatic effort allocation into bioenergetically expensive cortical real estate facilitating the development of specialized cognitive abilities.

1. Introduction

Brain dimensions have long been considered an important determinant of mental ability (e.g. Darwin, 1871; Galton, 1888). Subsequent research has corroborated the association between brain volume and mass and IQ (McDaniel, 2005; Pietschnig, Penke, Wicherts, Zeller, & Voracek, 2015; Rushton & Ankney, 2009). Studies have found evidence for secular increases in cranial vault dimensions within Western populations during the 20th century (e.g. Ounsted, Moar, & Scott, 1985). Other studies have also found indications of increasing brain mass among autopsy samples (Haug, 1984; Kretschmann, Schleicher, Wingert, Zilles & Löblich, 1979; Miller & Corsellis, 1977) covering a similar time period.

Based on the assumption that increasing brain mass should be associated with increased IQ, Lynn (1989) and others (e.g. Mingroni, 2004; Storfer, 1999) have argued that the secular increase in brain mass may be an important corollary of the Flynn effect — the increase in Fullscale IQ of three points per decade, since the beginning of the 20th century (Flynn, 2009a, 2012; Pietschnig & Voracek, 2015; Trahan, Stuebing, Hiscock, & Fletcher, 2014).

In the present paper, the IQ increase resulting from the secular trend in brain mass will be determined formally for the first time via secondary analysis of two cross-sectional datasets. Such trends constitute a potentially significant source of convergent validity for the Flynn effect, as they concern changes in an actual biological endophenotype of IQ, rather than performance on pencil-and-paper tests. An attempt will also be made to determine whether there exist sex-differences in the rates of brain mass increase, and also whether secular trends in brain mass exhibit affinity for Flynn effects on specific ability measures via temporal correlation. Finally, a detailed theoretical unpacking of these results in the context of various models of the Flynn effect that predict associations with increasing brain mass will be presented in the discussion.

2. Method

2.1. Datasets

Two cross-sectional datasets presenting evidence of secular trends in brain mass in two countries (the UK and Germany) will be considered in the present study.

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2.1.1. British data

Miller and Corsellis (1977) reported increases in brain mass, utilizing autopsy materials sourced from the London Hospital Pathological Institute amounting to 52 g (from 1372 g to 1424 g) over 80 years (between birth years 1860 and 1940) among their male sample (N = 4319), and 23 g (from 1242 g to 1265 g) over the same period for their female sample (N = 3878). Miller and Corsellis admitted into their comparison groups all individuals aged between 20 and 50 years at time of death for whom the brains were not considered pathological (approximately 36% of the brains were excluded on this basis). To determine the secular mass change they simply regressed the mean brain mass of those aged between 20 and 50 at time of death against birth year.

The running five-year means for both males and females employed by Miller and Corsellis in their analysis were extracted from their figure. 1 (p. 254) and are reproduced graphically here in Fig. 1.

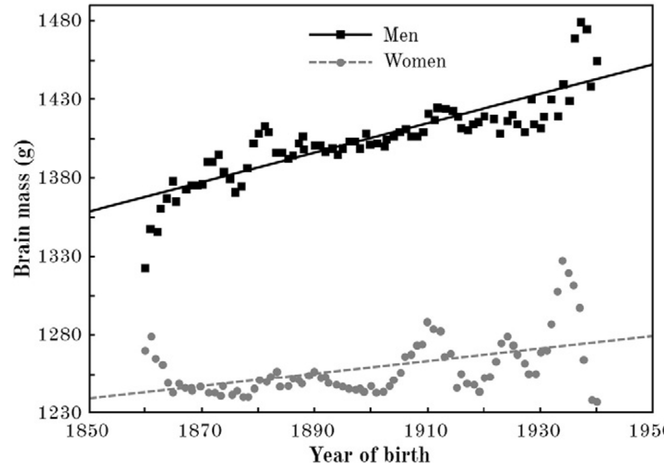

Fig. 1. Secular trend in brain mass across a sample of 4319 British males and 3878 females born between 1860 and 1940 and aged between 20 and 50 years at time of death.

2.1.2. German studies

Haug (1984) presents the results of 12 studies reporting aggregate brain masses for both males and females (tables 6 and 7, p. 493) collected via autopsy from various pathological and forensic institutes and broken out by age. The studies span the period from 1861 to 1978. Six of the studies involve German-sourced samples. A smaller seventh study (Kretschmann, et al., 1979), not considered by Haug, also reports brain mass means for German subjects.

The trend in brain mass across the seven German studies spanning the study years 1880 to 1979 will here be analyzed in order to determine the presence of secular trends within this country. A weighted average of brain masses collected from those with ages ranging from 30 to 49 and 50 to 59 is utilized as the basis for cross-sectional comparison,[1] via regression against study year.

The secular trend in height is not controlled in the present analysis, as gains in height and brain mass share variance stemming from a more general secular increase in body mass, which indicates substantial collinearity. Consistent with this Haug (1984, p.492) found a correlation between the two of > 0.8.

The analysis of the German brain mass means will be conducted using fixed-effects meta-regression (implemented utilizing software available at http://statstodo.com) with weighting by standard error of the mean, that is SEM = $s / \sqrt{N}$, where s = standard deviation and N = sample size.

For the meta-regression, standard deviation values for brain mass are required in order to calculate SEM values. In the absence of sample specific parameters, Hunter and Schmidt (2004, pp. 47–49) recommend importing higher quality parameters derived from benchmark studies, thus synthetically correcting for error stemming from range restriction. The study of Ho, Roessmann, Straumfjord, and Monroe (1980) provides data on US brain mass and associated values, representatively sampled from across 1261 cases that had all been processed using precisely the same protocols. It can be reasonably assumed given the time periods involved that the autopsy data collected in the London Pathological Institute and the seven German studies primarily concerned European whites, therefore only the white male and female standard deviation values from Ho et al. (1980) will be utilized. For a sample of 416 white males of an average age of 60, a standard deviation value of 130 g is reported. For a sample of 395 white females of an average age of 59, a standard deviation value of 125 g is reported (p. 636).

The weighted mean brain mass values for all seven studies, along with sample size and location data are presented in Table 1.

[1] The 15-29, 60-69 and > 70 age categories were not used, as age-related brain mass increases will still be occurring among the earlier cohort (Dekaban & Sadowski, 1978; Ho, Roessmann, Straumfjord & Munroe, 1980), and age-related decreases are occurring among the older cohorts (Haug, 1984). Only the age-ranges at which 'peak' brain mass is obtained are compared, thus approximately matching the methodology and age-range (20-50 years) employed in Miller & Corsellis' (1977) UK analysis.

2.2. Estimating secular gains in IQ from increasing brain mass

Jensen (1998, p.326) proposed a method for estimating Fullscale IQ gains stemming from secular increases in brain volume/mass. The method involves converting the gains into a change in standard deviation units by dividing the gains in grams by the reference standard deviations of brain mass for males and females. Based on the assumption that increasing brain mass is boosting IQ this d value must be multiplied by the correlation between brain mass and IQ. The resultant d value can then be multiplied by 15 (the "standard" standard deviation of IQ) yielding IQ points gained throughout the birth and study years covered by Miller and Corsellis (1977) and the German studies respectively.

2.2.1. Correlation between brain volume/mass and IQ

A recent comprehensive meta-analysis has established that the population correlation between brain volume and IQ is significantly positive at $\rho = 0.24$ (Pietschnig et al. 2015). This value is somewhat smaller than the value presented in a previous meta-analysis (i.e. McDaniel, 2005; $\rho = 0.33$), however Pietschnig et al. sampled more representatively than did McDaniel. Multiplying the increase in brain mass (in standard deviation units) by this estimate will yield the standardized IQ gain (as per Jensen, 1998).

Rushton and Ankney (2009) noted that brain volume is an extremely strong proxy for brain mass, and that, while rarely ever investigated, similar correlations with IQ are obtained when mass is directly estimated instead of volume. Thus the IQ–brain volume correlation can be considered synonymous with the IQ–brain mass correlation.

Pietschnig et al. (2015) noted no significant sex-differences in the strength of the IQ–brain volume correlation; therefore the value of 0.24 will be used in computing IQ gains for both sets of male and female data.

2.3. Testing for dimorphism in the rates of brain mass increase

A general linear model (implemented in SPSS v.21) will be utilized in order to test for the presence of a sex * year interaction and also main effects of sex and year over brain mass using both the running five-year-mean UK data (obtained from Miller & Corsellis, 1977) and the aggregate-level German data. The models (Type I and III Sum of Squares respectively) will be run sequentially with sex (dummy coded: 0 = female, 1 = male) and year entered first, followed by the sex * year interaction. In order to obtain the correct degrees of freedom for the German data, each study mean-year pairing is replicated in proportion to its sample size prior to analysis, thus simulating the results of analyzing the original pooled data.