Relationship between Crystallized & Fluid Intelligence during Development (#7746)

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1) Have any data been collected for this study already?
It's complicated. We have already collected some data but explain in Question 8 why readers may consider this a valid pre-registration nevertheless.

2) What's the main question being asked or hypothesis being tested in this study?
What is the relationship between crystallized (gc) and fluid intelligence (gf) during development?
- More specifically, we are investigating the relationship between gc and gf in child and adolescent populations to understand whether the relationship between both measures changes during these developmental periods (e.g. Craik & Bialystok 2006).

3) Describe the key dependent variable(s) specifying how they will be measured.
- Neurally, we will use tract-based mean FA for 10 JHU white matter tracts and fractal dimensionality (e.g. Madan & Kensinger 2016).
- Behaviourally, we will use raw scores on tests of gf (WASI matrix reasoning), working memory (Automated Working Memory Battery), and gc (the single word reading, spelling and numerical operations assessments from the Wechsler Individual Achievement Test II and the Peabody Picture Vocabulary Test).
- We will also include age as a covariate to examine model heterogeneity (i.e. age differentiation).

4) How many and which conditions will participants be assigned to?
N/A

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
We will use multivariate Structural Equation Models (SEMs) to answer our research question. These models will be implemented using Full Information Maximum Likelihood with Satorra-Bentler scaled test statistics in R's lavaan package for hypothesis 1-3 and OpenMX for hypotheses 2 and 4.

Hypothesis 1. Gc and gf are separable constructs.
- We will compare a 2-factor model (gc and gf as separate latent variables) to a unidimensional model (gc and gf as a single latent variable). We expect the 2-factor model to be a better fit, suggesting separable gc and gf factors.

Hypothesis 2. There is different covariance between gc and gf in children and adolescent cohorts.
- We will conduct Multiple Age Group comparisons between children and adolescent populations. Age groups will be determined using a median split in order to produce equal sample sizes in both subsets and validated using SEM trees (Brandmaier et al., 2016). We expect the covariance between gc and gf to decrease with increasing age in line with previous findings on age differentiation (Hülür et al. 2011; Mooij et al., in revision).

Hypothesis 3. Grey and white matter make complementary contributions to gc and gf within age groups
- We will examine whether grey and white matter make unique and complementary contributions to our latent variable(s) (whether unidimensional or 2-factor model). We hypothesize that grey and white matter will make complementary contributions to both gc and gf.
- We will use a Multiple Indicator, Multiple Cause (MIMIC) models, which will allow us to compare a full model in which paths between gc and gf are freely estimated to models in which either of these paths are constrained to 0. We expect the full MIMIC model to fit best.

Hypothesis 4. The contribution of grey and white matter to gc and gf changes with age (e.g. Mooij et al., in revision).
- We will identify changes in the relationship between gc and gf and grey and white matter with age in a data-driven way (Brandmaier et al., 2016). We will use SEM trees with age as a covariate, and expect the parameters relating neural measures to cognitive factors to either remain static with age or decrease.

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.
Exclusion criteria for referrals to the CALM clinic, from which our sample stems, were: significant and uncorrected known problems in vision or hearing and a native language other than English. Moreover, due to low quality of some MRI scans because of movement artefact, we will exclude diffusion data with a frame-by-frame displacement higher than 3mm as determined by FSL eddy. Otherwise, we will not impose any exclusion criteria on individual data points.

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.
We will use the CALM sample in its N = 550 release, half of which have contain complete MRI data. See http://calm.mrc-cbu.cam.ac.uk/.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

All of the data we are planning to use stems from existing, publicly available datasets with timelined data release approvals along the way. The study was preregistered here before full data access to any of the samples had been received (i.e. no data inspection or analysis has taken place prior to this preregistration).