Longitudinal pathways between socioeconomic status and educational attainment: mediation by executive functions and processing speed

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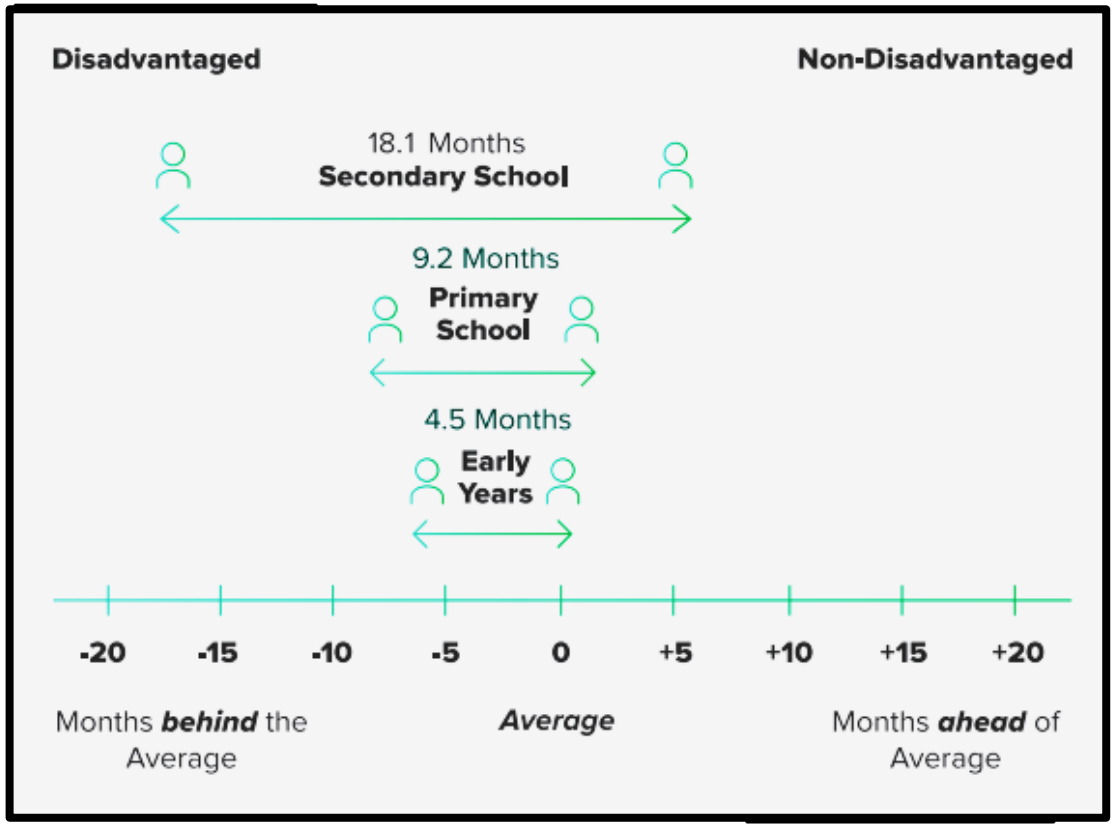
Background

Socioeconomic inequalities in children's educational outcomes have consistently been demonstrated.

This is referred to as the socioeconomic 'attainment gap'.

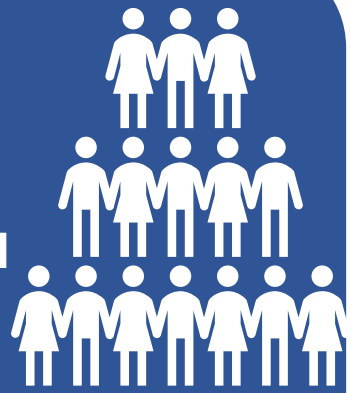


Disadvantage by having Free School Meals (FSM) at anytime in the last six years, published by the Education Policy Institute (2019)

Background (2)

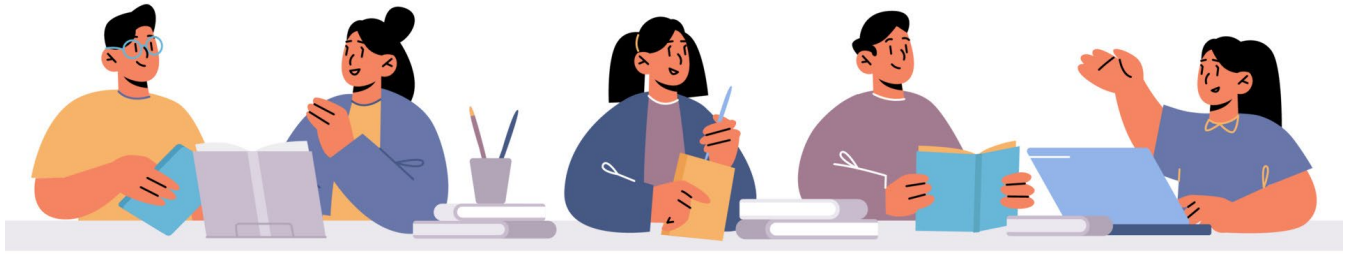
This hinders further progression as children become adults, in both their future education, employment, and health

This leads to long term challenges for both the individual, and society as a whole



Approximately half of the association between earlier and later occupational class can be explai attair

Educational inequality leads to reduced economic productivity & increased income inequality, perpetuating a cycle of inequality (Aiyar and Ebeke, 2020; Marmot, 2020)



Background (3)

Socioeconomic Status —— ? ——→ **Educational attainment**

Executive Function (EF) refers to the processes responsible for purposeful, goal-directed behaviour:

(1) Working Memory (WM), a limited capacity system that allows the storage and manipulation of information over short time periods

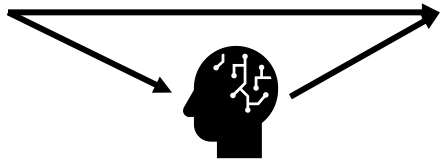
(2) Inhibition, which can be defined as the ability to deliberately inhibit dominant or automatic responses.

Processing Speed refers to how quickly we process information, and is normally measured using a reaction-time task

Diamond & Lee, 2011; Baddeley, 2010; Aron, 2007; Gordon et al., 2018; Mulder et al., 2010.

Background (4)

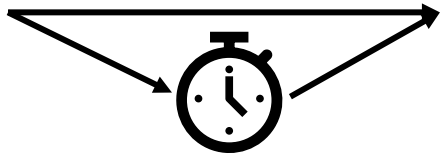
Socioeconomic Status → **Educational attainment**



- A measure of 'global' EF mediates the association between SES and broader educational attainment (Deer et al., 2020, Nesbitt et al., 2013).
- Four studies have tested the role that individual components of EF play;
  - Three found that WM significantly mediated the association, in comparison to other abilities (including verbal ability, cognitive flexibility, inhibition, and attentional control) (Albert et al., 2020; Waters et al., 2021; Poon et al., 2022).
  - One study demonstrated contradicting results in a cross-sectional study with 3-4-year-olds, finding a relationship between SES and educational attainment via inhibitory control, but not via WM (James-Brabham et al., 2023).

Background (5)

Socioeconomic Status → **Educational attainment**

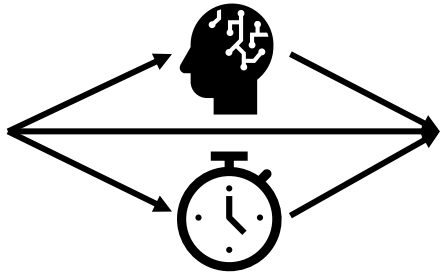


- **Childhood SES is associated with processing speed (Buckhalt et al, 2007; St John et al., 2019)**
- **Processing speed has distinct associations with children's educational attainment (Mulder et al, 2010; Passolunghi & Lanfranchi, 2012)**

➢ **No studies have examined whether processing speed mediates the association between socioeconomic status and educational attainment.**

Background (6)

Socioeconomic Status



Educational attainment

- **Childhood SES is associated with processing speed (Buckhalt et al, 2007; St John et al., 2019)**
- **Processing speed has distinct associations with children's educational attainment (Mulder et al, 2010; Passolunghi & Lanfranchi, 2012)**

➢ **No studies have examined whether processing speed mediates the association between socioeconomic status and educational attainment,** ***nor compared it to EF's role.***

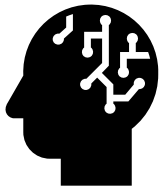
Study rationale and objectives

Cross-sectional

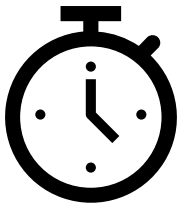
Approximate educational outcomes

Exploratory analyses

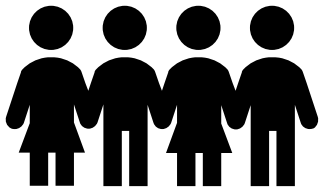
The previous research comparing the contributions of EF components has limitations



No study has tested whether processing speed mediates this association



EF research predominantly relies on higher-income and 'White' ethnic groups (Miller-Cotto et al, 2021)

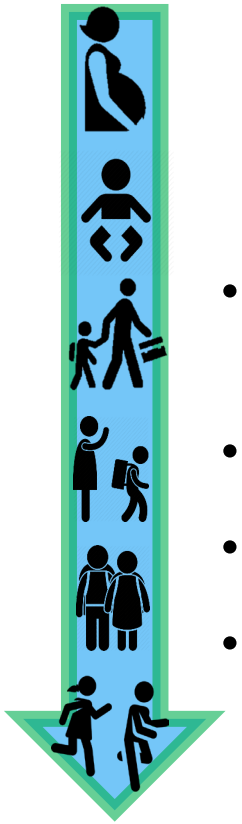


We therefore tested the different contributions of EF and processing speed abilities measured during middle childhood, to the relations between SES and educational attainment.

- **Model 1: We tested whether global EF and/or processing speed mediated the association**
- **Model 2: We tested whether the two core EF components (WM and/or Inhibition) mediated the association**

Methods

Data



Design: Secondary analyses of longitudinal cohort study data

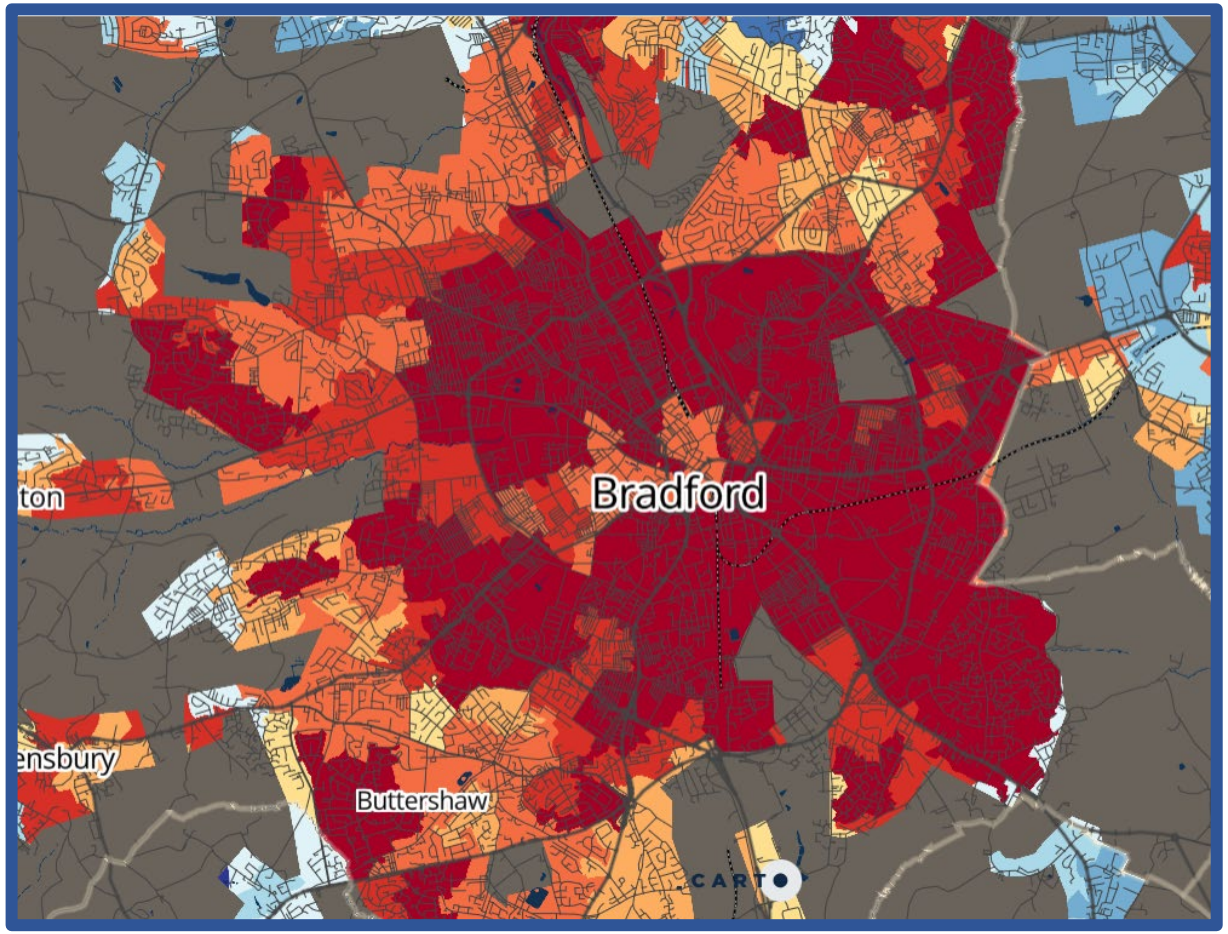
Longitudinal cohort study: Born in Bradford

- The Born in Bradford (BiB) cohort comprises 13,500 children and their families
- Recruited families during pregnancy between 2007-2010
- Links to routinely collected educational data
- 'Primary School Years' data collection wave with large sample of BiB and non-BiB children

For more information: https://borninbradford.nhs.uk

Wright et al (2013); Hill et al. (2021)

Bradford



Index of Multiple Deprivation 2019

- No data
- Most deprived decile
- 2nd
- 3rd
- 4th
- 5th
- 6th
- 7th
- 8th
- 9th
- Least deprived decile

13th most deprived local authority in England, with a third of neighborhoods falling into the most deprived decile

Index of Multiple Deprivation (IMD) | CDRC Data. (2019). Retrieved January 18, 2024, from https://data.cdrc.ac.uk/dataset/index-multiple-deprivation-imd

Measures

BiB Baseline questionnaire

1. Socioeconomic status (0-5)

Latent class construct based on 19 variables relating to employment, education, benefits, and material deprivation collected during the baseline questionnaire (Fairley et al., 2014)

2. Parent country of birth (0=born in UK, 1=not born in UK)

National Pupil Database

3. Child ethnicity (0=White British, 1=Other)

4. Child gender (0=male, 1=female)

5. Child EAL (0=EAL, 1=not EAL)

6. Child age in months

7. Educational attainment

Key Stage 2 Assessment; a statutory, national, standardised test. It is completed towards the end of Year 6 at school (age 10-11 years). There are continuous scaled scores that range between 80 and 120 for each domain: (1) Mathematics, (2) Reading, and (3) Grammar/Punctuation/Spelling

Before birth → **Aged 7-10** → **Aged 10-11**

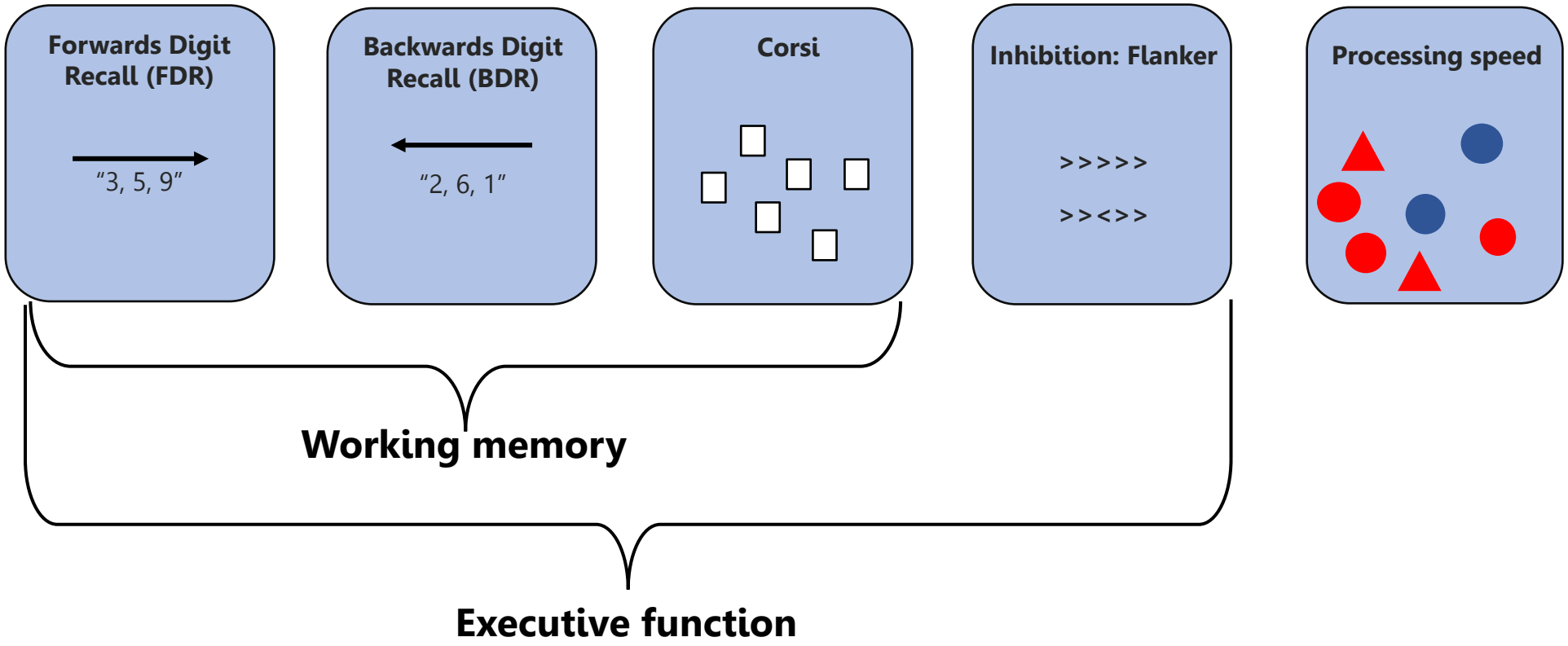
BiB Primary School Years sweep

All tasks were administered at 7–10 years (M_{age} =8.42, SD =0.66). Tasks were administered by researchers in the classroom, presented via a tablet computer with instructions delivered by headphones, and finger touch used for response input.

'Primary School Years' Measures

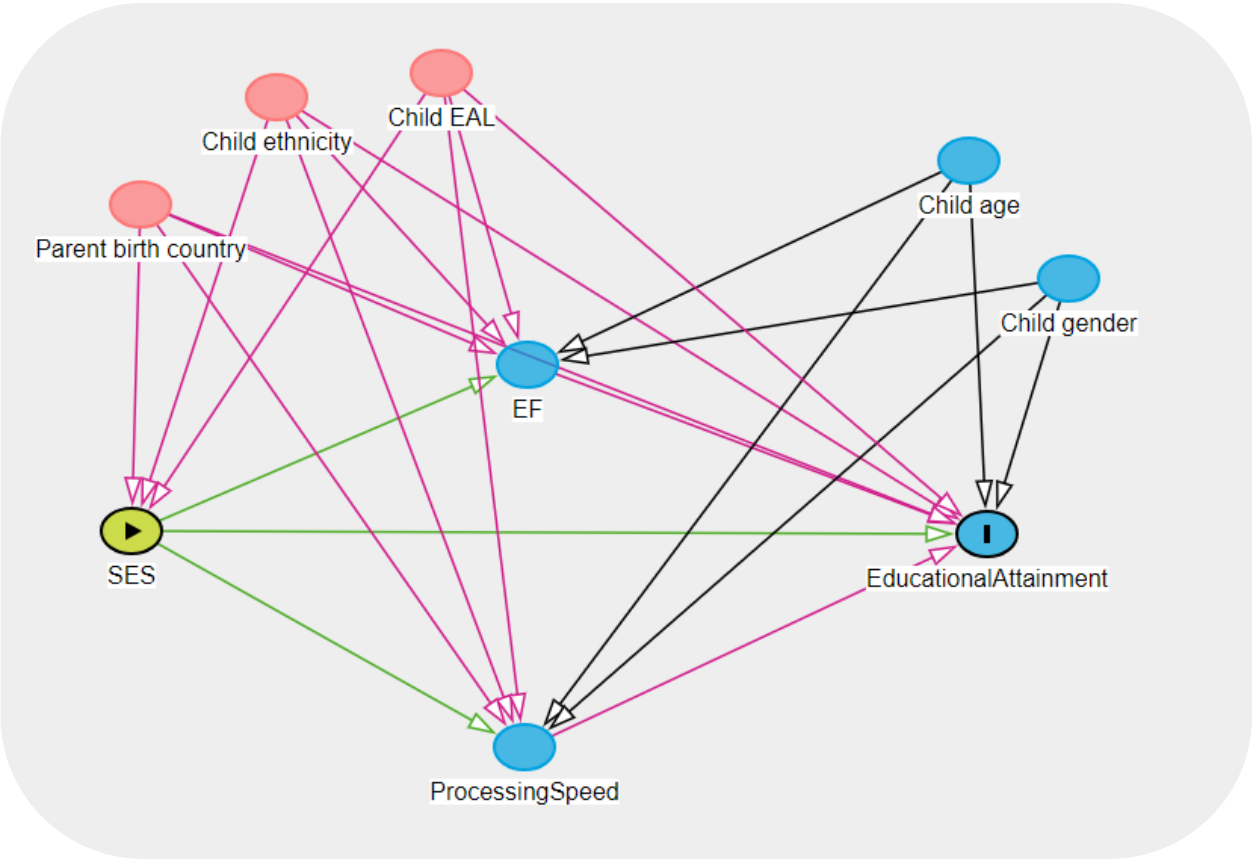
Mediating variables

All tasks were administered at 7–10 years (M_{age} =8.42, SD =0.66). Tasks were administered by researchers in the classroom, presented via a tablet computer with instructions delivered by headphones, and finger touch used for response input.



Analyses

- **Participant eligibility for analyses:**
  - Available data on exogenous variables
  - No diagnosis of SEND
- **Pre-registered study and analyses plan**
  - osf.io/2v6rz/
- Prespecified a causal structural model using a **Directed Acyclic Graph (DAG)** with confounders and covariates using DAGitty



Johannes Textor, Benito van der Zander, Mark K. Gilthorpe, Maciej Liskiewicz, George T.H. Ellison. Robust causal inference using directed acyclic graphs: the R package 'dagitty'. *International Journal of Epidemiology* 45(6):1887-1894, 2016.

Analyses (2)

- **Structural Equation Modelling (SEM)**
  - Answers interrelated research questions and uses a combination of 'latent' variables and indicator variables
  - Two separate models

Software. Cleaning and merging took place in Stata-17, and analysis took place in R using the *lavaan* package (Rosseel, 2012).

Bootstrapped indirect effects with 1000 repetitions (a non-parametric resampling procedure used to assess the variability of a statistic by examining the variability of the sample data)

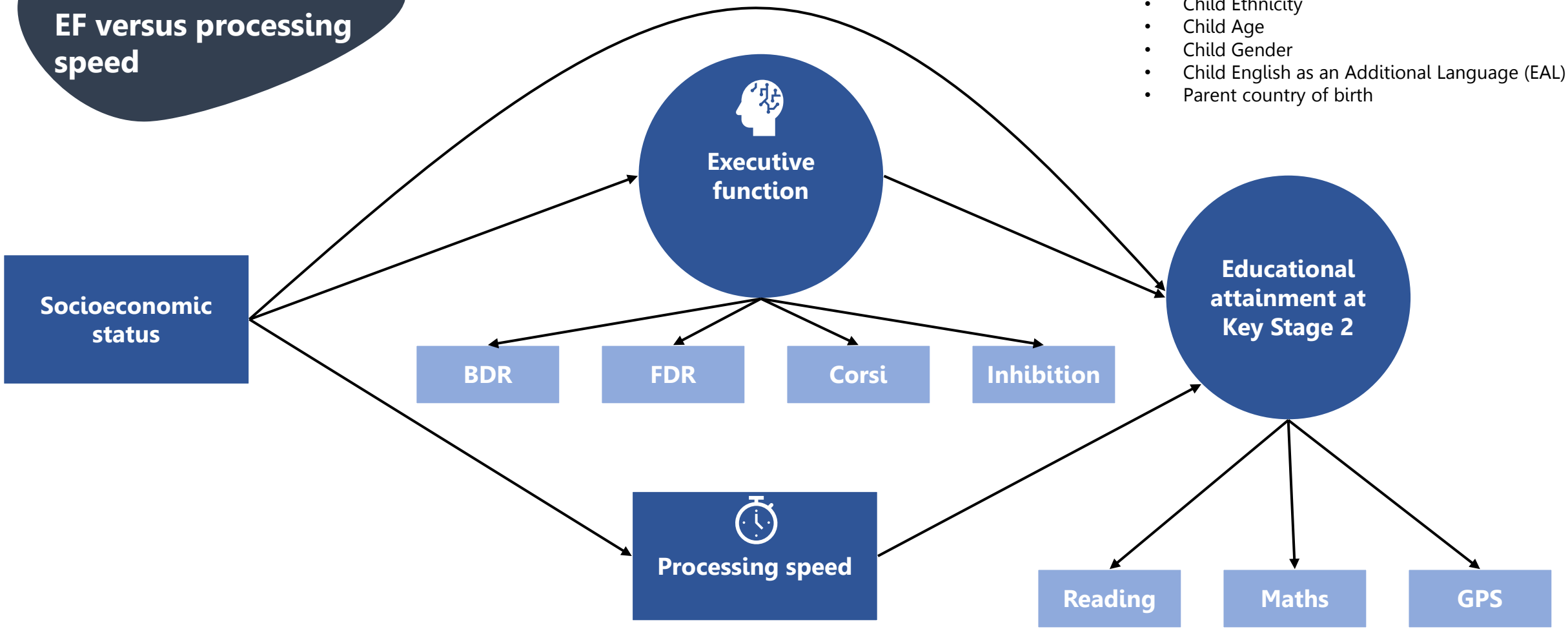
Full Information Maximum Likelihood (FIML) for missing data. FIML estimates a likelihood function for each individual based on the variables that are present so that all the available data are used (Enders & Bandalos, 2001).

Analyses (3)

Model 1:
EF versus processing speed

Models adjusted for effects of:

- Child Ethnicity
- Child Age
- Child Gender
- Child English as an Additional Language (EAL)
- Parent country of birth



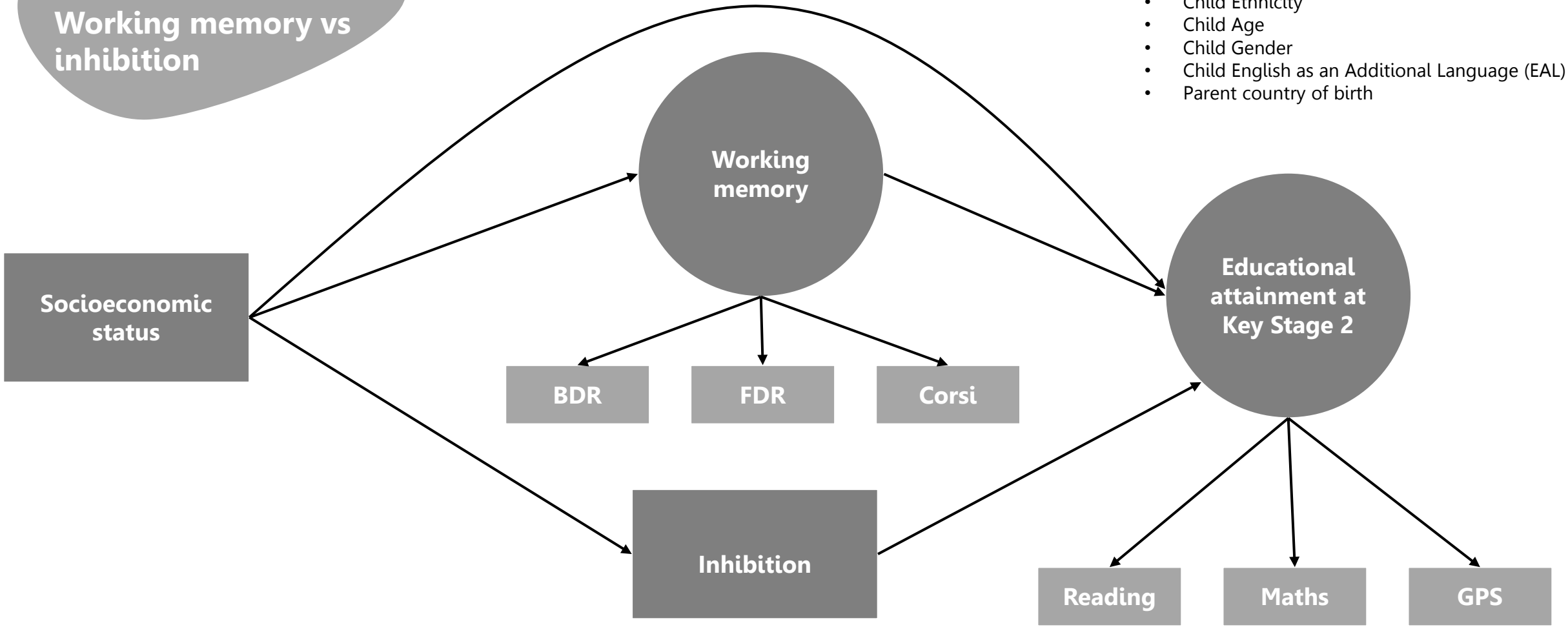
Before birth | Aged 7-10 | Aged 10-11

Analyses (4)

Model 2: Working memory vs inhibition

Models adjusted for effects of:

- Child Ethnicity
- Child Age
- Child Gender
- Child English as an Additional Language (EAL)
- Parent country of birth



Before birth | Aged 7-10 | Aged 10-11

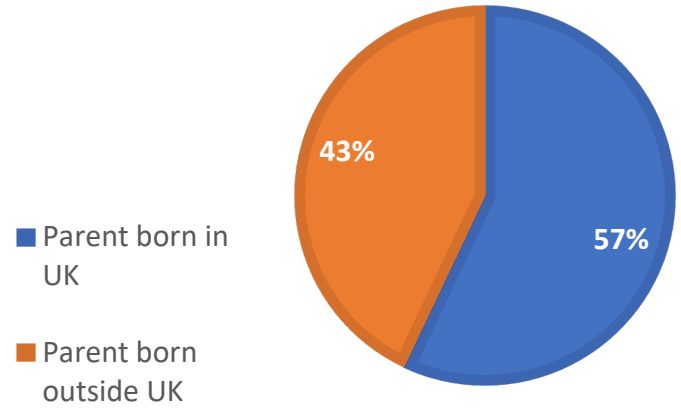
Results

Results (1)

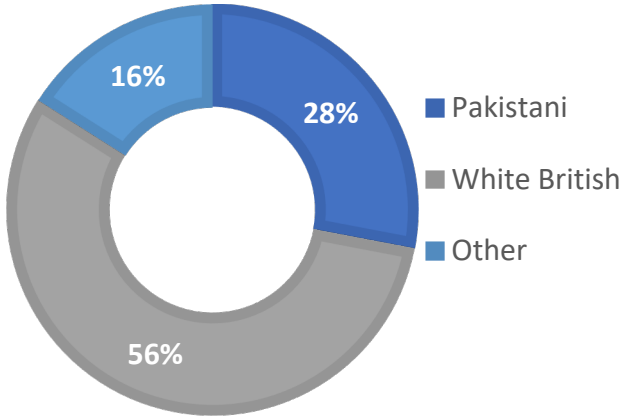
n=4201 individual children

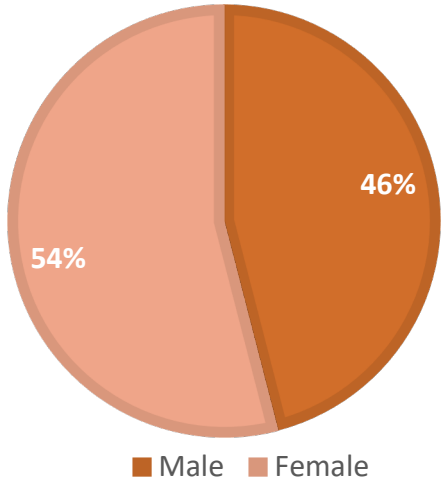
Parent level:

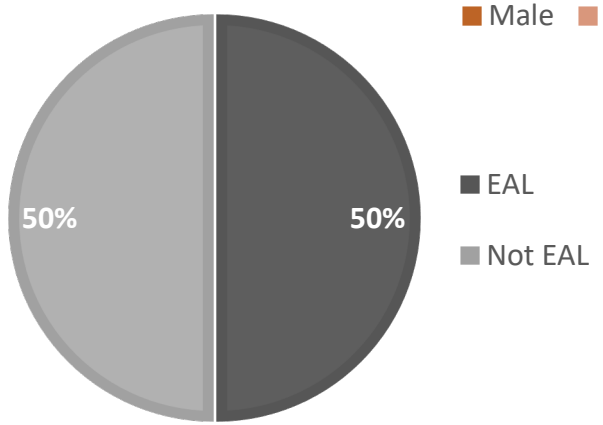
Socioeconomic status	
Least deprived	683 (16)
Employed, not materially deprived	1372 (32)
Employed, no access to money	683 (16)
Benefits, but coping	749 (18)
Most deprived	714 (17)



Child level:

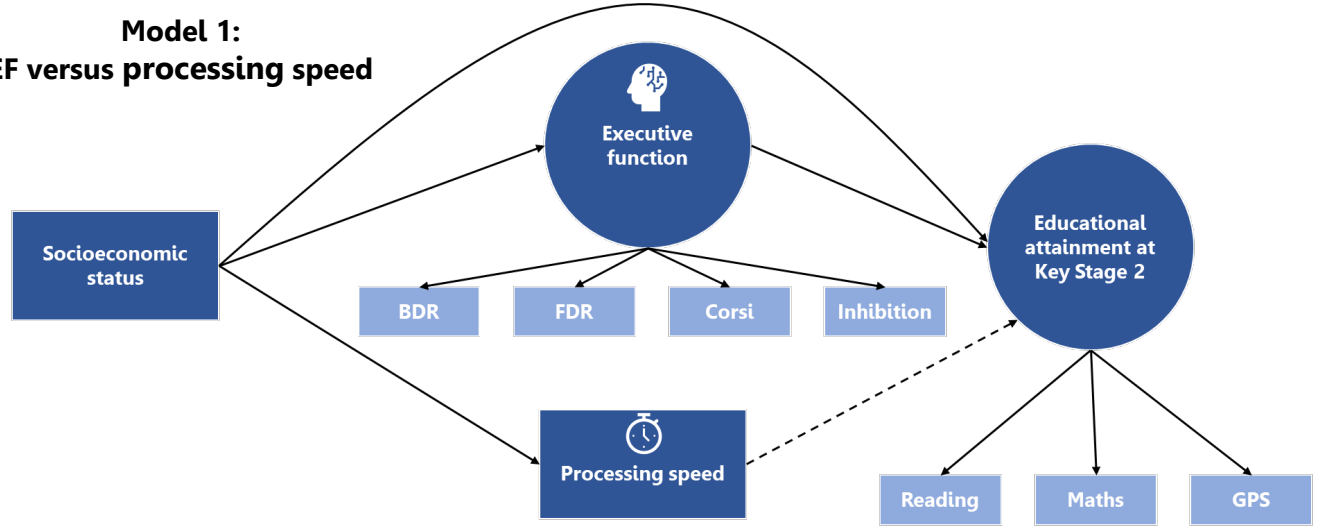






Results (2)

Model 1:
EF versus processing speed

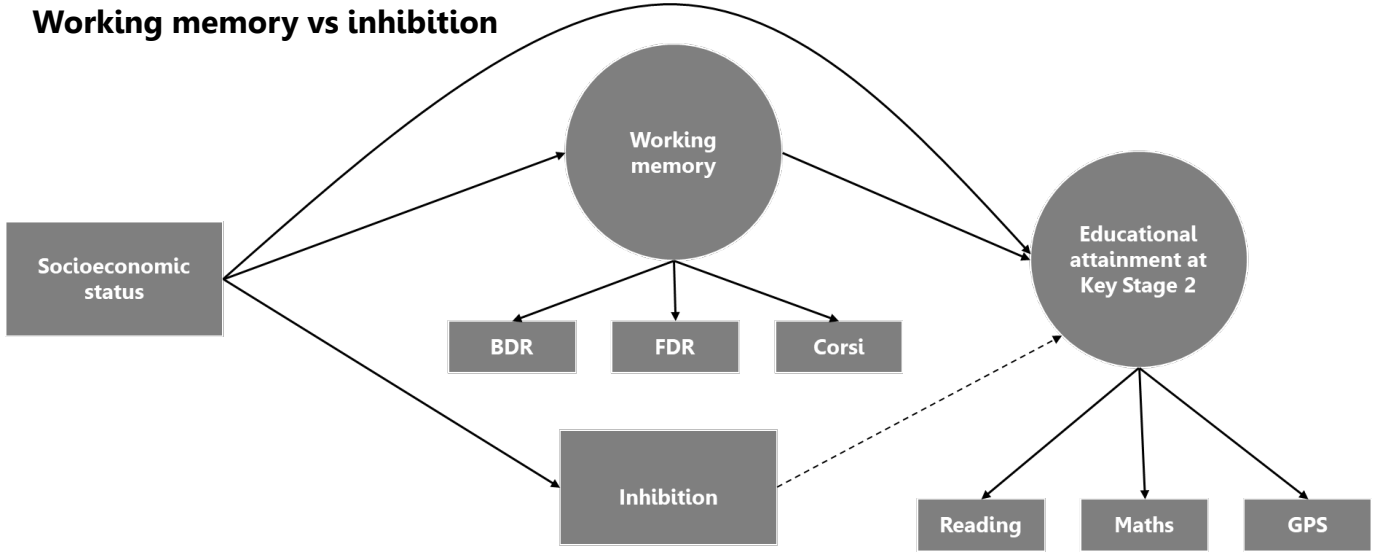


	Estimate [95% CI]	*p*	Mediation ratio
Total effect (combined effect of all below paths)	0.259 [.195 to .322]	<.001	100%
Direct effect (SES→educational attainment)	0.152 [.089 to .215]	<.001	58%
Indirect effect (SES→executive function→educational attainment)	0.109 [.082 to .135]	<.001	42%
Indirect effect (SES→processing speed→educational attainment)	-0.002 [-.006 to .001]	.397	<1%

The model fit values generally indicated adequate fit (CFI=0.858, RMSEA=0.066 [.062 to .069], SRMR=.044), although the CFI value is slightly lower than is considered acceptable (where <.90 is acceptable, Hooper et al., 2008).

The R^2 value for the latent educational attainment variable was 0.501.

Model 2:
Working memory vs inhibition



	Estimate [95% CI]	*p*	Mediation ratio
Total effect (combined effect of all below paths)	.258 [.193 to .320]	<.001	100%
Direct effect (SES→educational attainment)	.158 [.095 to .221]	<.001	61%
Indirect effect (SES→working memory→ educational attainment)	.100 [.076 to .125]	<.001	39%
Indirect effect (SES→inhibition→educational attainment)	.001 [-.003 to .006]	0.643	<1%

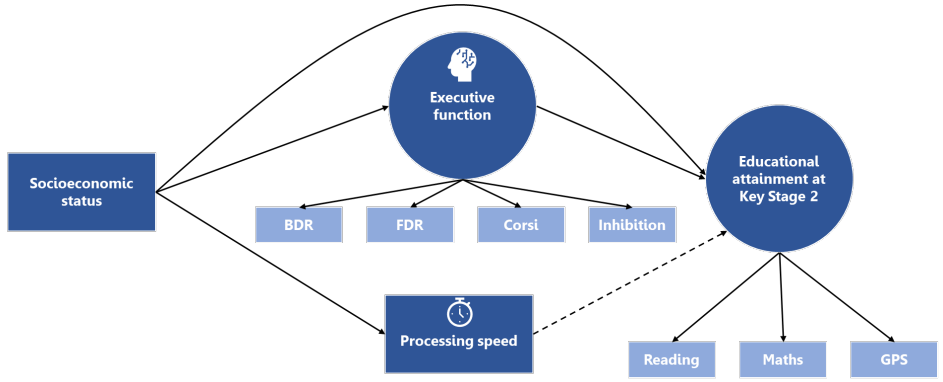
The model fit values indicated adequate fit, and were more favourable in this model (CFI=.930, RMSEA=.047 [.043 to .052], SRMR=.033).

The R^2 value for the latent educational attainment variable was .485.

Results (3)

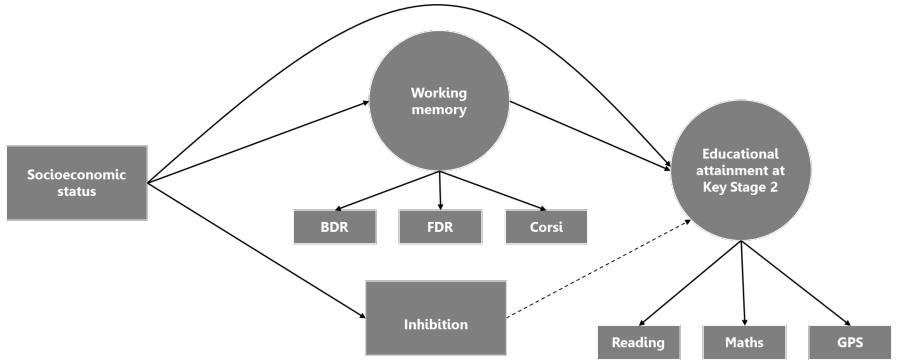
Model 1:

Executive functions significantly mediated the association between SES and educational attainment (B=0.109), whilst processing speed did not.



Model 2:

Working memory significantly mediated the associated between SES and educational attainment (B=.100), whilst inhibition did not.



Conclusions

Key findings

WM was the key mediating factor between SES and educational attainment, with no evidence that processing speed or inhibition mediated the relationship

This builds on other findings in this area, corroborating the evidence that WM is a key factor for this relationship

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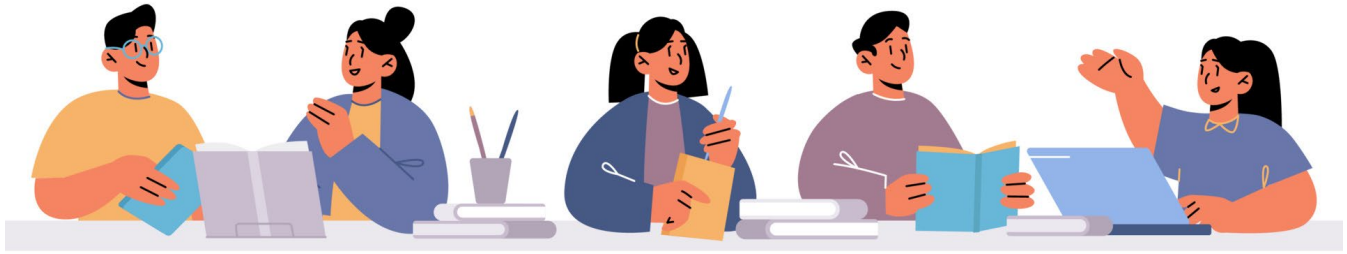
Implications

Reduction of social inequality itself *may* reduce differences in children's WM, and hence reduce educational inequalities

Whilst 'WM training' has been found to be ineffective; alternative ways of supporting WM in the classroom *may* be a promising avenue to closing the socioeconomic attainment gap.



Conclusions (2)

Limitations

1. Due to the observational study design, we need to exercise caution when discussing any causal nature of the pathways.

2. The sample are from one city in the UK with high socioeconomic deprivation and ethnic diversity.

3. Not all children had educational outcome data available.

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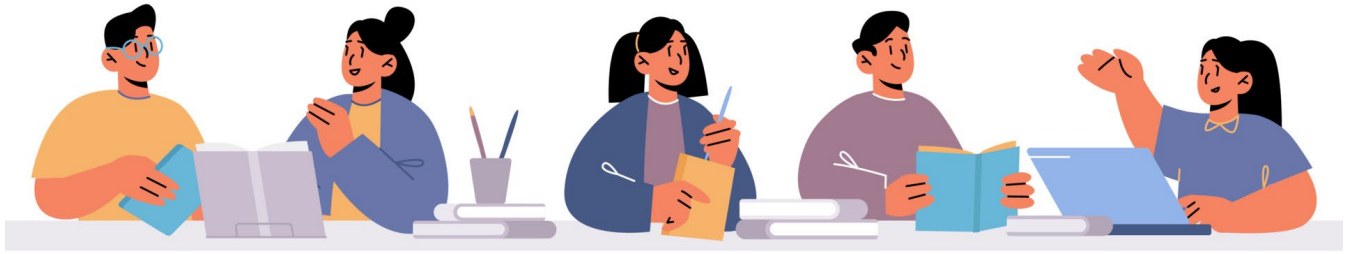
Future research

- Investigate whether these pathways are causal using an RCT
- Collect repeated measurements in longitudinal samples to build our understanding of these mechanisms
- Investigate ways to support WM in the classroom



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Thank you for listening!

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