

What does the transition from primary to secondary education mean for maths achievement and maths anxiety?

Professor Andy Field

2019-02-27

Collaborators

Collaborators

ALSPAC

- Danielle Evans (University of Sussex)

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ALSPAC

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[1] www.nfer.ac.uk/news-events/nfer-blogs/international-school-spending-how-does-the-uk-compare/

[2] assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/574925/PISA-2015_England_Report.pdf

School transition

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A Review of the Academic and Psychological Impact of the Transition to Secondary Education

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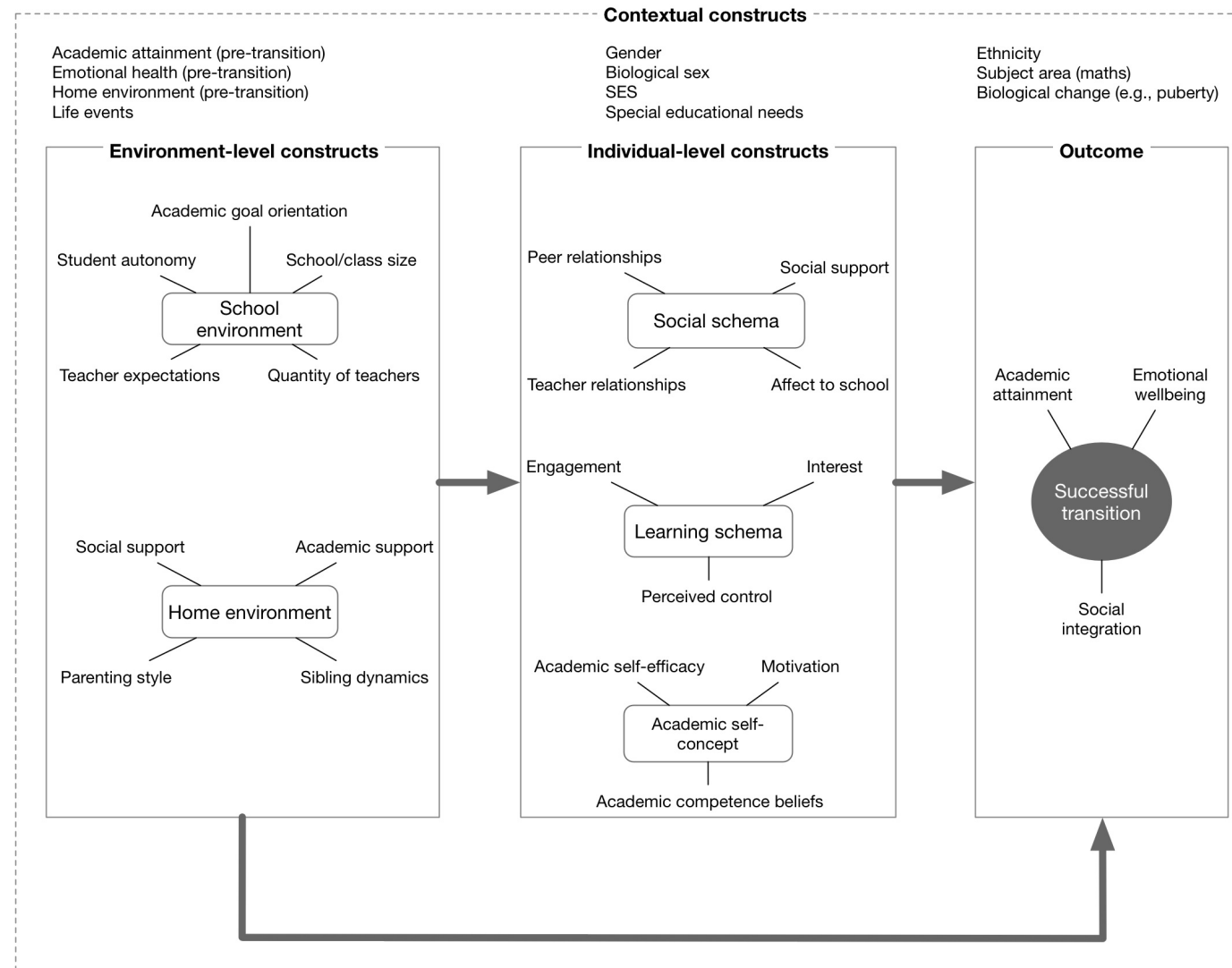
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The transition from primary to secondary education is one of the most stressful events in a young person's life (Zeedyk et al., 2003) and can have a negative impact on psychological well-being and academic achievement. One explanation for these negative impacts is that the transition coincides with early adolescence, a period during which certain psychological disorders (i.e., anxiety disorders) become more salient (Kessler et al., 2005) and marked social, biological, and psychological development occurs (Anderson et al., 2000). This review evaluates the existing literature on the psychological and academic impacts of the transition to secondary education on young adolescents. We examine the factors that plausibly increase or mitigate the risk of developing mental health issues and/or a decline in academic performance during the transition to secondary education. We also review the interplay between psychological health and academic achievement across and beyond the transition. We conclude with a summary of what schools and parents can learn from these findings to support children in a successful transition into secondary education.



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- Cognitive performance will be lowest if WMC is low and trait anxiety is high
- Cognitive performance should improve if WMC and anxiety are both high

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Does WMC moderate the effects of anxiety on trajectories of maths achievement across school transition?

Study 1: Predictors of mathematical trajectories across the transition

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Avon Longitudinal Study of Parents and Children (ALSPAC)¹

- 15,438 pregnancies
- Has been found to be broadly representative of children in the UK at that time.
- Children in Avon were as likely as other UK children to be living with a single parent (4% ALSPAC, 5% UK), to have parents with a university degree (14% ALSPAC, 13.7% UK), and to have non-European, non-Caucasian parents (5.1% ALSPAC, 6.4% UK)

[1] www.bristol.ac.uk/alspac/researchers/cohort-profile/

Exclusions

Exclusions

before exclusions

- 15,438

Exclusions

before exclusions

- 15,438

after exclusions

- Those alive at 1-year (= 14,684)
- We took only the first born of any multiple births (= 14498)
- English not the first language (= 14484)
- Special educational needs at either 7-8 or 10-11 years (= 11832)
- No key stage maths data (= 9556)
- Missing data for > 50% of the model predictors (= 7219)

Contextual predictors

Contextual predictors

Sex: Biological sex (Male = 0, Female = 1)

SES: Socio-economic status measured using the Cambridge Social Interaction and Stratification Scale (CAMSIS).

- Scores can range from 1 (least advantaged) to 99 (most advantaged).
- The largest of the parent's CAMSIS scores at 32 weeks gestation was used.

Parental education: measured using the highest of the parent's qualifications at 32 weeks gestation

- No qualifications, no higher than CSE, vocational training, O-level or equivalent, A-level or equivalent, university degree
- Dummy coded (CSE as baseline)

Life events age 5-7: Traumatic Life Events score (0-72) at age 6.75 years.

- Parents/carers were asked about traumatic events that have happened since the child's 5th birthday.

Within-individual predictors

Within-individual predictors

Emotionality

- The Emotionality Activity Sociability (EAS) temperament measurement scale (Buss & Plomin, 1986) at 38 months (3.17 years). (Range: 5 to 25 with a high score corresponding to higher emotionality).

Internalizing:

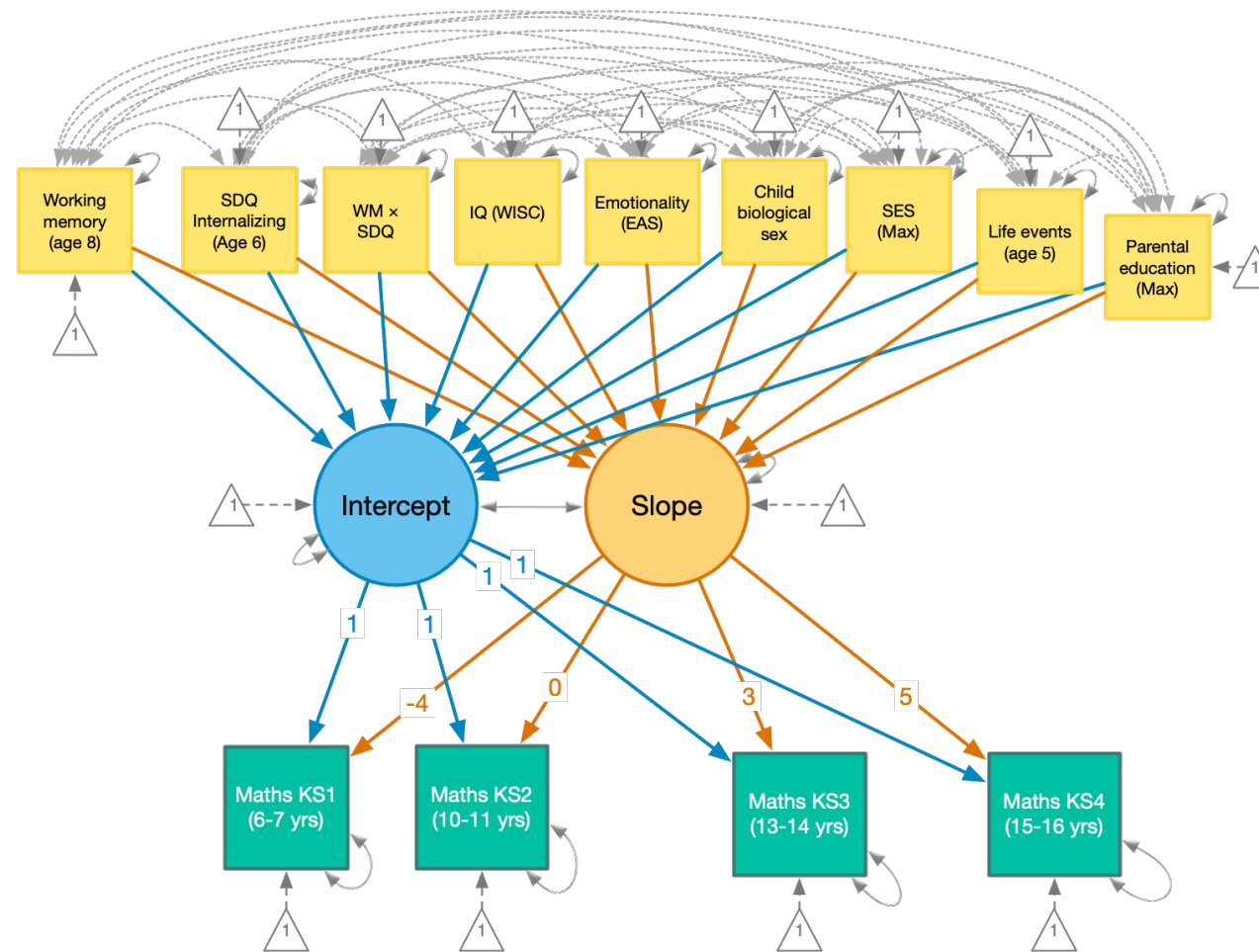
- Internalizing (proxy for anxiety) measured using the The Strengths and Difficulties Questionnaire (SDQ) at age 6.75.
- The sum of _____ and _____ were used.

Working memory

- The Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1992) at age 8 (forwards and backwards digit span).

IQ

- IQ at age 8 measured using the WISC-III.



Statistical considerations

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Centring: To ease interpretation, predictors for which 0 is not a meaningful value were centred

- SES
- IQ
- Working memory
- Emotionality

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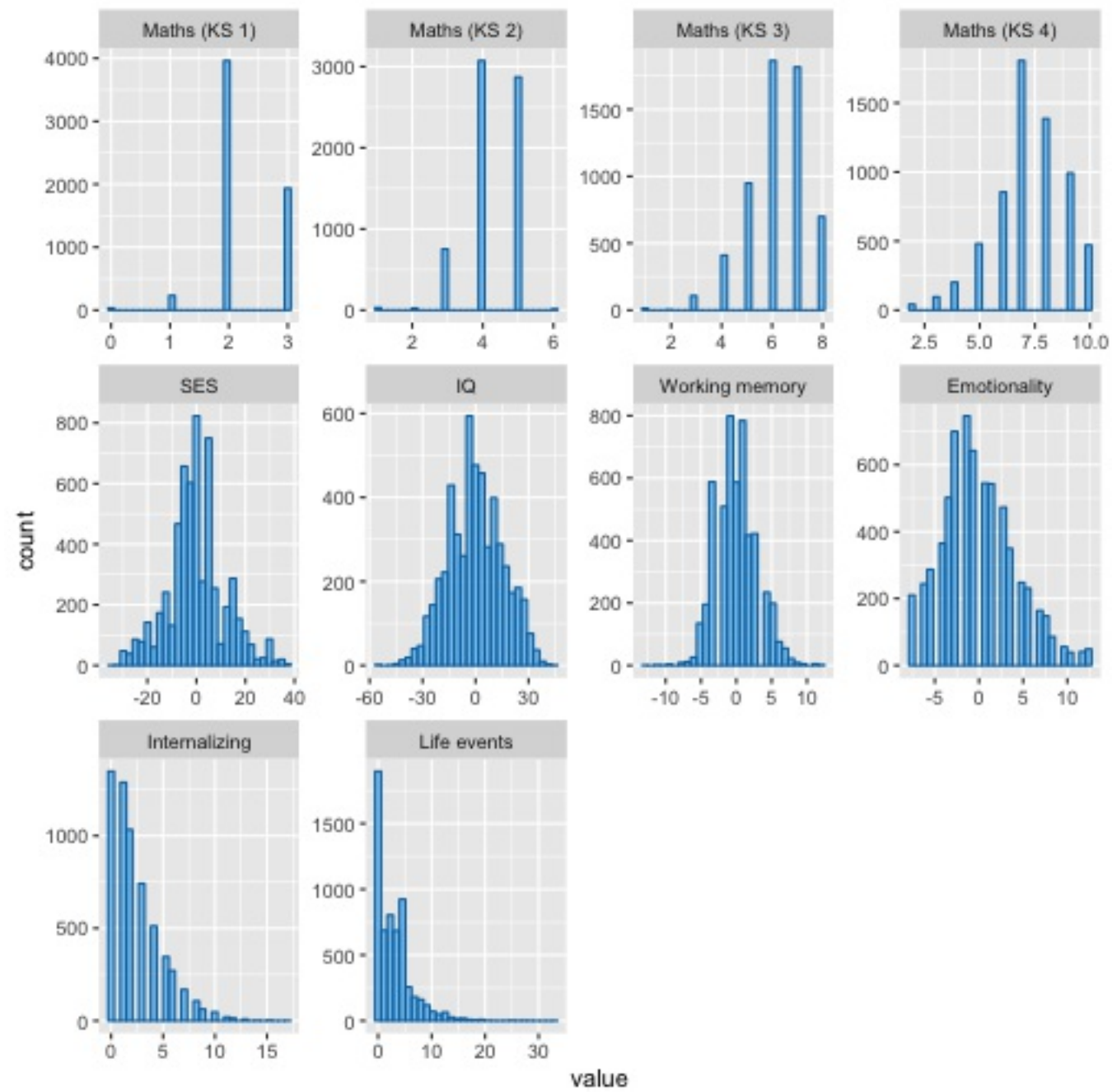
- SES
- IQ
- Working memory
- Emotionality

Missing data

- Patterns of missing data in predictors
- Models fit with lavaan¹ using multiple imputation based on 70 imputed data sets imputing predictors only²
- FIML estimator

[1] Rosseel, Y. (2012). Lavaan: an R package for structural equation modeling. Journal of Statistical Software, 48, 1–36.

[2] Using the **semTools** (Jorgensen, Pornprasertmanit, Schoemann, & Rosseel, 2018) and **Amelia** (Honaker, King, & Blackwell, 2011) packages



Predictors of the intercept

Table 1: Model parameters for predictors of the intercept of maths achievement

			95% CI			
Effect	Estimate	SE	lower	upper	Std. estimate	p
Working memory	0.019	0.004	0.010	0.027	0.070	0.000
Internalizing (SDQ)	-0.015	0.004	-0.022	-0.008	-0.048	0.000
IQ	0.020	0.001	0.018	0.021	0.405	0.000
Emotionality	0.001	0.002	-0.003	0.005	0.006	0.595
SES	0.005	0.001	0.003	0.007	0.080	0.000
Edu: CSE vs. vocational	-0.020	0.044	-0.106	0.066	-0.006	0.648
Edu: CSE vs. O Level	0.186	0.031	0.125	0.248	0.110	0.000
Edu: CSE vs. A Level	0.264	0.032	0.203	0.326	0.167	0.000
Edu: CSE vs. Degree	0.449	0.037	0.376	0.521	0.252	0.000
Sex	-0.049	0.017	-0.083	-0.015	-0.033	0.005
Life events age 5-7	-0.004	0.003	-0.009	0.001	-0.019	0.110
Working memory × SDQ	0.002	0.001	0.000	0.005	0.032	0.051

Predictors of the slope

Table 2: Model parameters for predictors of the slope of maths achievement

			95% CI			
Effect	Estimate	SE	lower	upper	Std. estimate	p
Working memory	0.001	0.001	0.000	0.003	0.032	0.112
Internalizing (SDQ)	-0.001	0.001	-0.003	0.000	-0.026	0.072
IQ	0.003	0.000	0.002	0.003	0.348	0.000
Emotionality	0.000	0.000	-0.001	0.001	0.005	0.744
SES	0.001	0.000	0.001	0.001	0.091	0.000
Edu: CSE vs. vocational	0.002	0.008	-0.015	0.018	0.004	0.813
Edu: CSE vs. O Level	0.027	0.006	0.016	0.039	0.100	0.000
Edu: CSE vs. A Level	0.053	0.006	0.041	0.065	0.209	0.000
Edu: CSE vs. Degree	0.095	0.007	0.081	0.109	0.332	0.000
Sex	-0.004	0.003	-0.010	0.003	-0.015	0.296
Life events age 5-7	-0.001	0.001	-0.002	0.000	-0.016	0.273
Working memory × SDQ	0.000	0.000	0.000	0.001	0.024	0.224

Bayesian estimates (intercept)

Table 3: Bayesian estimates for predictors of the intercept of maths achievement

	Estimation		95% HPD		
Effect	ML	Bayesian	Lower	Upper	Prior
Working memory	0.019	0.022	0.013	0.030	dnorm(0,1e-2)
Internalizing (SDQ)	-0.015	-0.008	-0.016	-0.001	dnorm(0,1e-2)
IQ	0.020	0.011	0.010	0.013	dnorm(0,1e-2)
Emotionality	0.001	0.001	-0.003	0.005	dnorm(0,1e-2)
SES	0.005	0.000	-0.002	0.002	dnorm(0,1e-2)
Edu: CSE vs. vocational	-0.020	0.024	-0.074	0.124	dnorm(0,1e-2)
Edu: CSE vs. O Level	0.186	0.058	-0.014	0.133	dnorm(0,1e-2)
Edu: CSE vs. A Level	0.264	0.020	-0.052	0.096	dnorm(0,1e-2)
Edu: CSE vs. Degree	0.449	0.013	-0.066	0.101	dnorm(0,1e-2)
Sex	-0.049	0.055	0.022	0.088	dnorm(0,1e-2)
Life events age 5-7	-0.004	0.000	-0.005	0.005	dnorm(0,1e-2)
Working memory × SDQ	0.002	0.000	-0.002	0.003	dnorm(0,1e-2)

Bayesian estimates (slope)

Table 4: Bayesian estimates for predictors of the slope of maths achievement

	Estimation		95% HPD		
Effect	ML	Bayesian	Lower	Upper	Prior
Working memory	0.001	0.002	0.000	0.004	dnorm(0,1e-2)
Internalizing (SDQ)	-0.001	-0.001	-0.003	0.001	dnorm(0,1e-2)
IQ	0.003	0.004	0.004	0.004	dnorm(0,1e-2)
Emotionality	0.000	0.000	-0.001	0.001	dnorm(0,1e-2)
SES	0.001	0.001	0.000	0.001	dnorm(0,1e-2)
Edu: CSE vs. vocational	0.002	-0.001	-0.028	0.025	dnorm(0,1e-2)
Edu: CSE vs. O Level	0.027	0.021	0.002	0.040	dnorm(0,1e-2)
Edu: CSE vs. A Level	0.053	0.046	0.026	0.065	dnorm(0,1e-2)
Edu: CSE vs. Degree	0.095	0.080	0.060	0.102	dnorm(0,1e-2)
Sex	-0.004	0.002	-0.006	0.010	dnorm(0,1e-2)
Life events age 5-7	-0.001	-0.001	-0.002	0.001	dnorm(0,1e-2)
Working memory × SDQ	0.000	0.000	0.000	0.001	dnorm(0,1e-2)

Summary

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Significant predictors of intercept (maths at KS2)

- Working memory = higher attainment (tiny effect)
- SDQ = lower attainment (tiny effect)
- IQ = higher attainment (small effect)
- Parent education: strongest effects of the bunch
- Sex: girls attainment is lower than boys (tiny effect)

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- SES = increased RoC (small effect)
- Parent education: higher education = increased RoC (reasonable effect size)

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Substantive predictor

- SDQ had a 'teeny weeny' effect in moderating the effect of working memory on attainment at KS2
- SDQ had a basically zero effect in moderating the effect of working memory on the RoC of maths achievement

Study 2: predictors of maths anxiety

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Math anxiety

- Hinders achievement in mathematics (Ashcraft, 2002)
- Is a barrier to learning statistics (Field, 2014)
- Is associated with lower earning potential, impaired financial planning, poor self-efficacy in teachers, and poorer drug calculations in nurses (Maloney, 2016)

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Theories of maths anxiety (Carey et al., 2016)

- Maths anxiety leads to worse mathematical achievement
- Poor mathematical achievement leads to maths anxiety
- The relationship is reciprocal

TEDS study

Aims

- The primary- to secondary transition potentially affects the trajectories of emotional health and academic achievement (Evans, Borriello & Field, 2018)
- Does the trajectory of mathematical attainment across this transition predict later maths anxiety?

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A secondary analysis of data from the Twin Early Development Study (TEDS)

- Longitudinal study of over 16,000 twin pairs born between 1994 and 1996 (Haworth, Davis & Plomin, 2013)

TEDS study

Phase 1

- A multilevel growth model predicting mathematical achievement from time (age from 9 years: 0, 1, 3 years)
- The intercept and slope for each child were used as predictors in phase 2

$$\text{Maths achievement}_{ij} = \pi_{0i} + \pi_{1i}\text{Time}_{ij} + \epsilon_{ij}$$

$$\pi_{0i} = \gamma_{00} + \zeta_{0i}$$

$$\pi_{1i} = \gamma_{10} + \zeta_{1i}$$

TEDS study

Phase 2

A linear model predicting maths anxiety from

- Sex
- Socio-economic status (centered)
- Emotional health (SDQ at ages 9 and 12)
- Average verbal cognitive ability (centered) at 10-12 years
- The intercept and slope of maths achievement from 9 to 12 years
- The interactions between each predictor and the slope of maths achievement

Due to heteroscedastic residuals, HC4 robust standard errors were used¹

[1] Using the **sjstats** package (Lüdtke, 2017) in R 3.5.1 (R core team, 2018)

Exclusions

Exclusions

before exclusions

- 12586

Exclusions

before exclusions

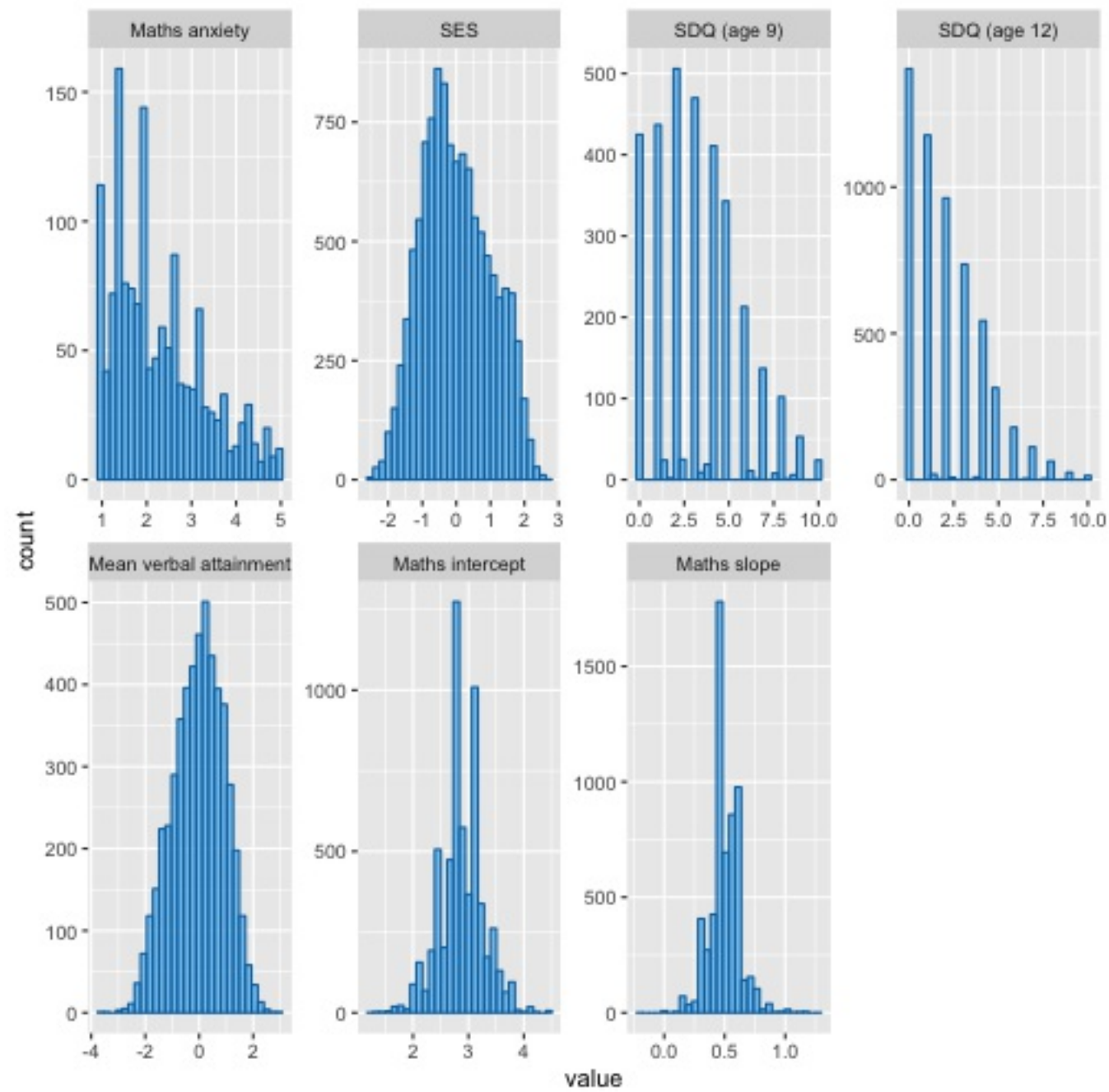
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after exclusions

- No maths anxiety data (= 1457)
- No maths trajectory data (= 1241)

Missing data

sex1	maths_int	maths_slope	ases	sdq_09	sdq_12	verbal_mean	n
1	1	1	1	1	1	1	936
1	1	1	1	0	1	1	71
1	1	1	1	1	0	1	50
1	1	1	1	1	1	0	51
1	1	1	0	1	1	1	45
1	1	1	1	0	0	1	18
1	1	1	1	0	1	0	15
1	1	1	1	1	0	0	20
1	1	1	0	0	1	1	2
1	1	1	0	1	1	0	3
1	1	1	1	0	0	0	26
1	1	1	0	0	0	1	2
1	1	1	0	0	0	0	2



Predictors of maths anxiety

Table 5: Model parameters for predictors of maths anxiety age 17

Predictor	Estimate	SE	95% CI		t	p
			lower	upper		
Intercept	4.521	0.376	3.783	5.260	12.019	0.000
Sex	-0.992	0.285	-1.552	-0.433	-3.480	0.001
SES	0.078	0.184	-0.283	0.438	0.423	0.673
SDQ (age 9)	0.143	0.066	0.013	0.273	2.154	0.032
SDQ (age 12)	0.016	0.080	-0.140	0.172	0.200	0.842
Verbal	0.071	0.179	-0.280	0.423	0.399	0.690
Maths (intercept)	-0.786	0.100	-0.982	-0.591	-7.890	0.000
Maths (slope)	0.161	0.610	-1.036	1.358	0.264	0.792
Sex × Maths (slope)	0.938	0.498	-0.040	1.915	1.882	0.060
SES × Maths (slope)	-0.075	0.333	-0.728	0.579	-0.224	0.822
SDQ (age 9) × Maths (slope)	-0.240	0.115	-0.467	-0.014	-2.081	0.038
SDQ (age 12) × Maths (slope)	0.144	0.145	-0.140	0.428	0.995	0.320
Verbal × Maths (slope)	-0.098	0.327	-0.739	0.544	-0.299	0.765

Figure 4: Predicted values of maths anxiety from emotional health (SDQ) and the trajectory of mathematical achievement (9 to 12 years)

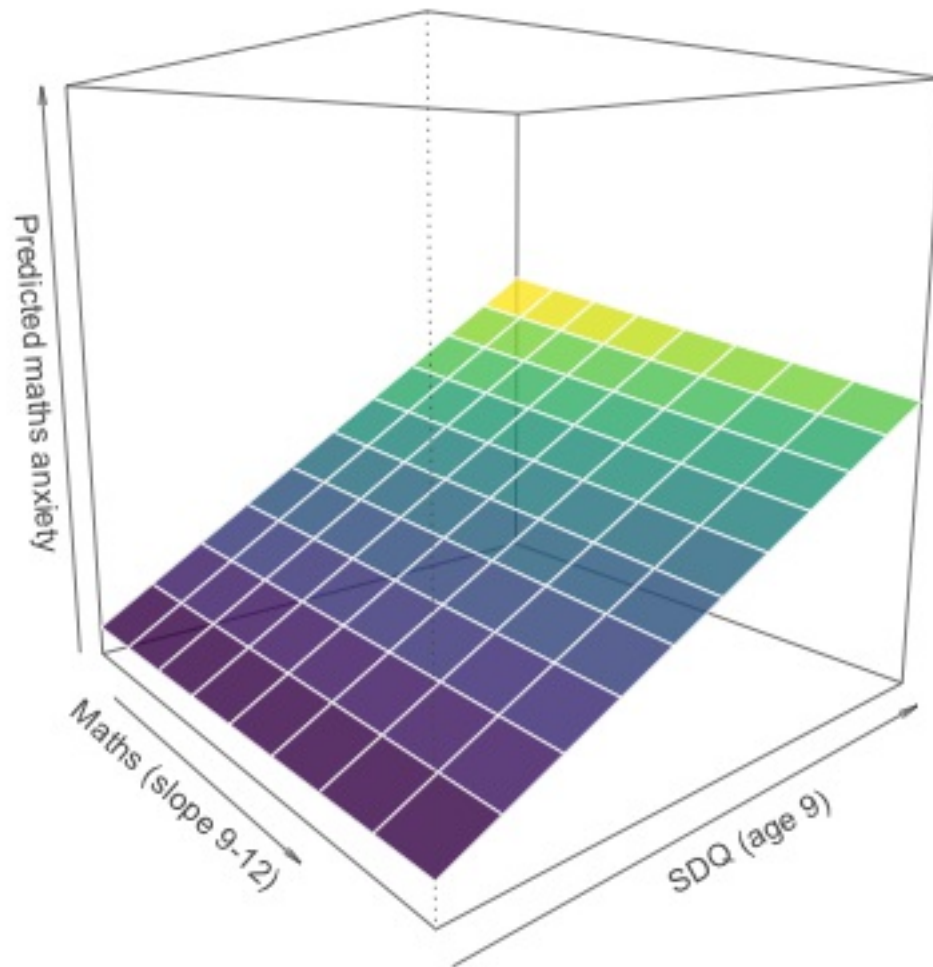
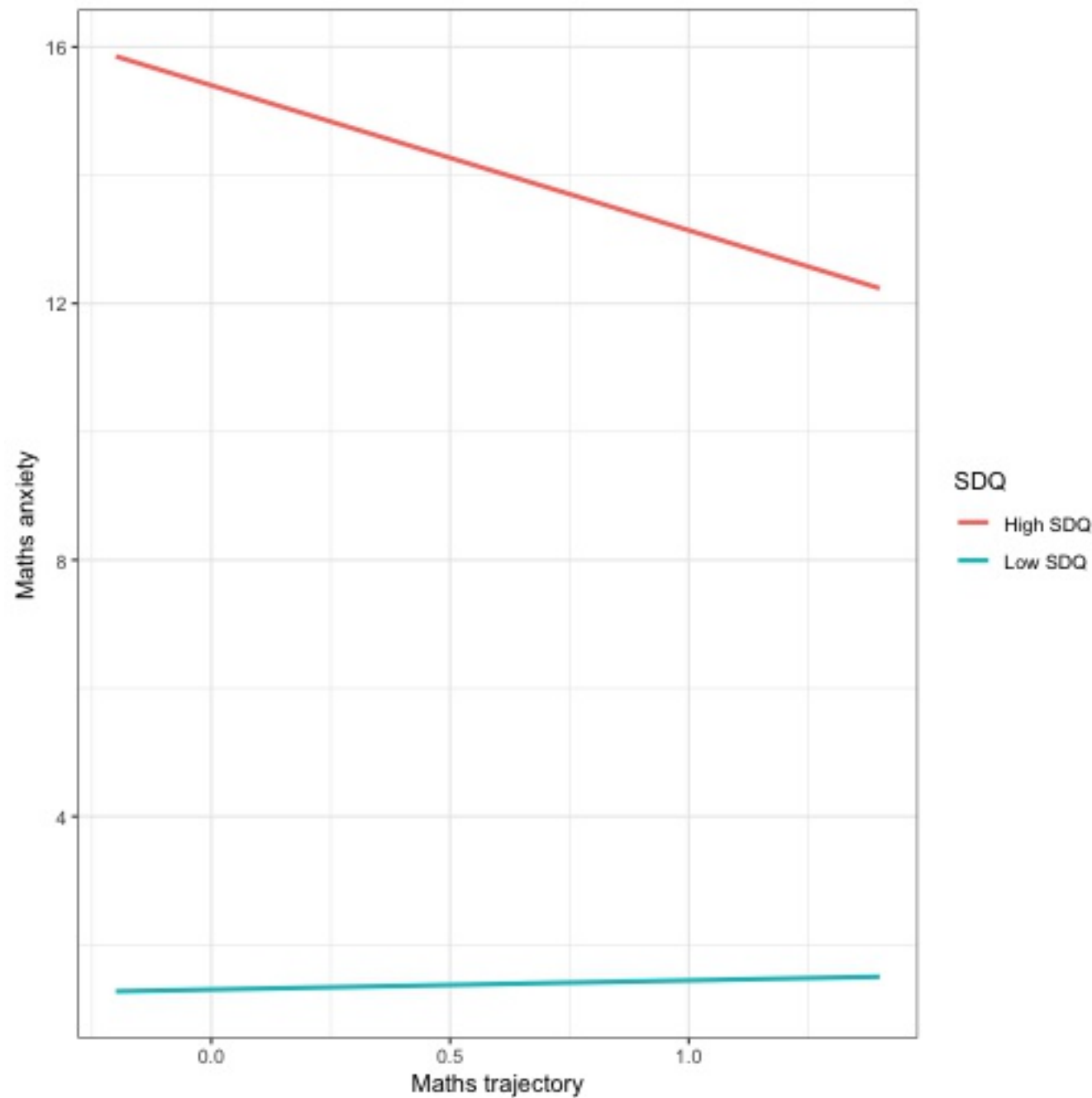


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Summary

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Significant predictors of maths anxiety

- Sex: boys are less maths anxious than girls (1.5 points lower on a 5 point scale)
- SDQ age 9 = higher maths anxious (small effect)
- Maths ability pre-transition: more ability = less anxiety (1.1 points lower on a 5 point scale)
- The effect of SDQ at age 9 on maths anxiety was moderated by the trajectory of maths attainment.
- The relationship between high SDQ and maths anxiety gets weaker as the trajectory in maths attainment increases

General conclusions

- If you want your children to be good at maths, get a degree
- Internalizing had a small impact on maths attainment at KS2, but not the trajectory over time.
- Maths anxiety is mostly affected by maths ability pre-transition
- The effects of SDQ were, at best, tiny
- We need to work on mathematical confidence early on

Join my cult



@profandyfield



www.discoveringstatistics.com



www.miltonthecat.rocks



www.youtube.com/profandyfield

Reducing anxiety

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- There is a dearth of tightly controlled experimental studies to demonstrate the efficacy of narrative-based teaching.
- Can embedding statistical teaching within a fictional narrative help to reduce anxiety and increase comprehension?
- This pilot study looked at the feasibility and plausible effects of using a fictional narrative to teach 11 statistical concepts.

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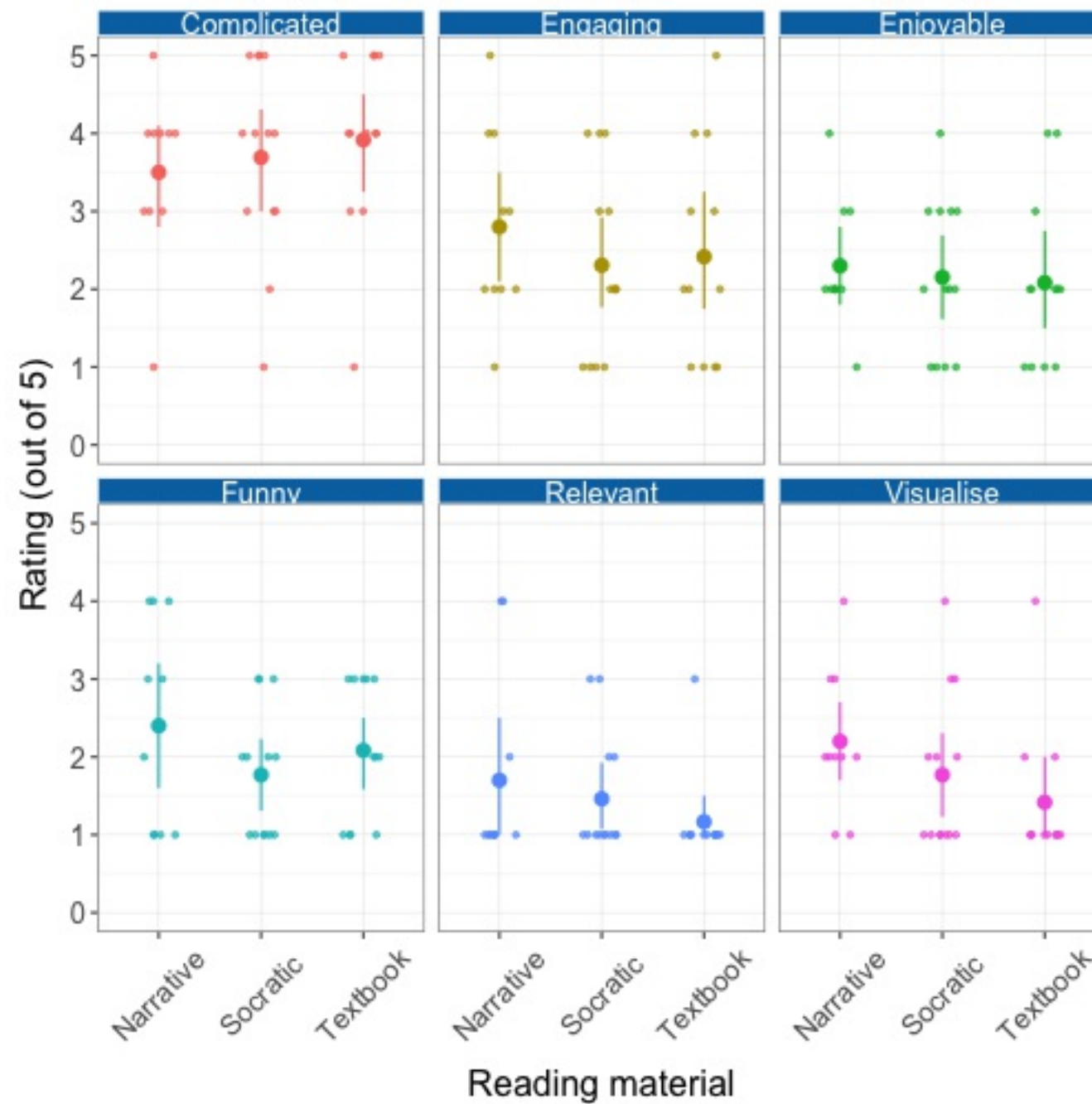
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- 22 multiple choice questions (2 per concept) were used to assess their understanding of the statistical concepts.

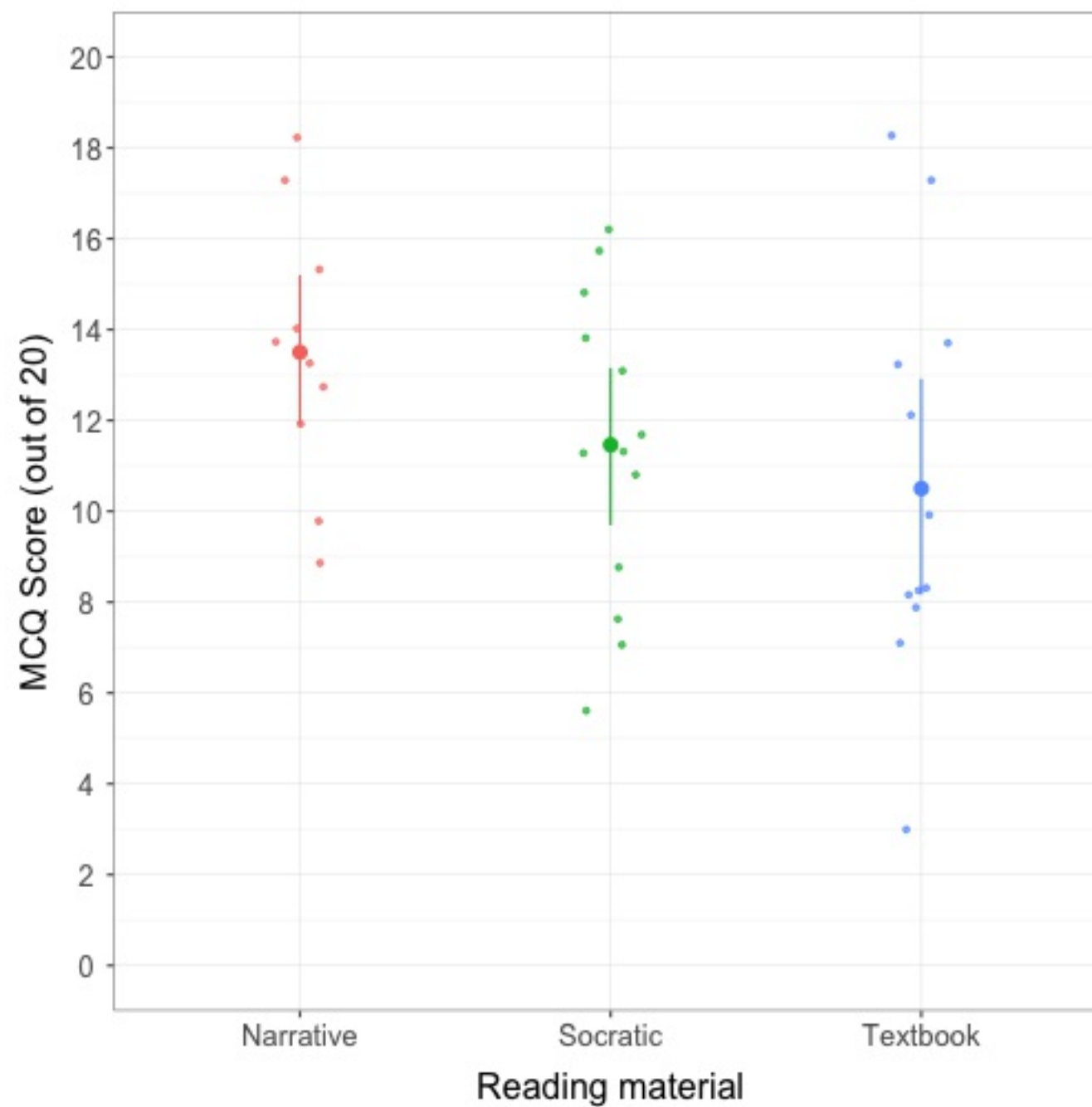
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- 22 multiple choice questions (2 per concept) were used to assess their understanding of the statistical concepts.
- We took Likert-scale measures of how complicated, engaging, enjoyable, funny, and relevant the teaching materials were as well as their ability to visualise them.

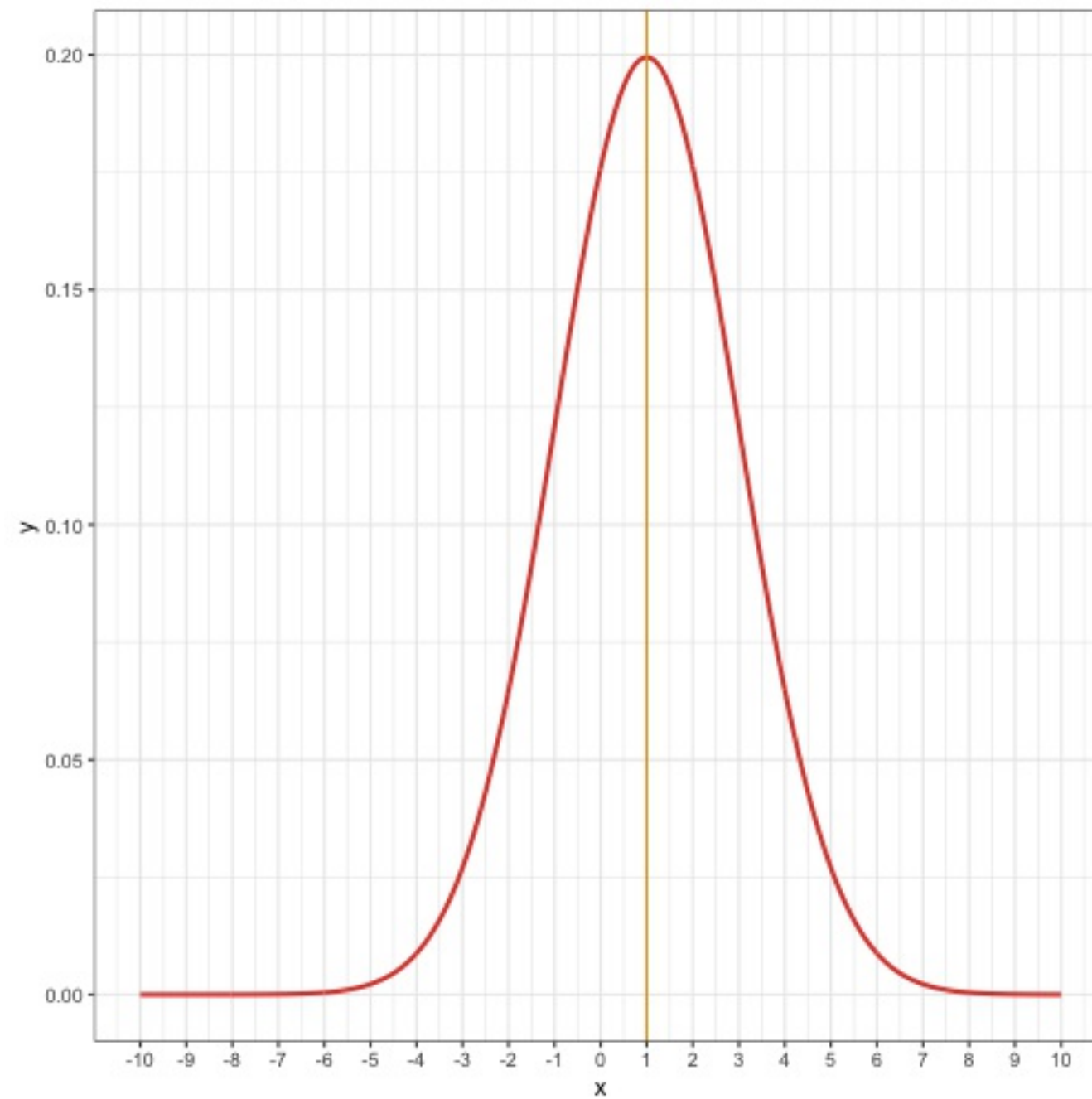
Engagement



Statistical comprehension



Bayesian prior



Bayesian estimates

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- The 95% HPDI intervals indicated that the plausible effect of using fictional narratives compared to standard textbook presentation ranged from $\beta = 0.28$ to 4.85 ($\beta = 2.43$)
- In contrast, the plausible effect of using Socratic materials compared to standard textbook presentation ranged from $\beta = -1.28$ to 3.11 ($\beta = 0.81$)

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