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

- Danielle Evans (University of Sussex)

TEDS

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- Danielle Evans (University of Sussex)

Slides created via the R package xaringan.

The chakra comes from remark.js, knitr, and R Markdown.

Why maths?

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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

School transition

frontiers in Psychology

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

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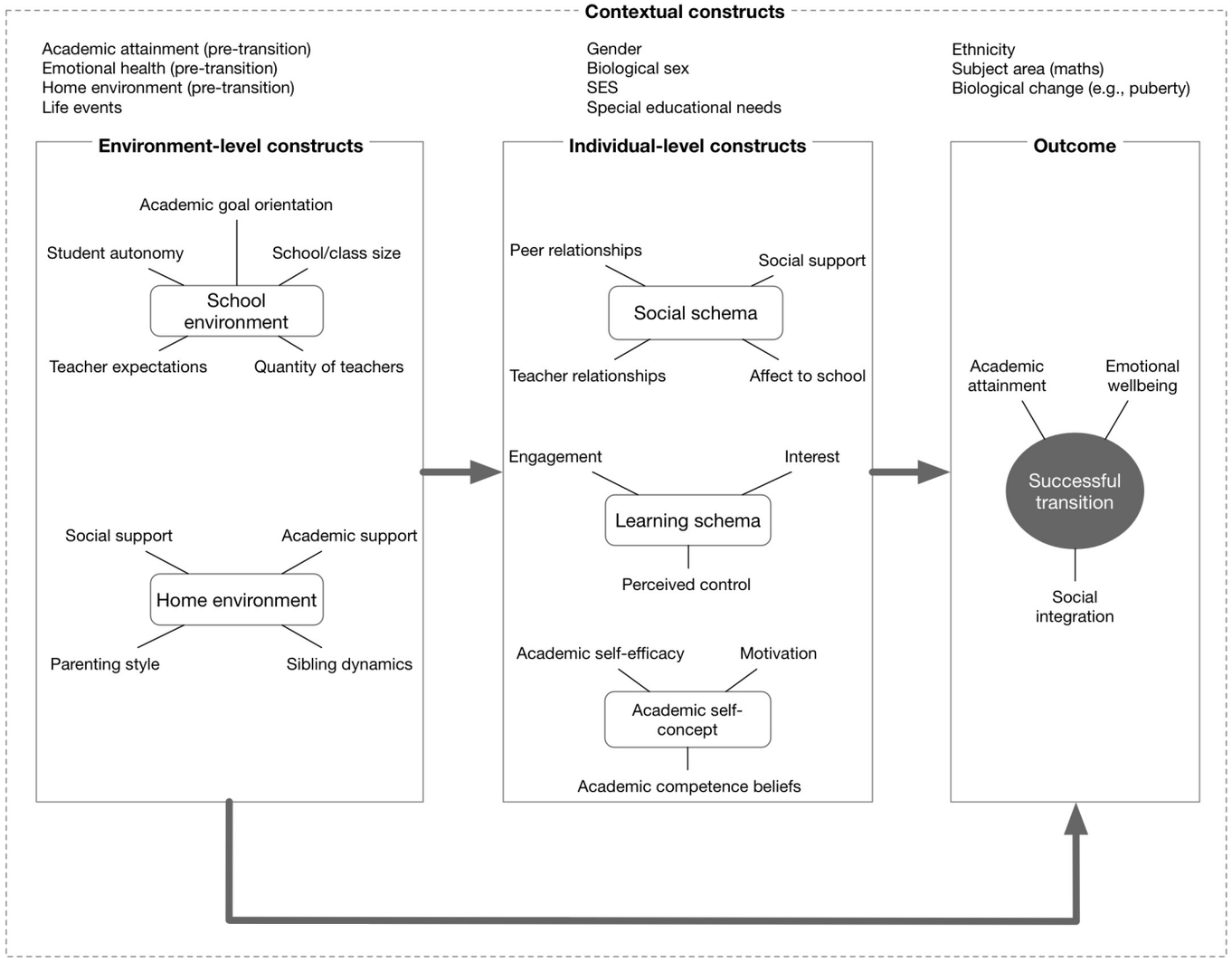
The transition from primary to secondary education is one of the most stressful events in a young person's life (Zeedyk et al., 2003) and can have a negative impact on psychological well-being and academic achievement. One explanation for these negative impacts is that the transition coincides with early 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.


Contextual constructs
Academic attainment (pre-transition)
Emotional health (pre-transition)
Home environment (pre-transition)
Life events
Gender
Biological sex
SES
Special educational needs
Ethnicity
Subject area (maths)
Biological change (e.g., puberty)
Environment-level constructs
Academic goal orientation
Student autonomy
School/class size
School environment
Teacher expectations
Quantity of teachers
Social support
Academic support
Home environment
Parenting style
Sibling dynamics
Individual-level constructs
Peer relationships
Social support
Social schema
Teacher relationships
Affect to school
Engagement
Interest
Learning schema
Perceived control
Academic self-efficacy
Motivation
Academic self-concept
Academic competence beliefs
Outcome
Academic attainment
Emotional wellbeing
Successful transition
Social integration

Attentional control theory

Eysenck et al. (2007)

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Working memory capacity (WMC) moderates anxiety effects on cognition (Owens et al., 2014)

- 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:

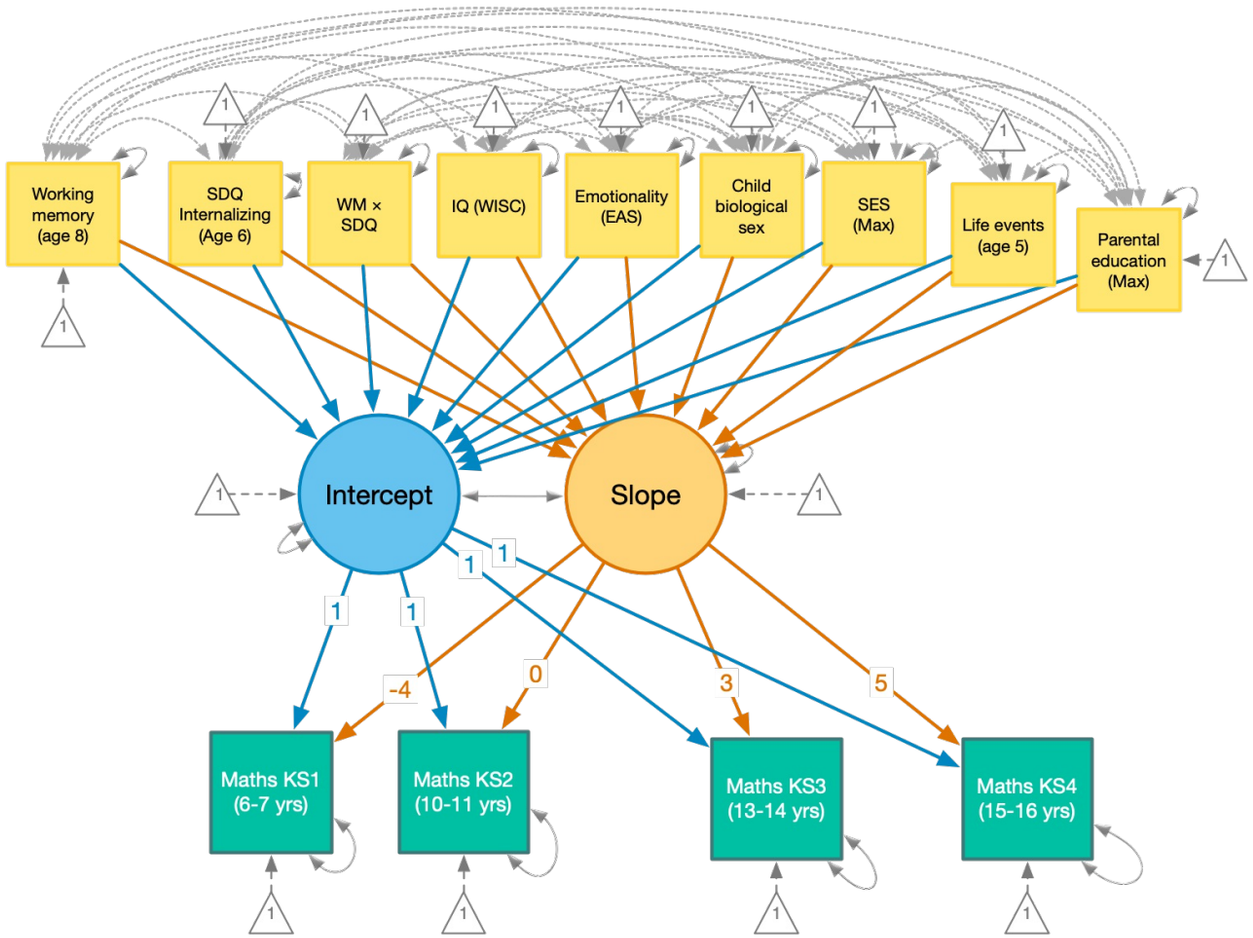
- Internalizing (proxy for anxiety) measured using the The Strengths and Difficulties Questionnaire (SDQ) at age 6.75.
- The sum of and were used.

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.


Working memory (age 8)
SDQ Internalizing (Age 6)
WM × SDQ
IQ (WISC)
Emotionality (EAS)
Child biological sex
SES (Max)
Life events (age 5)
Parental education (Max)
Intercept
Slope
Maths KS1 (6-7 yrs)
Maths KS2 (10-11 yrs)
Maths KS3 (13-14 yrs)
Maths KS4 (15-16 yrs)
-4
0
3
5

Statistical considerations

Statistical considerations

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

- SES
- IQ
- Working memory
- Emotionality

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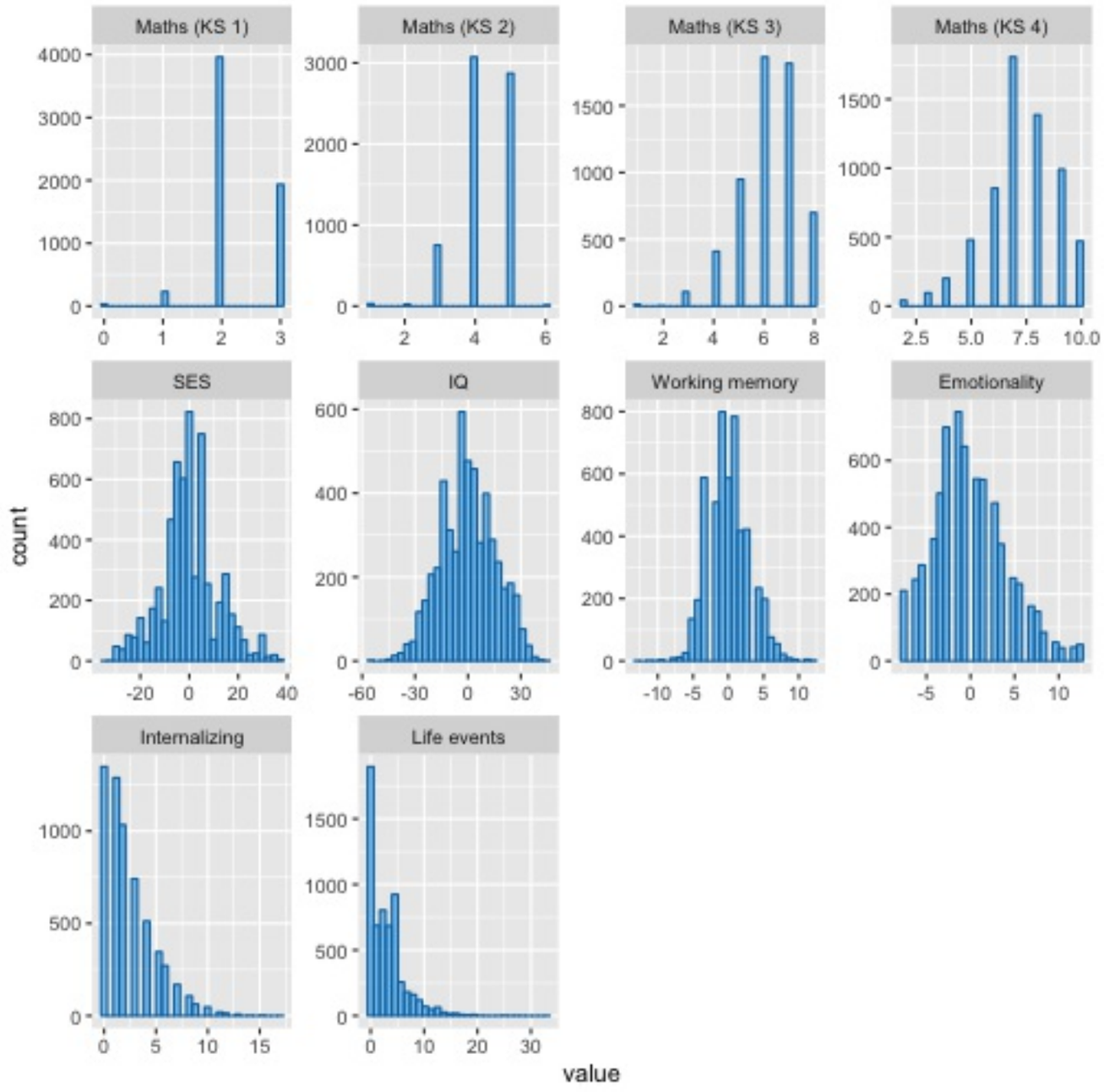
- SES
- IQ
- Working memory
- Emotionality

Missing data

- Patterns of missing data in predictors
- Models fit with lavaan[1] using multiple imputation based on 70 imputed data sets imputing predictors only[2]
- 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


Maths (KS 1)
Maths (KS 2)
Maths (KS 3)
Maths (KS 4)
SES
IQ
Working memory
Emotionality
Internalizing
Life events
count
value

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

Summary

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)
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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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- 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 used[1]

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

Exclusions

Exclusions

before exclusions

- 12586

Exclusions

before exclusions

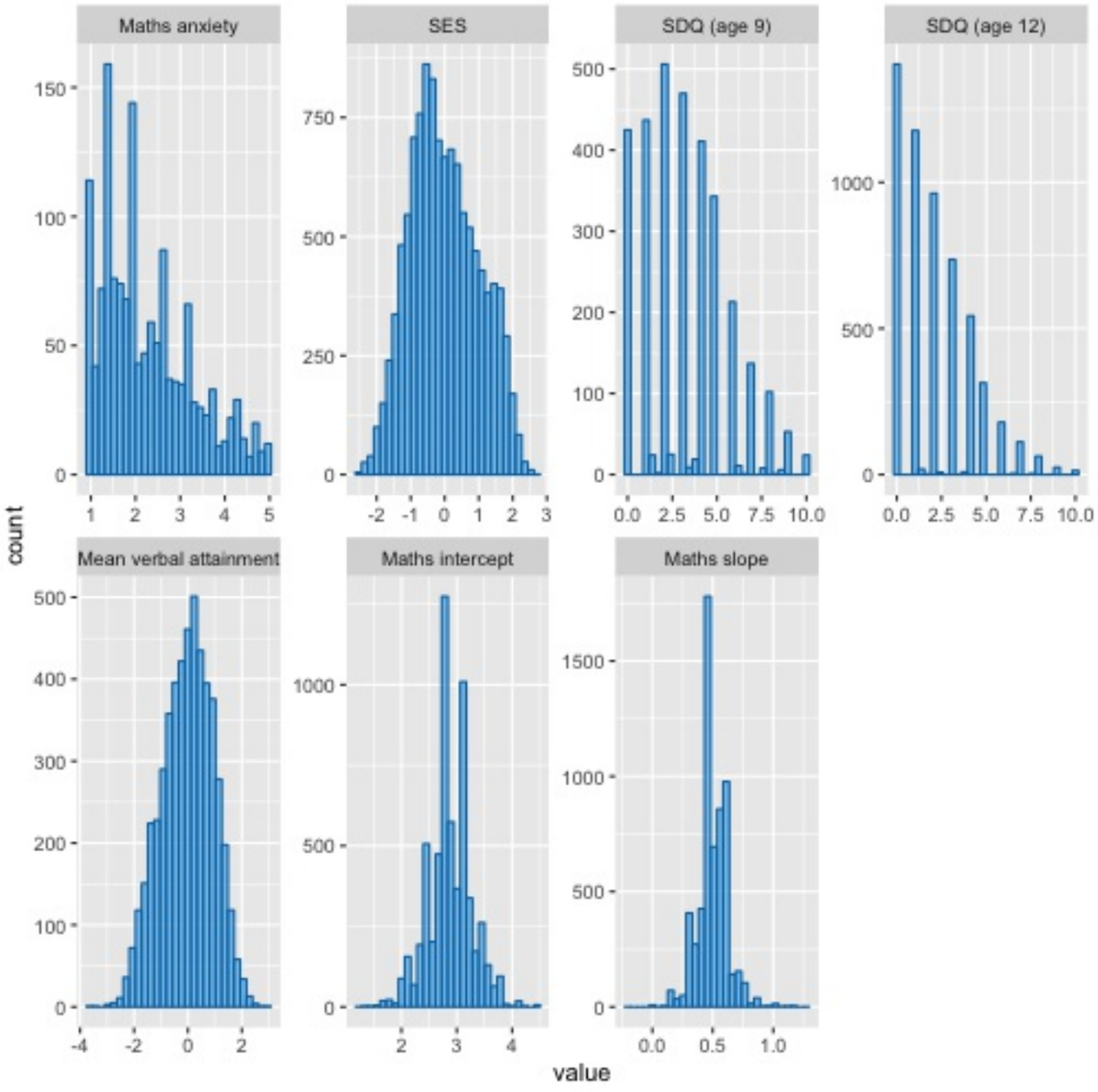
- 12586

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

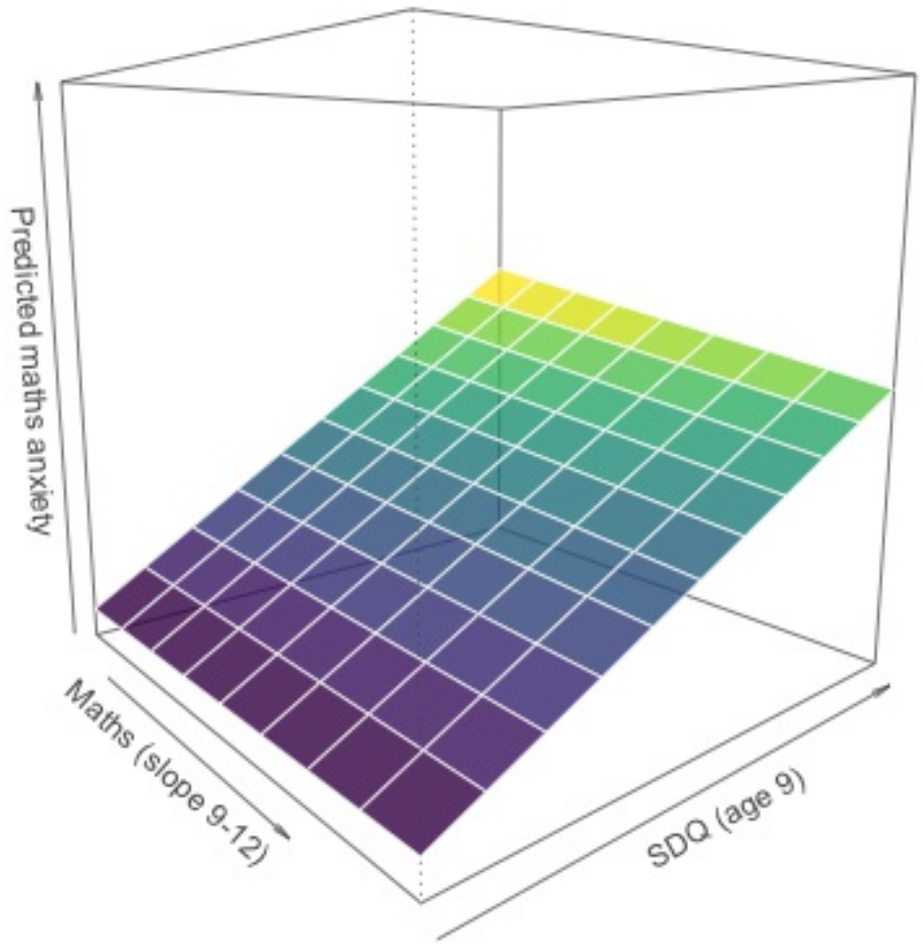

Maths anxiety
SES
SDQ (age 9)
SDQ (age 12)
Mean verbal attainment
Maths intercept
Maths slope
count
value

Predictors of maths anxiety

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

			95% CI			
Predictor	**Estimate**	**SE**	**lower**	**upper**	**t**	**p**
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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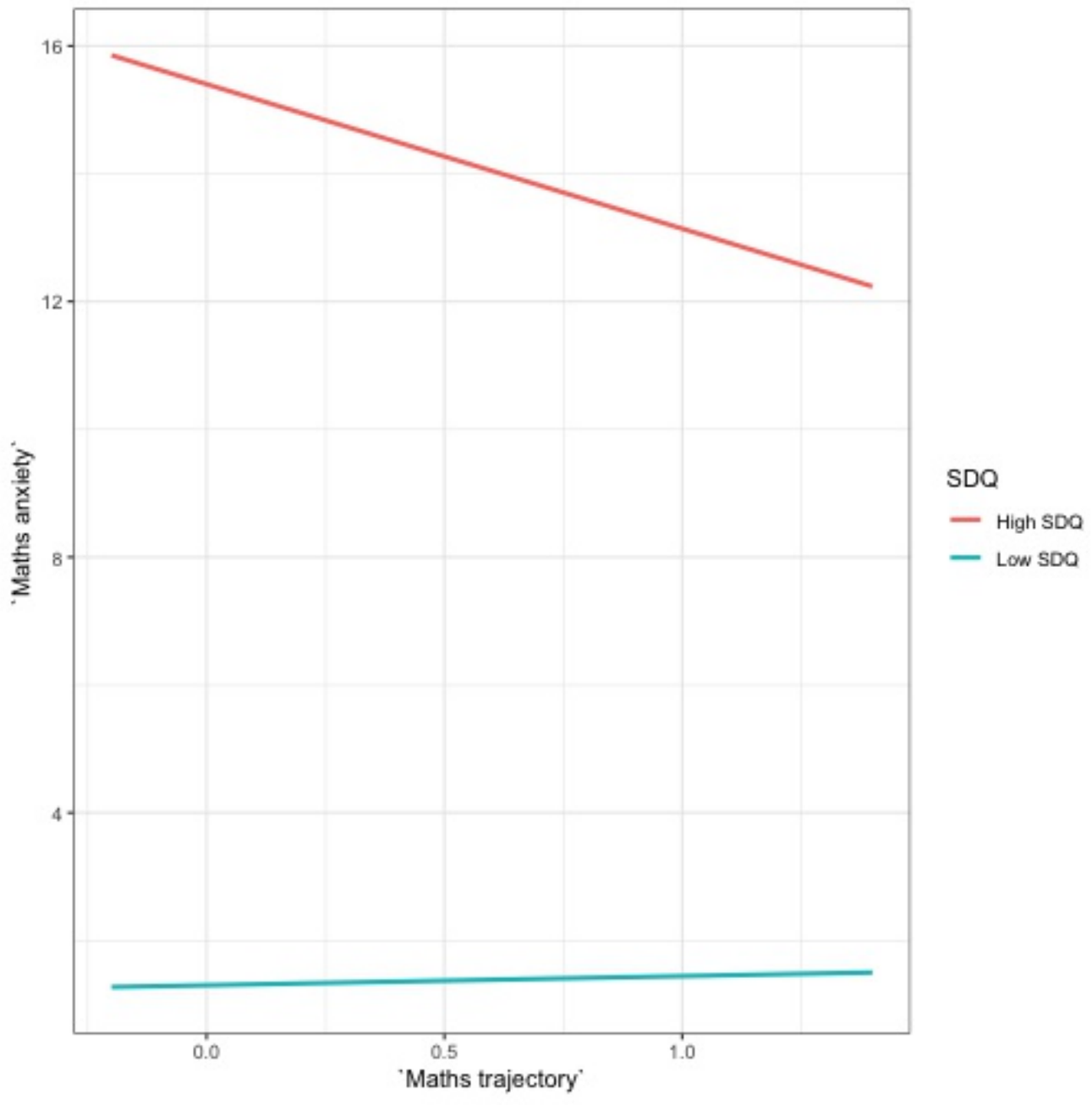

Summary

Summary

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

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www.discoveringstatistics.com

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www.youtube.com/profandyfield

Reducing anxiety

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- Children engage in story-based learning from a very early age, using metaphor to infer knowledge and description to create mental imagery (Egan & Gillian 2016).
- There is a dearth of tightly controlled experimental studies to demonstrate the efficacy of narrative-based teaching.

Reducing anxiety

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- Maths anxiety is a barrier to learning maths and related subjects (Carey et al., 2016) but little is known about how to reduce it.
- Children engage in story-based learning from a very early age, using metaphor to infer knowledge and description to create mental imagery (Egan & Gillian 2016).
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Reducing anxiety

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- 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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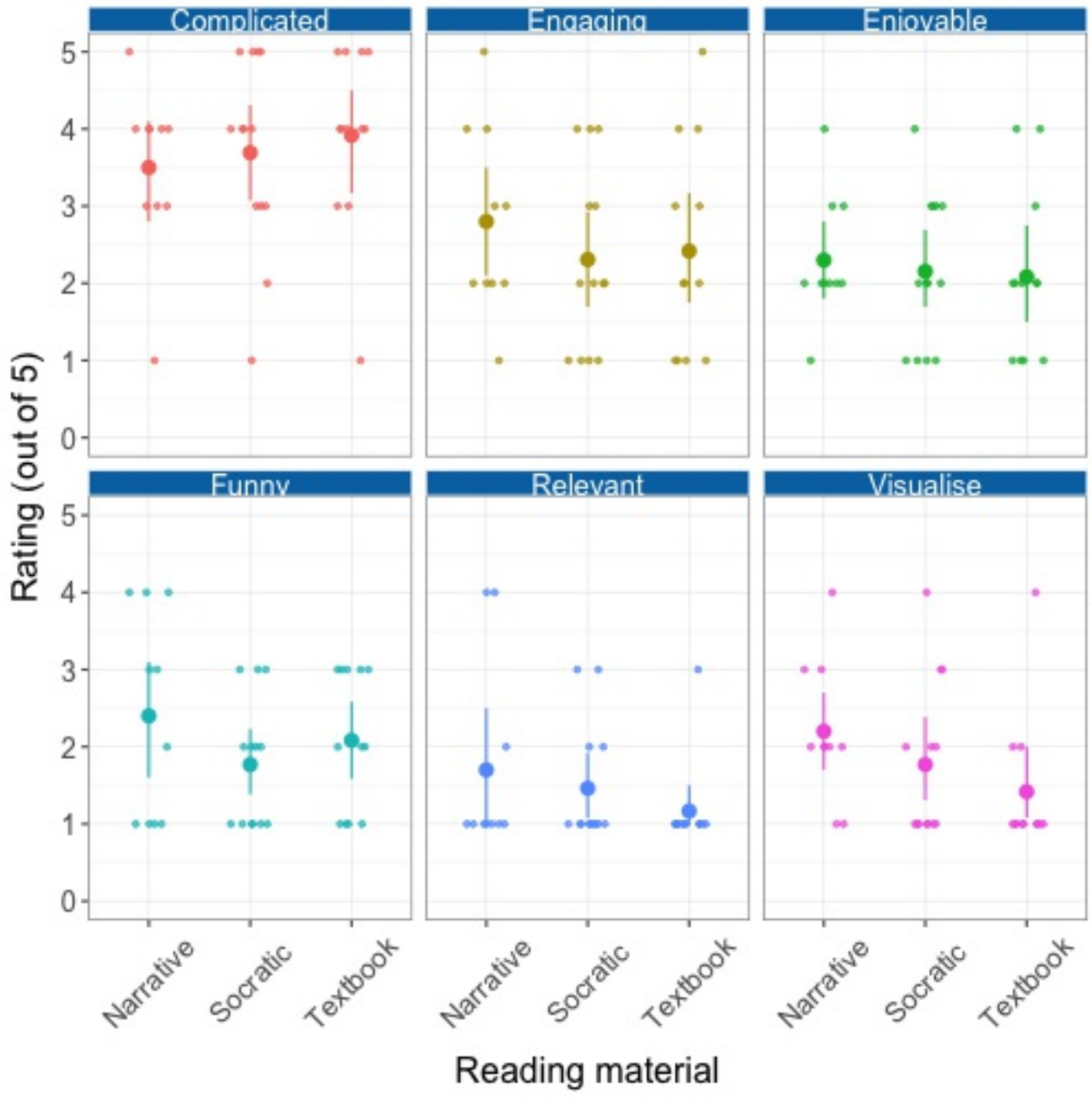
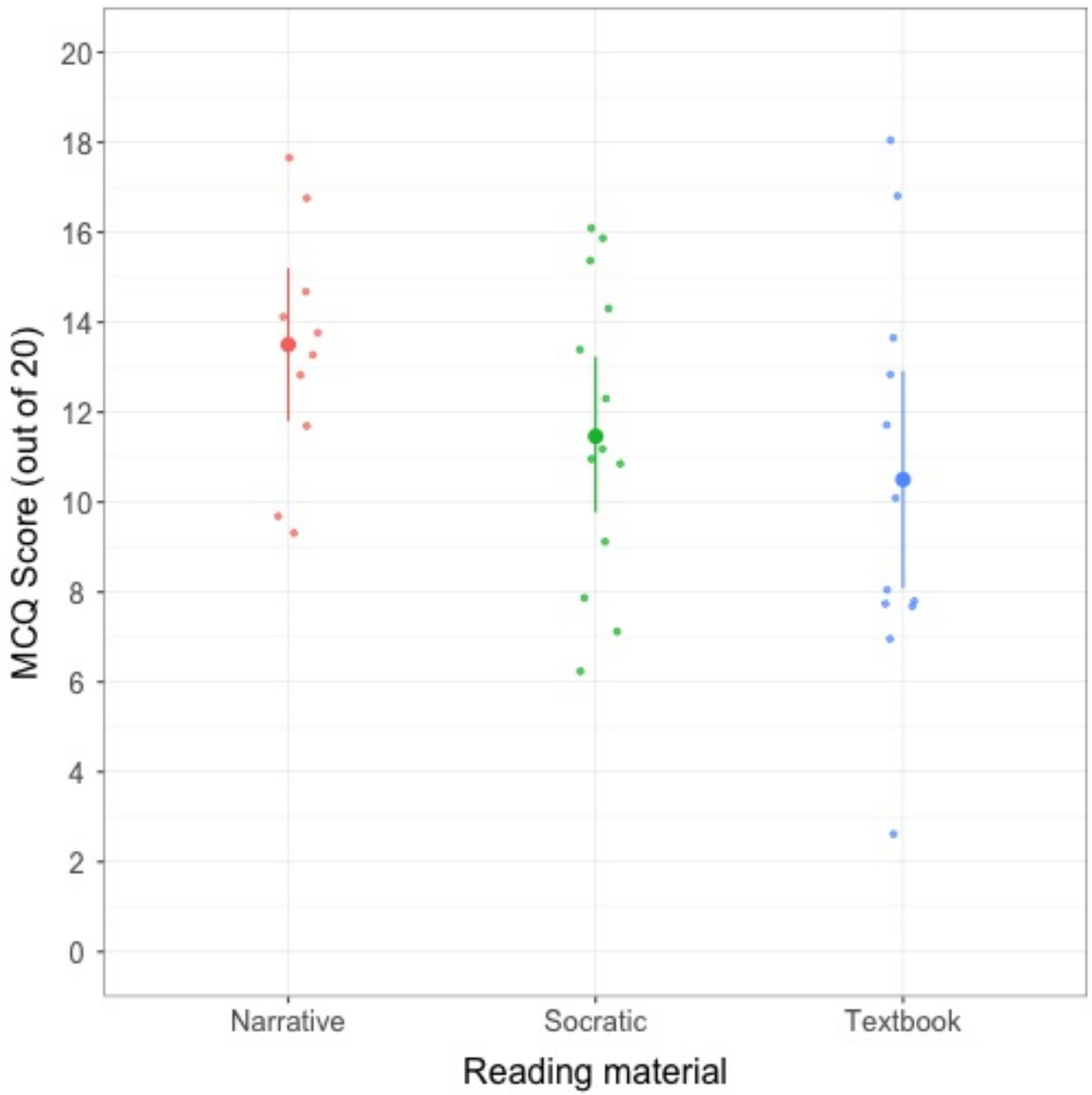
- We took Likert-scale measures of how complicated, engaging, enjoyable, funny, and relevant the teaching materials were as well as their ability to visualise them.

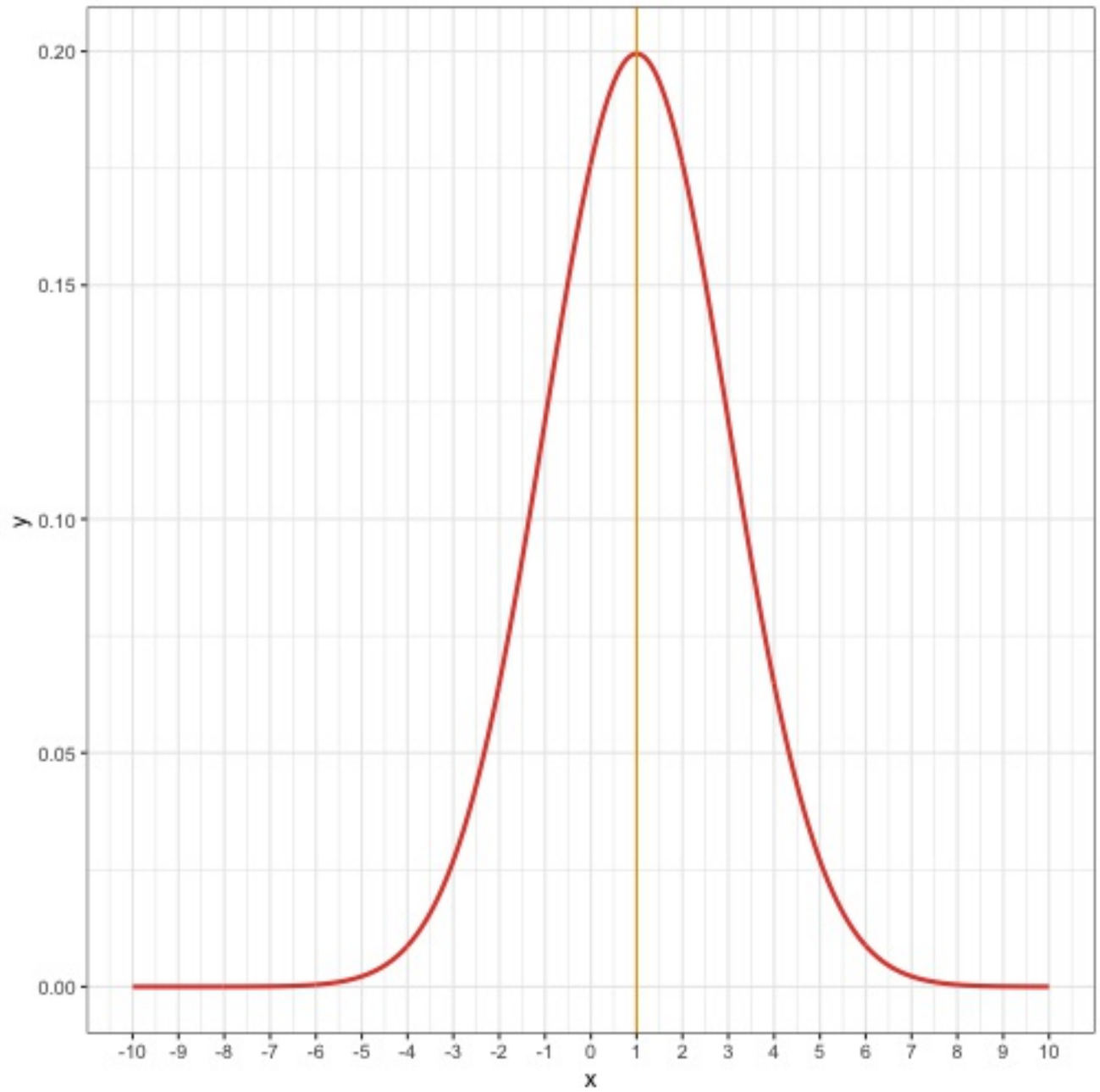
Engagement


Complicated
Engaging
Enjoyable
Funny
Relevant
Visualise
Rating (out of 5)
0
1
2
3
4
5
Narrative
Socratic
Textbook
Reading material

Statistical comprehension



Bayesian prior



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- A broad Guassian prior was used representing a mean difference centred on 1, with plausible mean differences ranging between extremes of -5 to 7 (approx.)
- The 95% HPDI intervals indicated that the plausible effect of using fictional narratives compared to standard textbook presentation ranged from = 0.28 to 4.85 (= 2.43)
- In contrast, the plausible effect of using Socratic materials compared to standard textbook presentation ranged from = -1.28 to 3.11 (= 0.81)

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