

Investigating Math Motivation and Math Anxiety in Undergraduate Students

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Introduction

Math anxiety

- Enormous interest (scholarly and otherwise)
- Avoidance of math and math-based careers (Ashcraft, 2002)
- Frequently studied, but not perfectly understood

Math motivation

- How can we conceptualize it?

Study Motivation

- ▶ Anxiety and motivation extensively studied as predictors of academic performance (e.g., Halat & Çimenci Ateş, 2016, Struthers et. al, 2000)
- ▶ Math anxiety and math motivation have studied as predictors of math performance (e.g., Chang & Beilock, 2016, Steinmayr & Spinath, 2009)
- ▶ Examine math anxiety and math motivation directly to better understand both concepts

Self Determination Theory (SDT)

- ▶ Richard Ryan and Edward Deci (Ryan et. al, 1985)
- ▶ Growth tendencies, self-motivation, personality integration
- ▶ Amotivation, Extrinsic Motivation, Intrinsic Motivation
 - ▶ Degree of “self-regulation” or internalization



SDT (continued)



Motivation is activity-specific



Wide range of academic disciplines, including chemistry, business, and math



Breaks down extrinsic motivation into several regulatory styles



Students A & B: A case study

Math Anxiety



Ashcraft (2002): “a feeling of tension, apprehension, or fear that interferes with math performance” (p. 181)



Chang & Beilock (2016): “a separate phenomenon from general trait anxiety or test anxiety...associated with specific impairments in processing math-related or number-related tasks” (p. 33)



Two key points

1. Interferes with performance on math-related tasks
2. More than test anxiety

Research Question

- ▶ Does type and degree of motivation predict math anxiety experienced by undergraduates?
- ▶ Hypothesis: Math motivation is predictive of math anxiety levels
 - ▶ Amotivation and more extrinsically-regulated forms of motivation: positive correlation
 - ▶ Intrinsically-regulated motivation: negative correlation

Methods



37-item Likert-style questionnaire



College Algebra or Precalculus for Business, Life, and the Social Sciences course (n=56)



Multiple Regression Analysis in R (R Core Team, 2018)



Literature review to construct conceptual model

Methods

Academic Motivation Scale-Math (AMS-Math)

- Why do you take math courses?
- Adapted from AMS-Chemistry (Liu et. al, 2017)

Abbreviated Math Anxiety Scale (AMAS) (Hopko et. al, 2003)

- How much anxiety do you feel in the following situations?

Why do you take math courses?

Using the scale provided, indicate to what extent each of the following items presently corresponds to one of the reasons why you take math courses.

	Not at all	A little	Moderately	A lot	Exactly

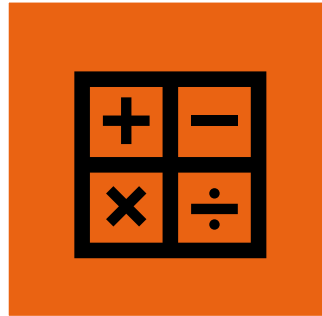
1. Because without having taken math I would not find a high-paying job later on.
2. Because I experience pleasure and satisfaction while learning new things.
3. Because I think that math courses will help me better prepare for the career I have chosen.

How much anxiety do you feel in the following situations? Please respond below according to the scale provided.

	Not at all anxious	Slightly anxious	Moderately anxious	A lot anxious	Very much anxious

1. Having to use the tables in the back of a math book.
2. Thinking about an upcoming math test one day before.
3. Watching a teacher work an algebraic equation on the blackboard.

Survey Validation: Cronbach's Alpha



AMS-Math

.87 (identified regulation) to
.93 (introjected regulation)



AMAS

.88 (.90 in Hopko et. al, 2003)

Linear Model Assumptions

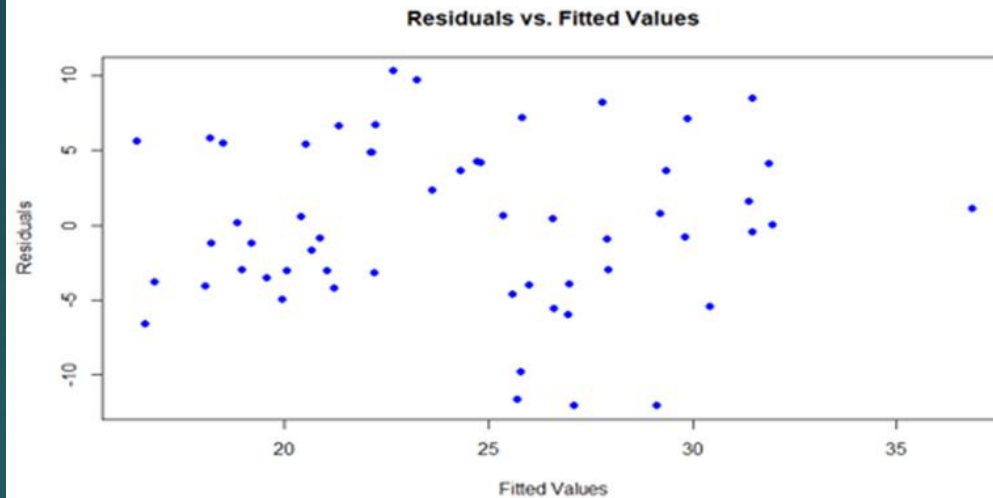


Figure 2a) Homoscedasticity

Random scatter observed on residual plot suggests that the fitted linear model is appropriate

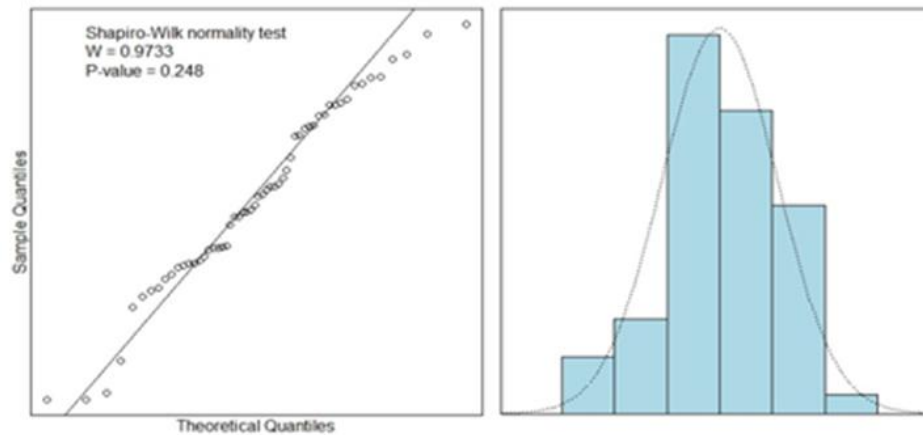


Figure 2b) Normal Distribution of Residuals

Shapiro-Wilk test provides insignificant evidence to reject the null hypothesis that the residuals are normally distributed

Regression Results

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Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)   17.6617    6.9081    2.557  0.01379 *
Amotivation    1.0108    0.3595    2.811  0.00712 **
External.Regulation  0.4853    0.3263    1.488  0.14340
Introjected.Regulation  0.1593    0.3249    0.490  0.62621
Identified.Regulation -0.2348    0.4396   -0.534  0.59571
Experience    -0.5042    0.4568   -1.104  0.27517
Accomplish    0.4167    0.5142    0.810  0.42175
Know         -0.5912    0.6368   -0.928  0.35781
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.877 on 48 degrees of freedom
Multiple R-squared:  0.4311,    Adjusted R-squared:  0.3481
F-statistic: 5.196 on 7 and 48 DF,  p-value: 0.0001863
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Figure 3: Multiple Linear Regression Results

Key Findings

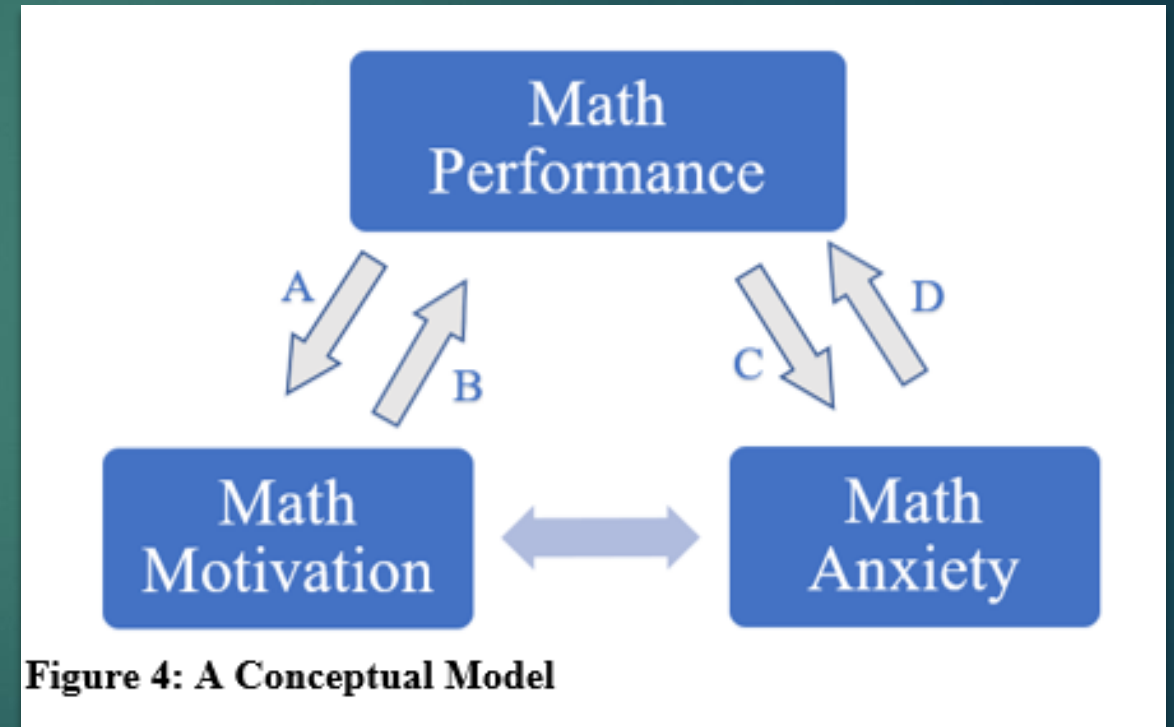
Amotivation is a statistically significant predictor variable (p-value=.007, point estimate=1.01)

Non-significant variables (except for “To Accomplish”) show expected slope direction

Females didn't experience significantly higher math anxiety levels than males (p-value for difference = .77)

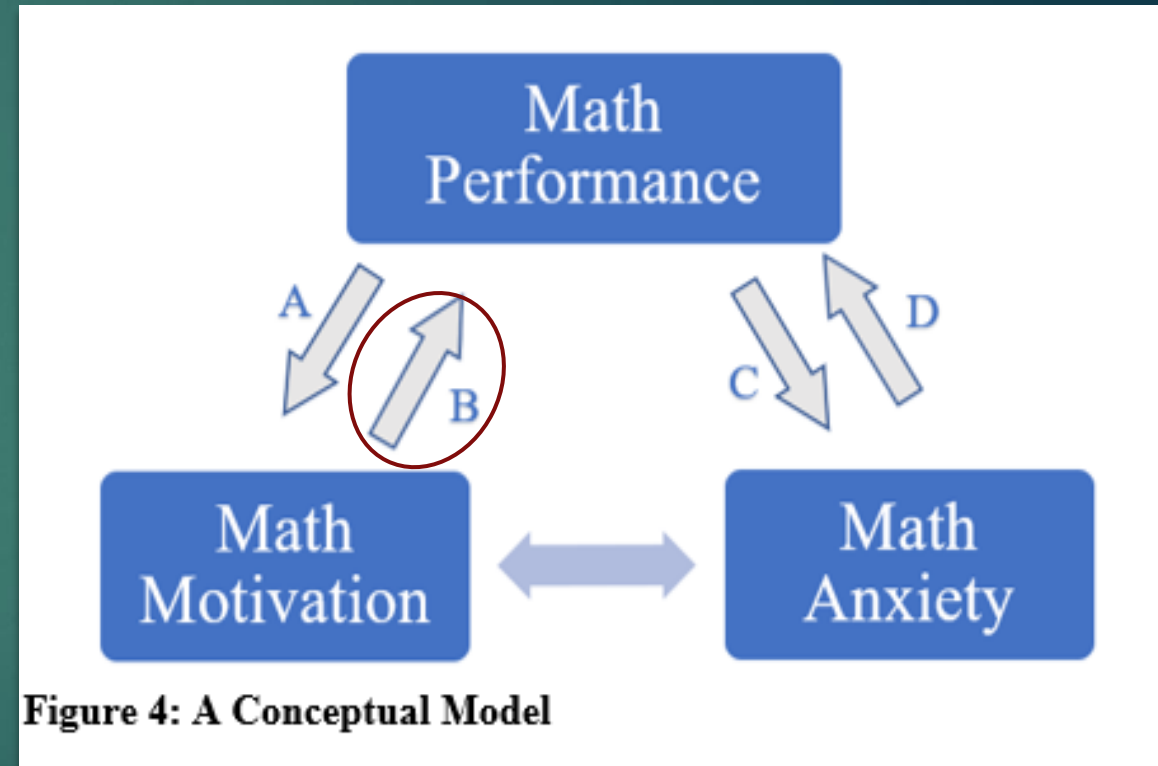
Discussion: Towards a Conceptual Model

- ▶ Why the correlation between amotivation and math anxiety?
 - ▶ Hembree's (1990) meta-analysis: $-.64$ mean correlation
- ▶ Conjecture: math performance mediates relationship between math anxiety and motivation



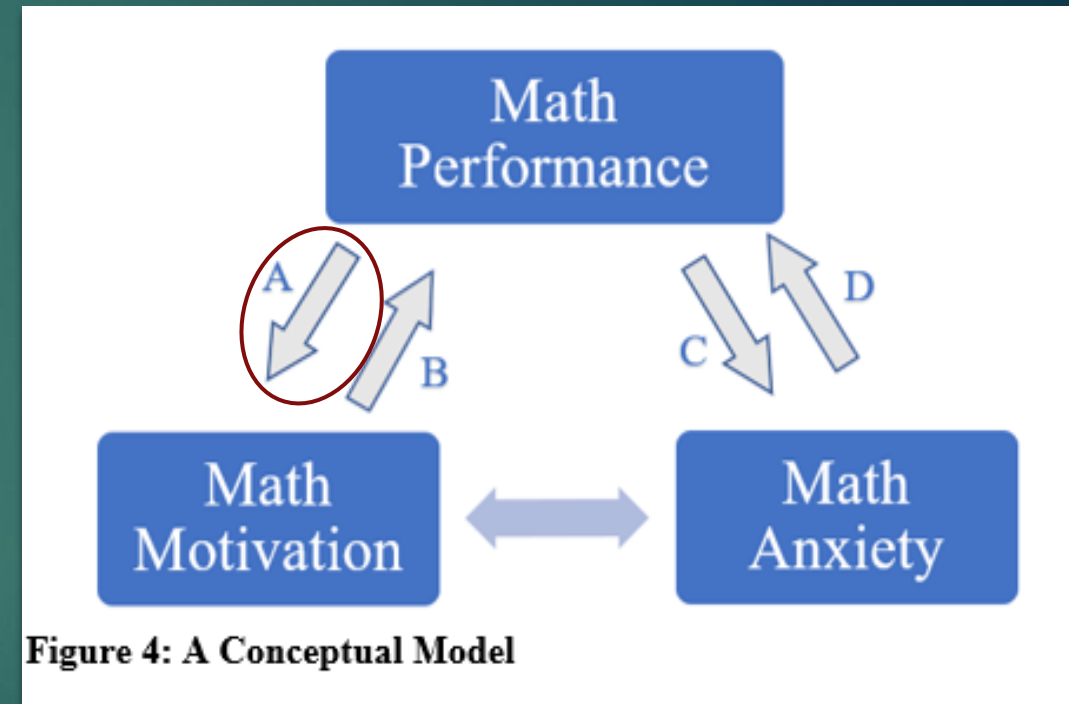
Relationship B: Math Motivation to Math Performance

- ▶ Fortier et. al (1995)
 - ▶ Self-determination/ autonomous motivational profile leads to higher school grades
- ▶ Conceptualized this way by SDT (Ryan & Deci, 2000)
 - ▶ “Motivation is highly valued because of its consequences: motivation produces” (p. 69)
- ▶ Practical experience: motivated students perform well



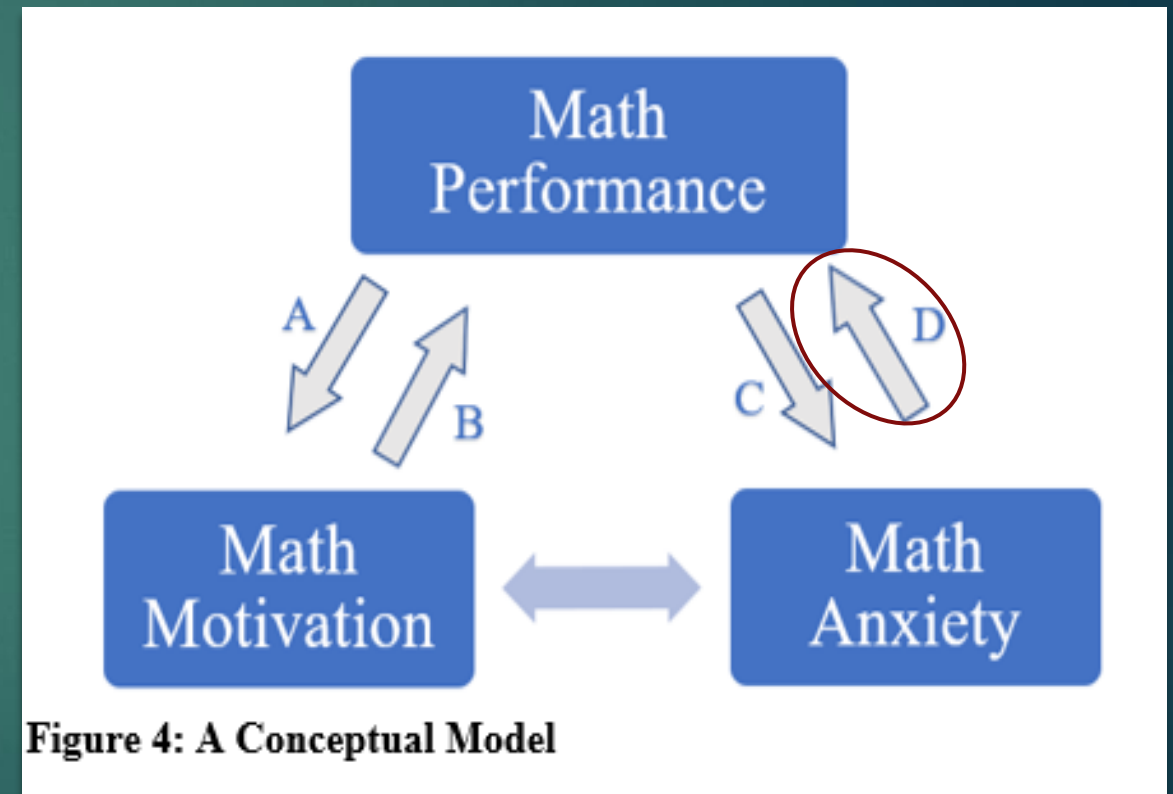
Relationship A: Math Performance to Math Motivation

- ▶ Marsh & Yeung (1997)
 - ▶ Longitudinal study of 603 high school students in English, Math, and Science
 - ▶ Performance and self-concept (often considered a motivational variable) are reciprocally related
- ▶ Cleary & Chen (2009)
 - ▶ Negative performance comparisons with other students lead to “maladaptive motivational behaviors, such as poor effort and persistence” (p. 294)
- ▶ Practical example: students dropping class after poor first exam



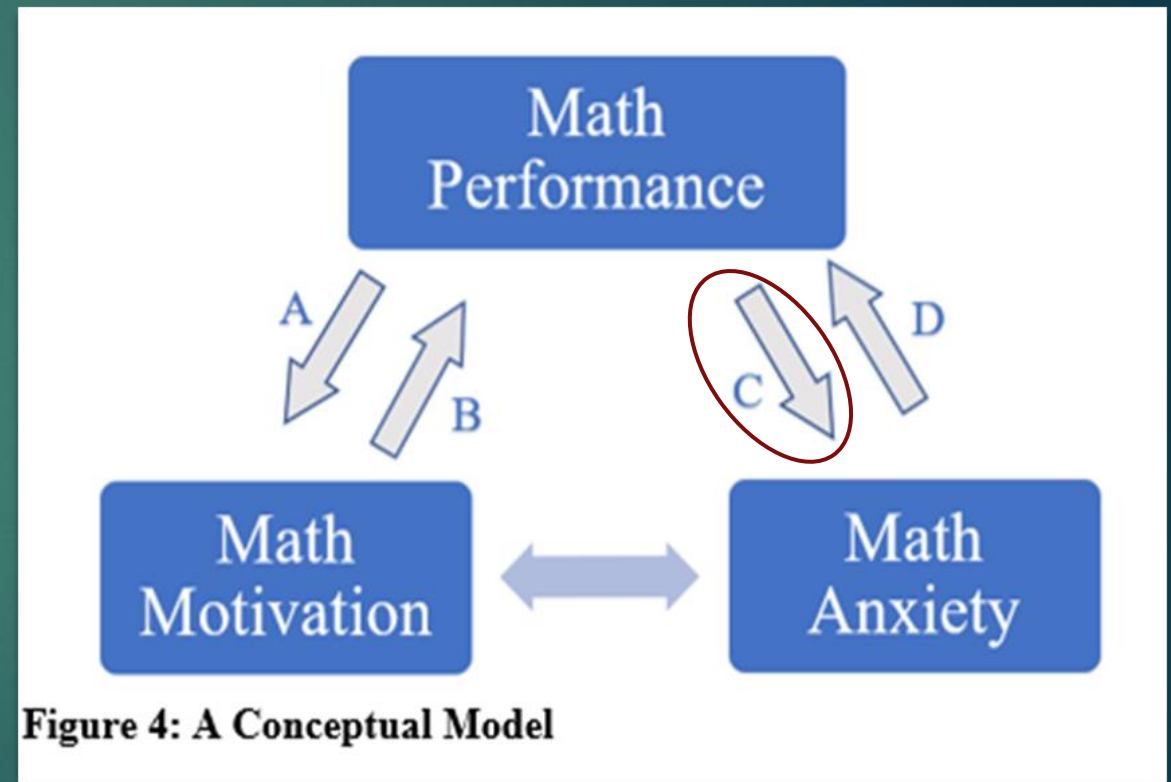
Relationship D: Math Anxiety to Math Performance

- ▶ Math anxiety inhibits math performance by definition
 - ▶ Ashcraft (2002)
 - ▶ Chang & Beilock (2016)
- ▶ Hembree (1990)
 - ▶ “Math anxiety depresses performance” (p. 44)



Relationship C: Math Performance to Math Anxiety

- ▶ Ma & Xu (2004)
 - ▶ Data from Longitudinal Study of American Youth (LSAY)
 - ▶ “Prior low mathematics achievement significantly related to later high mathematics anxiety” (p. 165)
 - ▶ “Deficits model”
 - ▶ Poor math performance increases math anxiety



Study Limitations

- ▶ Convenience sample, results not fully generalizable
- ▶ Only lower division courses studied
- ▶ Response bias
 - ▶ More motivated students more likely to take survey
- ▶ Self-reported
 - ▶ Social desirability bias (Edwards, 1953)
- ▶ No re-testing
 - ▶ Motivation levels change over the course of a semester (Liu et. al, 2017)

Conclusions

- ▶ Amotivation is associated with math anxiety
- ▶ Math performance may mediate relationship between math motivation and anxiety
- ▶ Further research:
 - ▶ Larger sample across more levels of math, re-testing over time
 - ▶ Incorporate other constructs, such as study habits (Ryals & Keene, 2017) and self-efficacy (Bandura, 1997) into the conceptual model

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