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Short Communication

Trait beliefs that make women vulnerable to math disengagement

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ABSTRACT

This study examined if women's beliefs regarding the malleability of traits influences their tendency to disengage from the math domain following failure. As predicted, women who believed their math skills were fixed and unchangeable showed less math identification and less interest in math tasks than women who believed their math skills were malleable. These results suggest that women with fixed-trait beliefs are more likely to fall prey to the gender gap that exists in mathematics fields.

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1. Introduction

Great strides have been made over the past few decades to encourage and support women in the math-related fields. Despite this progress, however, women continue to lag behind men in terms of math performance in college courses (Hyde, Fennema, & Lamon, 1990), standardized math test scores (National Center for Education Statistics, 1997), and pursuit of math-related careers (Hewitt & Seymour, 1991). One reason for this gender gap is that women may be more likely than men to disengage from the domain. Explanations for math disengagement have varied from genetic, to sociocultural, to situational (for reviews, see Ceci & Williams, 2007; Ceci, Williams, & Barnett, 2009).

The present work approaches this issue in a unique way by examining the role that individual differences play in this dynamic. Clearly, not all women fall prey to math disengagement; therefore, our goal was to identify an individual difference variable that may impact this effect. Specifically, we believe that differences in trait beliefs may make some women more vulnerable to math disengagement than others. We first review the literature on domain disengagement and then turn our attention to the belief structures that may make some women more vulnerable to this disengagement.

1.1. The role of belief structures in domain disengagement

One factor that plays an important role in people's engagement with a particular domain is how identified they are with that do-

main (for a more thorough review of this topic, see Steele, 1992). Domain identification is defined as perceiving a domain as attractive, important, and having favorable outcomes (Smith & White, 2001; Steele, 1997). Highly identified individuals perceive the domain as self-relevant and their sense of well-being depends on achievement in that domain. Domain identification is important for an individual's success because it is perceived to play an integral role in academic achievement (Steele, 1997). This means that women high in math identification would be more likely to pursue careers in math, despite external deterrents such as teachers' low expectations or society's rigid gender roles.

The majority of work on domain disidentification focuses on differences between minority and majority members. This work shows that minority members are more likely than majority members to disengage from a domain after failure, and this is particularly likely when negative stereotypes are present (Major & Schmader, 1998; Osborne, 1995; Steele, 1997). This work so far assumes that minority members as a whole tend to show this tendency; however, it seems likely that some minority members are more likely than others to respond to failure in this extreme manner. The present study will explore this possibility by examining the trait beliefs that may make some minority members more likely to respond in this way.

According to Dweck's (1986, 1999) implicit theories model, people differ in their lay beliefs about the malleability of personal attributes. Such beliefs are divided into two categories: entity and incremental. People who hold an *entity* perspective view traits as fixed. An "entity woman" believes that she is either born with good math skills or not and that no amount of work will enable her to improve. People who hold an *incremental* perspective view traits as malleable and improvable. An "incremental woman" believes

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that her math skills are developed through education and practice and that she can always improve. Differences in these trait beliefs are important because they have been shown to strongly influence motivation. Entity individuals are particularly motivated to prove that they possess high abilities; therefore, they adopt performance goals and focus on the outcome of a task in an attempt to demonstrate their competence. Incremental individuals are motivated to improve their abilities; therefore, they adopt learning goals and focus on discovering new strategies or behaviors that will help them complete the task.

Research shows that these trait beliefs are especially important in determining how people respond to failures (for reviews, see Dweck, 1999; Dweck & Leggett, 1988). Because entity individuals believe their traits are unchanging, they view failure as an indication of low ability. This attribution produces negative emotions and leads to avoidance as well as reduced expectations, effort, persistence, and performance. Conversely, incremental individuals view failure as an indication of lack of effort. This attribution produces feelings of optimism, leads to attempts at self-improvement, and results in sustained or enhanced expectations, effort, persistence and performance.

Although researchers have not directly investigated the link between individual differences in trait beliefs and domain disengagement, two studies are suggestive. Blackwell, Trzesniewski, and Dweck (2007) found that junior high students who believed intelligence was malleable showed an upward trajectory in math grades over two years, whereas those who believed intelligence was fixed showed a flat trajectory. Although this study showed general intelligence beliefs do impact test performance, their study did not examine the more psychological variable of domain engagement. The distinction between test performance and domain engagement is an important one, especially in regards to the gender gap in mathematics. For example, consider a young woman who earns good grades in math but is completely disengaged from the domain. Despite her academic achievements, this woman would likely not pursue a career in mathematics. This example illustrates that low math engagement and low math performance are independent variables and therefore likely exert separate influences on women's career decisions. As a result, it is important that researchers not focus solely on grades when considering the gender gap issue.

A study by Aronson, Fried, and Good (2002) comes closer to examining the impact of belief systems on relevant psychological variables. In their study, Black and White students participated in a program that encouraged them to view intelligence as malleable. After several sessions, Black students in this program stated they enjoyed and valued academics more than those in the control conditions. This provides the best evidence so far that trait beliefs are related to domain disengagement; however, several questions remain. First, although their study showed that students who completed their program were less likely to disengage, their study did not examine if naturally occurring changes in these beliefs systems result in similar effects. That is, are stereotype targets who naturally believe that traits are fixed more likely to disengage than those who believe traits are changeable? If this were the case, teachers could identify those students who are in greatest need of the intervention program. Second, it is unclear if the relationship found in their study would generalize to women in the math domain.

1.2. Present theory

The purpose of this study was to examine the role that trait beliefs play in women's disengagement from the math domain. We assert that women with entity beliefs regarding math are more likely to disengage from the math domain, and this disengagement

leads to future decrements in math performance (i.e., entity beliefs → disengagement → performance decrements). Although previous research has shown that entity beliefs in general are linked to performance decrements (Blackwell et al., 2007), no studies to date have tested the initial step in this process (i.e., the link between entity beliefs and disengagement). Therefore, the present study attempts to fill a gap in the current literature.

Based on this model, we predicted that women who believe their math abilities are fixed would be more likely to disengage from this domain following failure. Because entity individuals will attribute this failure to low ability, we expected these women to distance their self from the domain to protect their well-being. Conversely, incremental individuals will not view this failure as a lack of ability and therefore should be less likely to disengage.

Our decision to only examine women's reactions after a math failure was based on several considerations. First, research on women and math shows that trouble often occurs only after women receive negative feedback regarding their poor performance (e.g., Dweck, 1999). As such, gender differences in math are often perceived as a result of differences in coping with failures, rather than skill differences. Second, failure is inherent in the concept of domain disengagement. Domain disengagement is defined as an extreme protective strategy that individuals engage in following failures in a particular domain (Major & Schmader, 1998). Third, as previously stated, the distinction between entity and incremental individuals is most evident when examining responses to failure (e.g., Dweck & Leggett, 1988). For this reason, failure feedback is often present in studies that examine the impact of entity versus incremental beliefs (e.g., Bempechat, London, & Dweck, 1991; Mangels, Butterfield, Lamb, Good, & Dweck, 2006). Thus, it was expected that trait beliefs would most strongly influence women's responses following a failure experience.

A secondary purpose of the present study was to assess how well the concept of trait beliefs translates into the math domain. Most research on trait belief systems has examined beliefs about traits in general or has focused on the domain of intelligence (e.g., Aronson et al., 2002; Blackwell et al., 2007). To date, few studies have applied the implicit theories model to a specific school domain, such as math (c.f., Burns & Isbell, 2007). To extend this topic into the math domain, we created a new version of the trait beliefs measure that specifically targeted beliefs regarding math abilities. Our study also included the general beliefs measure so that we could directly identify which version better predicts women's math-relevant responses. Research on attitude specificity shows that specific attitude measures are better than general measures when predicting specific behaviors (Ajzen & Fishbein, 1977); therefore, we expected our math domain measure to be superior to the general measure.

In summary, we predicted that women who believe their math skills are fixed (i.e., entity beliefs) would be more likely to respond to a math failure by disengaging from the math domain. Furthermore, we predicted that beliefs directed towards math abilities would be more predictive of this effect than general beliefs.

2. Method

2.1. Participants

One hundred and sixty-eight female undergraduate students from the University of North Carolina-Chapel Hill (UNC) participated in this study (mean age was 19). Recruitment took place through introductory psychology courses and those who participated were compensated with course credit.

2.2. Procedure and measures

Participants first completed two belief systems measures (general and math). Next, they completed a math test and all received failure feedback. Finally, participants completed several measures of math disengagement.

2.2.1. Trait beliefs questionnaires

Participants completed two trait belief measures: A general version and a math-specific version. The general test was taken from Dweck, Chiu, and Hong (1995) and consists of three items designed to measure trait beliefs as a whole (e.g., “Everyone is a certain kind of person and there is not much that can be done to really change that.”) To create a math-specific measure, we used the three items from the intelligence-domain version used by Dweck et al. (1995) and modified them so that they referred to beliefs regarding math ability (e.g., “Your math aptitude is something about you that you can’t change very much.”) Ratings for both measures were made on a -3 (strongly disagree) to 3 (strongly agree) scale, with higher scores indicating entity beliefs and lower scores indicating incremental beliefs. Responses on the general version were averaged together ($\alpha = .86$) and the same was done for the math version ($\alpha = .93$).

2.2.2. Math failure feedback

Next, the women completed a “natural math ability” test that supposedly assesses one’s inherent ability to process mathematical information (taken from Burkley & Blanton, 2008). To increase feedback believability, participants were told their score would be based on a combination of accuracy and speed. The test consisted of 30 multiple-choice questions that required simple, numerical operations (e.g., “What is the next number in the sequence 2, 4, 8, 16?”) Once finished, all participants were told their score was 67/100 and were informed that this was “significantly below that of the average UNC student (80/100)”.

2.2.3. Math disengagement measures

The women then completed a 5-item assessment of math identification taken from Smith and White (2001; e.g., “How much is math to the sense of who you are?”). Responses were made on a 1 (not at all true) to 11 (very true) scale and were averaged to create an overall math identification score ($\alpha = .90$). Finally, participants indicated how important it was to be good at math, how much they enjoyed math-related subjects, how likely they would major in math, and how likely they would pursue a math career. Responses were made on a 1 (not at all) to 11 (very much) scale.

3. Results

Descriptive statistics and zero-order correlations for the variables are summarized in Table 1. All variables spanned the entire range of their scale.

We used regression analyses to examine the effects of the general and math-relevant trait beliefs on the domain engagement measures (see Table 2). For each criterion, the general and math beliefs variables were entered into the regression equation simultaneously. First, we examined how these beliefs related to math identification. As predicted, women who believed their math abilities were fixed reported less identification with the math domain than women who believed their math abilities were malleable. The general beliefs measure was not predictive over and above the specific measure.

Next, we examined how these beliefs related to interest in math-related activities. As predicted, women who believed their math abilities were fixed reported less enjoyment of math-related subjects, less likelihood of pursuing a math major, and less likelihood of pursuing a math career. They also placed less importance on being good at math, although this effect was only marginally significant ($p = .10$). Again, the general beliefs measure was not predictive over and above the specific measure. Finally, the R^2 values for all criterion measures were small, suggesting that even though belief structures play a significant role in predicting the criterion variables, they only account for a small percentage of the criterion variance.

Table 1
Descriptive statistics and correlations.

	M	SD	1	2	3	4	5	6	7
1. General trait beliefs ^a	-.40	1.41	1						
2. Math trait beliefs ^a	-.36	1.56	.34**	1					
3. Math identification ^b	6.06	2.16	-.05	-.30**	1				
4. Math importance ^b	5.54	2.60	-.07	-.14	.61**	1			
5. Math enjoyment ^b	4.30	2.89	-.04	-.21**	.79**	.71**	1		
6. Math major ^b	2.64	2.51	.06	-.13	.59**	.64**	.67**	1	
7. Math career ^b	2.67	2.23	.01	-.18*	.61**	.66**	.74**	.88**	1

^a Responses made on -3 to +3 scale.

^b Responses made on 1-11 scale.

* $p < .05$.

** $p < .01$.

Table 2
Impact of trait beliefs on math disengagement variables.

Predictor variables	Criterion variables														
	Math identification			Math importance			Math enjoyment			Math major			Math career		
	B	SE	β	B	SE	β	B	SE	β	B	SE	β	B	SE	β
General trait beliefs	.10	.12	.07	-.04	.15	.02	.06	.16	.03	.20	.15	.12	.12	.13	.08
Math trait beliefs	-.45	.11	-.33***	-.22	.14	-.13	-.40	.15	-.22**	-.28	.13	-.17*	-.29	.12	-.21*
R^2	.10			.02			.04			.03			.04		

* $p < .05$.

** $p < .001$.

*** $p < .001$.

4. Discussion

The results show that individual differences in trait beliefs impact women's math engagement. After experiencing a math failure, women with entity beliefs about math exhibited less identification with math, less enjoyment of math, and less intent to pursue a math major or math career, than women with incremental beliefs. Taken together, these results indicate that women who view their math skills as fixed are more likely to disengage from math following failure. The results also highlighted the importance of using domain-specific measures when assessing individual differences in entity versus incremental beliefs.

Overall, our results indicate that not all women are created equal when it comes to math disengagement. Women who view their math ability as fixed appear to be more vulnerable to disengagement following failure. As a result, it is these women who are likely to fall behind compared to men once they experience setbacks in their math courses. Thus, the gender gap in math fields may be largely driven by women who hold entity beliefs about math.

These results have important implications for resolving the gender gap issue. Women with an entity perspective towards math are most susceptible to disengagement; therefore, our attention should be focused on this vulnerable population. As such, it would be beneficial to identify young girls with these belief structures early in their academic career, before difficulties have set in. Our results also suggest that these women may be more likely than women with different belief structures to benefit from intervention programs. Although Aronson et al. (2002) developed an intervention program that emphasizes incremental beliefs, actually implementing this program on a wide scale could be costly. The present research suggests that a more efficient method would be to first identify the students who are most vulnerable – those high in entity beliefs. Only this selective group of students would then require the program, thereby saving time and money without losing any of the beneficial outcomes. Furthermore, our study suggests that an intervention targeting beliefs about math skills specifically may be even more effective in reducing gender differences in the math domain.

Third, in addition to these practical suggestions for reducing the gender gap, the present study also provides further theoretical insight into the relationship between trait beliefs and achievement. The majority of research on this relationship has focused largely on academic outcomes (e.g., test scores), but few studies have examined the psychological variables involved in the achievement process. The present study is unique because it shows these beliefs also impact how connected the individual feels with the math domain. Although good test performance may be a factor in why people pursue careers in a particular domain, it is likely not the only factor. How identified people are in a domain may be just as important, or even more important, than test performance in determining what career they will pursue. Therefore, it is imperative that researchers understand how trait beliefs change people's sense of identification with a domain.

4.1. Limitations and Future Directions

The present study focused solely on the belief systems of women; however, an examination of the belief systems of men could also be informative in explaining the gender gap. On the one hand, it could be that men are more likely to perceive their mathematics skills as malleable, and that this gender difference in beliefs may result in men having higher domain engagement and test performance. On the other hand, it could be that men have wide variability in their beliefs, much like women, but because they are not

stigmatized in the math domain, these beliefs do not impact domain engagement in the way that they do for women. Future research should compare men and women's trait beliefs about math to see which pattern is more plausible.

Second, the present study only examined the impact of trait beliefs after experiencing failure. As previously mentioned, this was done because theory and prior research suggested that trait beliefs would exert their strongest influence on women's responses following a failure experience. However, it is possible that even in the absence of a failure experience, trait beliefs may still exert such an influence. To examine this possibility, future research could manipulate whether participants receive failure feedback or not to determine if the failure experience moderates the relationship between trait beliefs and domain disengagement. These avenues of investigation are in need of pursuit but are beyond the scope of the present work.

Finally, our study was correlational in nature, so caution should be taken when inferring the direction of causality between these variables. Although our model suggests that women with entity beliefs are more likely to experience disengagement, the reverse is also possible: Women who have disengaged with the math domain may come to adopt an entity perspective. Reverse causality is always a concern in correlational research; therefore, future studies could instead incorporate an experimental design. For example, some researchers have successfully used priming techniques to put individuals into an entity or incremental mindset (e.g., Jourden, Bandura, & Banfield, 1991; Plaks & Stecher, 2007), and such a technique could be used to further explore the causal link between beliefs structures and domain disengagement.

4.2. Conclusions

Even though a great deal of attention and research has focused on the gender gap in mathematics, it still continues to persist. The results of the present study suggest that this gender difference may be primarily driven by a subset of women – those who believe their math ability is fixed and unchangeable. Identifying these vulnerable women early and designing interventions that change the way they perceive math skills are important steps that should be taken to increase the number of women in math and science fields.

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