The Influence of Women's Self-Perceptions of Ability and Effort Expenditure on Science, Technology, Engineering, and Math Field Persistence

by

SAMUEL ADCOCK

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Sara D. Hodges

Women in the United States consistently drop out of Science, Technology, Engineering, and Math (STEM) fields at various points along the career pathway. While discrimination is an important factor, women's perceptions of themselves and their field may influence the decision to leave STEM at the undergraduate level. The current study used questionnaires to measure 121 male and female undergraduates' self-perceived levels of natural ability, effort exertion relative to those of others in their field, domain motivation, beliefs about the relationship between effort and ability, and beliefs about the importance of high natural ability to success in their field to see if these variables predicted decreased likelihood of persistence in STEM. We found that domain motivation and self-reported ability predicted likelihood of persistence; however, self-reported ability unexpectedly had a negative relation with likelihood of persistence. Interestingly, we found no gender differences for likelihood of persistence. Taken together, these findings may represent positive news for women aspiring to work in STEM fields.

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Introduction

In the United States, women in science, technology, engineering, and math (STEM) fields are currently underrepresented, especially in engineering (where women make up 15% of the field), physical sciences (31%), and computer and mathematical sciences (25%; National Science Board, 2016). This lack of female representation may be due to women dropping out of their STEM field at various points (i.e., high school, undergraduate degree, graduate school) as they advance through their education and careers in STEM, which is described using the metaphor of a "leaky pipeline" (Halpern et al., 2007). Discrimination against women in STEM plays a role in this underrepresentation and can ultimately lead to women leaving the STEM fields before completion of an undergraduate degree in response to current as well as expected future discrimination (Steele, James, & Barnett, 2002).

There are other factors that may cause women to leave the STEM fields, such as lack of feelings of belongingness (Smith, Lewis, Hawthorne, & Hodges, 2012) as well as negative attitudes and stereotypes toward math (Nosek, Banaji, & Greenwald, 2002). Understanding and counteracting these effects is important for a number of reasons. First, there are not enough STEM workers produced in the United States to fill the number of positions that will be available in these jobs in the future (National Science Board, 2003). Second, science jobs represent economic opportunities for women, who on average earn only 80% of the wages that men earn (Miller, 2017). Finally, increasing diversity improves the quality of research through increased motivation to prepare for dissenting opinions leading to better research discussions, as well as leading to increased group performance, creativity, and innovation (Phillips, 2014). For these

reasons, it is important to examine further why women are underrepresented in STEM fields, with an eye towards figuring out ways to increase the percentage of women in STEM. Particularly of interest is the decision to go to graduate school, as graduate education is critical to STEM career paths and is a point in which many women "leak" out of the pipeline (Hill, Corbett, & St. Rose, 2010).

Future persistence

The decision to persist in a field is complex and is influenced by a multitude of factors. Cabrera, Castañeda, Nora, and Hengstler (1992) found that the intent to persist in college is the result of a successful match between a student and their institution, indicating that in order for a student to persist there needs to be input from both the student and the university, suggesting the institution plays an important role in persistence.

The *attributional gender bias* can also play a role in women's STEM underrepresentation. This bias is characterized by people perceiving the successes of women as due to effort and their failures as due to a lack of ability, while seeing male success as due to ability and failure as due to a lack of effort (Espinoza, Luz Fontes, & Arms-Chavez, 2014). Several studies examining the attributional gender bias have been conducted in the context of math ability. This bias has been demonstrated by elementary school children (Stetsenko, Little, Gordeeva, Grasshof, & Oettingen, 2000), junior high school students (Stipek & Gralinski, 1991), and high school students (Espinoza et al., 2014). Furthermore, the attributional gender bias does not just affect students' perceptions, but is also exhibited by teachers and parents toward students (Espinoza et al., 2014). In particular, parental beliefs about their children's abilities result in gender

stereotypes that can influence feelings of math-science efficacy later in life, leading to avoidance of STEM career paths (Bleeker & Jacobs, 2004).

The attributional gender bias is particularly pernicious in math-heavy fields, as failures when learning math are frequent and salient. While everyone experiences these failures, the attributional gender bias makes them especially detrimental for women, who internalize their failures as due to lack of personal ability rather than lack of effort. Thus, attributional gender bias may contribute to women's beliefs about their abilities that may influence their persistence in STEM fields. This negative bias has been shown in math by Kiefer and Shih (2006), who found that women's tendency to attribute their failures in math to a lack of natural ability explained lowered persistence.

In addition to ability-based beliefs, another factor that might affect women's desires to stay in a STEM field is the amount of effort they perceive they are expending, relative to their peers. Smith et al. (2012) found that women studying STEM in graduate school reported believing that they need to exert more effort to succeed than their male counterparts, even though the men and women who participated appeared to have equal ability. These beliefs about effort consequently reduced women's feelings of belongingness and motivation to pursue STEM fields (Smith et al., 2012). However, feeling a sense of belongingness is important for women in STEM because it leads to feelings of acceptance and value within the field (Good, Rattan, & Dweck, 2012). Without these feelings one may feel like an outsider, which in turn may potentially lead to abandonment of STEM in favor of a field where belongingness is higher (Good et al., 2012). Thus, previous literature indicates that both effort and ability-based beliefs may separately influence women's persistence in STEM fields.

Inverse relationship between effort and ability

The belief that higher levels of effort exertion are indicative of lower natural ability may also play an important role in future persistence in STEM fields. *Naturalness bias* occurs when observers favor natural talent-based achievements over effort exertion-based ones (Gladwell, 2002, as cited in Tsay & Banaji, 2011). As a result of this bias, observers of a musical performance will prefer performers described as naturally talented over those described as having attained their skills through high effort expenditure (Tsay & Banaji, 2011). This preference for talent over effort is accompanied by the assumption that greater effort exertion is indicative of lower natural ability (Jagacinski & Nicholls, 1984; 1987). Furthermore, due to the attributional gender bias, the achievements of women in math-based fields are viewed by those around them as stemming from effort rather than ability (Espinoza et al., 2014; Stetsenko et al., 2000; Stipek & Gralinski, 1991). Connecting this to Smith et al.'s (2012) results for female graduate students in STEM fields, women who believe that they need to exert more effort to succeed may also perceive themselves as lacking ability.

In male-dominated fields such as STEM, natural ability is often perceived as integral to success, a concept known as "brilliance." Leslie, Cimpian, Meyer, and Freeland (2015) found that academics in male-dominated fields believed that success in their field requires brilliance, while academics in female-dominated fields were less likely to display this belief. Additionally, academics in fields that displayed a stronger belief that natural ability is required for success were more likely to agree with the idea that women are less suited for high-level scholarly work in their field, and also rated

their field as less welcoming to women (Leslie et al., 2015). It seems quite possible that these beliefs contribute to fewer women persisting in STEM fields.

Motivation as a moderator

Motivation to work in STEM fields is an important component of persistence and may moderate the relationship between belongingness and persistence. Specifically, domain motivation is defined as "the sought, anticipated, or actual experience of interest" in a particular academic domain (Smith, Sansone, & White, 2007, p. 100), this interest then acts as a source of motivation leading to increased persistence (Sansone & Harackiewicz, 1996). Research by Lewis and Hodges (2015) has demonstrated that domain motivation is predicted by the extent people feel they belong in their field. As mentioned previously (Smith et al., 2012), feelings of belongingness are crucial in predicting whether people persist in their academic domain, thus implying that a lack of domain motivation may also predict lower persistence in STEM fields. Furthermore, Lewis and Hodges (2015) found that when people are less certain about their abilities in their field, they also exhibit less domain motivation. This relationship between ability and domain motivation indicates that feeling competent in one's field is important for maintaining an interest in that same field. Although ability-beliefs have already been related to general math/science persistence (Navarro, Flores, & Worthington, 2007) domain motivation has not been directly related to persistence in STEM fields as a whole.

The Current Study

Thus, in the current study, we are interested in whether many of the factors found to influence persistence in math fields generalizes to undergraduates' decision to

go to graduate school in STEM fields. Specifically, we are curious about the role of undergraduates' perceptions of their own abilities, assessment of comparative effort exertion, domain motivation, and beliefs about the relationship between ability and effort in this decision to pursue graduate school in a STEM field, and whether the effects of these variables differ for men and women. Additionally, we are curious whether other people interacting in academic contexts with these undergraduates may be able to detect those undergraduates' level of self-perceived ability and if the undergraduates are then rated as more prepared for graduate school. If this is the case, then undergraduates with higher self-perceived levels of ability may be greeted with greater acceptance within their discipline, feel greater belongingness, and ultimately, persist at higher rates.

We expect to find that undergraduates who believe they have high natural ability will be more likely to report that they intend to persist in their field, and will be perceived by others (in this case, a graduate student with whom they interact) as more likely to succeed in and be ready for graduate school. Related to this, we predict that individuals who believe that their field is dependent on natural ability will be more likely to report a greater intent to persist in their field. Additionally, we predict that individuals who have high domain motivation in their field will report greater future persistence.

We also expect to find that individuals who believe they need to exert less effort to succeed relative to others in their field will report higher persistence in their field. Furthermore, we expect to find an interaction between perceptions of relative effort and the perception of an inverse relationship between effort and ability. Specifically,

individuals who believe they exert comparatively low effort relative to peers and who also believe that higher effort expenditure is indicative of lower ability will show high levels of persistence in their field. In contrast, individuals who believe they expend more effort compared to peers in their field and also believe that high effort expenditure is indicative of lower ability will show low levels of future persistence. Finally, we expect that all of our predictions will be moderated by gender such that women will be more strongly influenced by factors that increase persistence than men.

Method

The data for the current study was collected as part of a larger project investigating gender differences in women and men considering STEM graduate school. Participants were recruited from STEM departments at the University of Oregon and Oregon State University. Participants were undergraduates interested in pursuing graduate school in their field, along with graduate students actively working toward an advanced degree in a STEM field. The sample included 121 (63 male, 58 female) undergraduate students and 58 (33 male, 25 female) graduate students. The average undergraduate age was 21.0 years old (SD = 2.8). Although the undergraduate sample was predominantly white (66.5%), participants also reported that their ethnicity was Asian/Pacific Islander (18.5%), multi-racial (9.2%), black (3.7%), Native American (0.8%), and other (1.5%). The average graduate student age was 28.2 years old (SD = 4.09). Again, the graduate sample was predominantly white (77.6%), though participants also reported that their ethnicity was black (10.3%), Asian/Pacific Islander (6.9%), multi-racial (3.4%), and other (1.7%). All participants were pursuing a degree in a field classified as STEM by the National Science Foundation (Gonzalez & Kuenzi,

2012), including biology, chemistry, computer science, engineering, geology, or physics. Undergraduates only participated once while graduate students were allowed to participate multiple times with different undergraduates (described in more detail below). Each session lasted about an hour and a half. Participants were paid for their participation, with undergraduates receiving $20 and graduates receiving $24 per session.

Procedure

Participants took part in the study in dyads that consisted of a graduate and an undergraduate student in the same STEM field. Both the undergraduate and graduate came to the lab and completed consent forms. Then, the graduate and undergraduate were instructed to have a five to ten minute unstructured conversation about graduate school preparation, qualification, and interest. Undergraduates were instructed to talk about their own preparation and qualifications; graduate students were instructed to provide feedback on these topics to the undergraduates. The interaction was video recorded, and afterward the participants were taken to separate rooms to complete the remainder of the study. Once separated, participants completed a questionnaire.[1]

Measures

All measures used in the study can be found in Appendix 1.

Comparative effort. Undergraduates were asked "Compared to other students who are applying to graduate school in this field, how much EFFORT do you believe you will have to expend in graduate school?" Participants responded on a 5-point Likert-scale of 1 (*much less effort*) to 5 (*much more effort*). This question served as our

[1] Empathic accuracy measures were also collected, but will not be analyzed in this study.

measure of how much effort undergraduates believed they would need to expend in graduate school relative to their peers. (See Measure 1 in Appendix 1.)

Self-reported natural ability. Undergraduates were asked "To what extent is YOUR success in your field dependent on your natural ability?" Participants responded on a 5-point Likert-scale of 1 (*not at all dependent*) to 5 (*entirely dependent*). This item served as our measure of each undergraduate's self-reported natural ability in their field. (See Measure 2 in Appendix 1.)

Inverse relationship between effort and ability. Undergraduates were asked the extent to which they agreed with the statement "In your field of study, people who have to put forth more effort have less natural ability." Participants responded on a 6-point Likert-scale of 1 (*strongly disagree*) to 6 (*strongly agree*). This item served as our measure of how much the undergraduates believed in the inverse relationship between natural ability and effort. (See Measure 3 in Appendix 1.)

Belief in importance of natural ability to field. Undergraduates were asked the extent to which they agreed with the statement "IN GENERAL, to what extent is success in your field dependent on natural ability?" Participants responded on a 5-point Likert-scale of 1 (*not at all dependent*) to 5 (*entirely dependent*). This item served as our measure of how strongly each undergraduate believed that success in their field required high natural ability. (See Measure 4 in Appendix 1.)

Domain motivation. To measure how motivated the undergraduates felt within their fields, we used a 25-item scale (Cronbach's $\alpha = 0.85$) previously utilized by Smith et al. (2012) and Lewis and Hodges (2015). Participants rated the extent to which they agreed with statements such as "I would describe my major as very interesting," "I

enjoy doing work in my major very much," and "I feel doing work in my major is an enriching experience" on a 6-point Likert-scale of 1 (*strongly disagree*) to 6 (*strongly agree*). Higher scores indicated greater domain motivation. (See Measure 5 in Appendix 1.)

Graduate student perceptions of undergraduate. We used three items (Cronbach's α = .65) to measure how the graduate students perceived the undergraduate they interacted with. Graduate students were asked to rate the undergraduate on qualification and preparation for graduate school, as well as expected future success. These questions were asked on 5-point Likert-scales (e.g., 1=*not at all qualified*, 5= *completely qualified*). Higher scores indicated greater qualification.[2] (See Measure 6 in Appendix 1.)

Future persistence. In order to measure within-field future persistence of the undergraduates, we used a 7-item scale (Cronbach's α = 0.81) based on Lewis and Hodges' (2015) adaptation of a scale from Cabrera et al. (1992). Participants rated the extent to which they agreed with statements such as "I am satisfied that I chose the right field of study," "I intend to pursue a graduate degree in my field of study," and "I have clear plan in mind for the path I will take in my field of study" on a 5-point Likert-scale of 1 (*strongly disagree*) to 5 (*strongly agree*). (See Measure 7 in Appendix 1.)

Results

Means and standard deviations for all measures, both overall and broken down by gender, can be found in Table 1 of Appendix 2. Data were analyzed using the linear

[2] Graduate students were also asked to rate the level of effort they expected the undergraduate would need to expend in graduate school. However, this item will not be analyzed in this study.

modeling command in the package "stats" in R (version 3.4.0), a free coding language and environment for statistical analysis. In the analysis of gender differences, women were coded as 0 and men as 1.

For each prediction, we conducted two models: one model in which the predictor(s) of interest interacted with the moderator of gender and another model in which the predictor(s) did not interact with the moderator. The two models were then compared to test whether the models were significantly different from one another. If the models were not significantly different, then the model without the moderator was reported.

Self-reported natural ability. We conducted two regressions with undergraduate self-reported natural ability predicting undergraduate future persistence, with one model including gender as a moderator and the other including no moderators. Statistics for both models can be found in Table 2 in Appendix 2. The two models did not significantly differ, $F(1,117)=0.02$, $p=0.67$, so we focused on the model that did not include gender as a moderator. Analysis of that model revealed a significant main effect of undergraduate natural ability predicting future persistence, $b=-0.06$, $t(117)=-2.01$, $p<0.05$. As demonstrated in Figure 1 below and contrary to our prediction, undergraduates with higher self-reported ability reported lower likelihood of future persistence in their field. The main effect of undergraduate gender was not significant, $b=-0.10$, $t(117)=-1.73$, $p=0.09$.

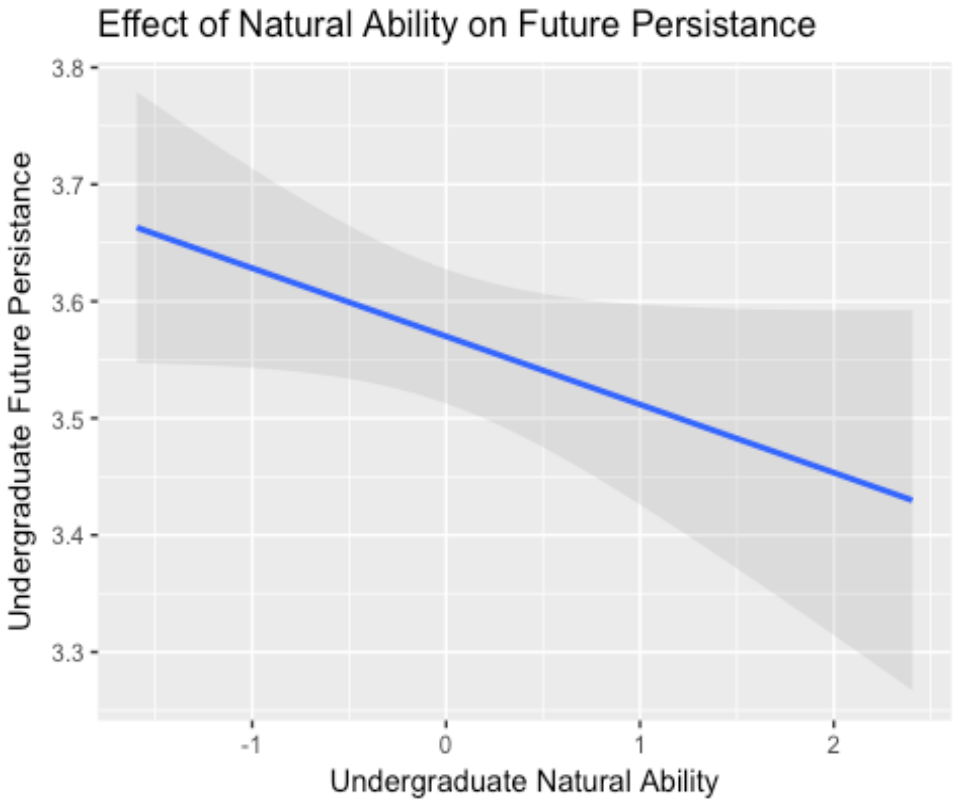

Figure 1. Undergraduate future persistence as a function of undergraduate self-reported natural ability

Domain Motivation. We conducted two regressions with undergraduate domain motivation predicting undergraduate future persistence, with one model including gender as a moderator and the other without gender as a moderator. Statistics for the models can be found in Table 3 in Appendix 2. The two models did not significantly differ, $F(1,117)=0.01$, $p=0.92$, so we focused on the model without gender as a moderator. Analysis revealed a significant main effect of undergraduate domain motivation predicting undergraduate future persistence, $b=0.42$, $t(117)=4.96$, $p<0.001$. As demonstrated in Figure 2 and in line with our prediction, undergraduates with higher domain motivation reported higher likelihood of future persistence in their field. The main effect of gender was not significant, $b=-0.02$, $t(117)=-0.37$, $p=0.71$.

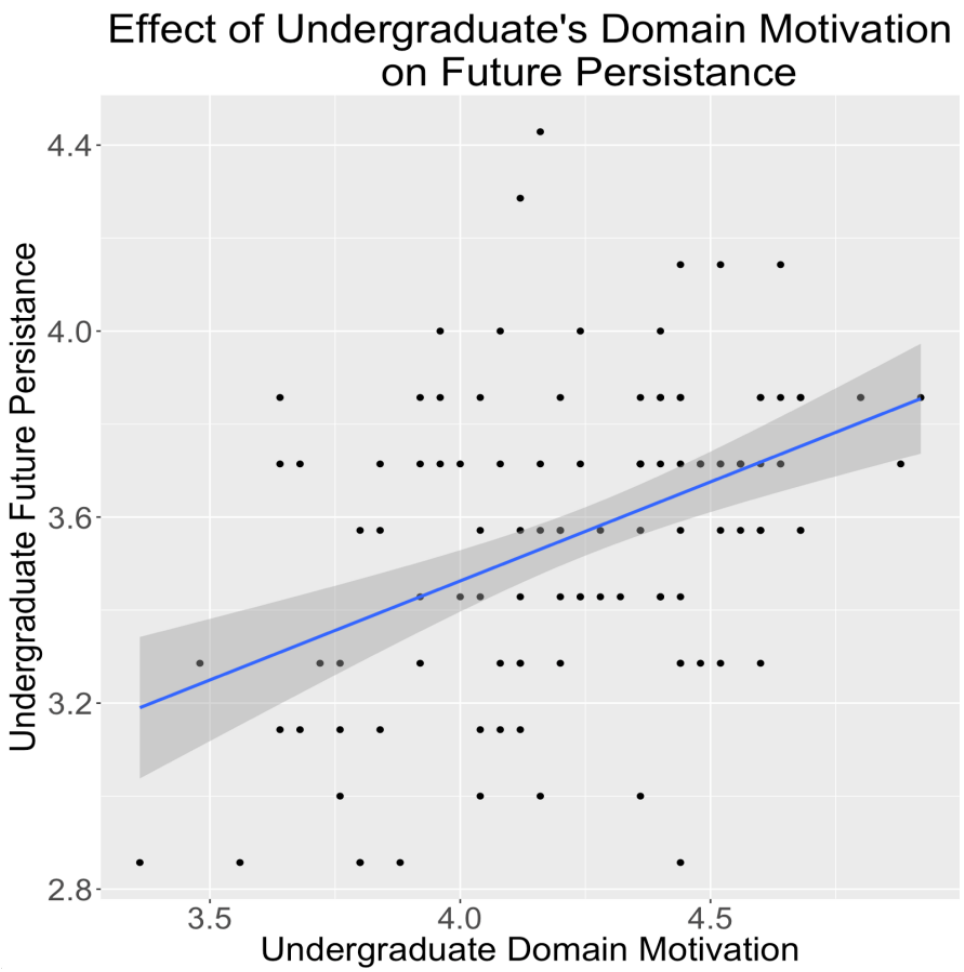

Figure 2. Undergraduate future persistence as a function of undergraduate domain motivation.

Graduate student ratings. Contrary to our hypothesis, graduate student ratings were not predicted by undergraduates' self-ratings of their own natural ability. Neither the model with gender as a moderator, nor the model without gender as a moderator were significant (see Table 4 in Appendix 2).

Belief in importance of natural ability to field. Contrary to our hypothesis, undergraduates who believed more in the importance of natural ability in their field were not more likely to report higher likelihood of persistence. The model with gender

as a moderator was not significant, nor was the model without gender as a moderator (see Table 5 in Appendix 2).

Comparative effort. The model with gender as a moderator was not significant, nor was the model without gender as a moderator (see Table 6 in Appendix 2).

Inverse relationship between effort and ability x comparative effort. The model with gender as a moderator was not significant, nor was the model without gender as a moderator (see Table 7 in Appendix).

Discussion

Most of our results were not as predicted. To begin with, there were no gender differences on any of the measures. The only hypothesis that was supported as predicted was the relationship between domain motivation and future persistence. Specifically, in line with previous research, we found that as domain motivation increased, future persistence also increased (Lewis & Hodges, 2015). Thus, one potential route to increasing female persistence in STEM could be by cultivating intrinsic motivation and interest in STEM fields early on, perhaps via parental involvement in academic achievement, communication of their expectations and valuation of their children's academic success, and conscious awareness and suppression of their biases against women's math abilities (Espinoza et al., 2014; Fan & Williams, 2010).

None of our other predictions were supported by our findings. The failure to find results consistent with our predictions may be due to the unique nature of our sample. Our sample consisted of undergraduates who expressed interest in attending graduate school prior to participation in the study. This self-selected sample may have been particularly likely to report future persistence in their field, resulting in low variability

in our key outcome variable. In other words, there may not have been enough variance across participants to pick up any significant effects of our predictor variables.

Our prediction that there would be a relationship between undergraduates' beliefs that natural ability is important to success in STEM fields and their likelihood of future persistence was not supported. This prediction came from the "brilliance" hypothesis for STEM gender distributions in which academics in male-dominated fields were shown to believe that high natural ability was a requirement for success in their field (Leslie et al. 2015). We predicted that individuals who strongly believed that natural ability was important for success in their field would be more likely to report a high likelihood of future persistence, and that this effect would be moderated by gender. The lack of a significant relationship in this case may have been due to our sample consisting of undergraduates and not researchers in the field. Perhaps the importance of brilliance is a concept that develops with extensive experience in the field, something the undergraduates we sampled lack. Additionally, these unexpected findings could again be due to the nature of our sample of highly committed students.

We also predicted that self-perceptions of the amount of effort the undergraduates expended relative to their peers would be related to future persistence, such that those who believe they expend more energy would report lower future persistence. This finding, however, was not supported. Interestingly, Smith et al. (2012) found that female graduate students in STEM believed that they expended relatively more effort in their field than their male peers reported, and these beliefs predicted a lower likelihood of future persistence. However, we did not find this pattern in our sample, as there was no significant effect of effort expenditure on the likelihood of

future persistence, nor was there any gender difference in the effort expenditure variable. One potential explanation for this difference is that our sample consisted of undergraduate students, while Smith et al.'s (2012) sample consisted of graduate students. It is also possible that within the undergraduates we sampled – students who had not yet made it to graduate school – everyone expected to exert a high amount of effort.

Furthermore, we found no support for our hypothesized three-way interaction between belief in an inverse relationship between effort and ability (i.e. higher effort is indicative of lower ability), comparative effort, and gender when predicting the likelihood of future persistence. We had predicted that a combination of perceiving that one has to expend relatively more effort, believing that effort indicates less ability, and being female would particularly undermine future persistence. Given that we did not find a relationship between relative effort and future persistence in a simpler analysis, it is perhaps less surprising that we also did not find support for our more complex prediction.

A novel aspect of this project was an attempt to find a relationship between undergraduates' beliefs about their natural ability and other peoples' evaluations of those undergraduates. We thought that undergraduates who self-reported higher ability would be perceived by the graduate students as more likely to do better in graduate school, showing that graduate students are not only able to evaluate the abilities of undergraduates through conversation, but also that they value the appearance of natural ability as an important aspect of graduate school success. We found no evidence of this. There are two possible explanations for this null finding. One is that undergraduates'

beliefs about their abilities are either hard to read or just not displayed through conversation. Another possibility is that graduate students perceive the undergraduates' beliefs about their abilities but instead use other information to evaluate the undergraduates, such as the undergraduates' research experience or expertise. We also predicted that gender would be a moderator for this relationship, but we found no evidence for this either.

A particularly unexpected finding was the *negative* relationship between self-reported ability and future persistence, indicating that as undergraduates' reported natural ability goes up, the reported likelihood that the undergraduate will continue on to graduate school in their field decreases. In contrast, our prediction was that undergraduates with high self-reported natural ability would be more likely to expect to persist in their field. Our finding is surprising in light of the "brilliance" stereotype among STEM academics that working in STEM fields necessitates a high degree of natural ability (Leslie et al., 2015). However, prior research has also shown that math self-assessment does not predict persistence after men and women select into STEM at the undergraduate level (Cech, Rubineau, Silbey, & Seron, 2011). Math self-assessment is instead predictive of the decision to choose a quantitative major in the first place (Correll, 2001). Considering that our sample consisted of STEM undergraduates, this may help explain why we failed to find the expected relationship between self-reported ability and future persistence, as the students had already made the decision to choose a quantitative major in college. Future research should examine whether the same variables that predict persistence in STEM from high school to college also predict persistence in STEM beyond college.

It is also possible that self-perceptions of STEM ability in school do not influence career choices. Andersen and Ward (2014) found that among high-ability ninth-grade students interested in STEM, expectations of success in STEM did not predict persistence, potentially due to the belief that success in school is not necessarily indicative of future career success. Additionally, students may not view "school science" and STEM career work as linked, suggesting a possible lack of connection between studying science in school and working in STEM fields (Andersen & Ward, 2014). This relationship makes sense with regard to graduate school, as it is more closely related to STEM career work than to high school or even undergraduate level classwork.

Additionally, it is possible that we did not find the expected relationship between self-reported ability and future persistence because our unique sample of high-achieving undergraduates had already realized the importance of effort for success in graduate school and therefore downplayed the role of natural ability. However, this would not explain why we found a significant relationship in the *opposite* direction. It could be that the undergraduates experienced humbleness triggered by their interaction with the graduate student. Because the undergraduates reported their natural ability and likelihood of persistence after the conversation with the graduate student, the undergraduates who were most likely to attend graduate school may have felt humbled by their interaction, resulting in lower reported natural ability but unchanged likelihood of persistence.

Interestingly, the current study did not find gender differences for any of our variables. This is surprising given other studies that have found male students are more

intrinsically interested in math, suggesting that men should show greater persistence (Fan & Williams, 2010). However, these findings make more sense when considering the profiles of students that choose to persist in STEM fields. Women who persist in STEM tend to have math/science self-concepts similar to those of men, while women who leave STEM have substantially lower math/science self-concepts than men as well as women who persist, indicating that personally viewing math/science as a good fit is important for women who persist (Ackerman, Kanfer, & Beier, 2013). This could explain why we found no difference between men and women on likelihood of persistence, as women who have progressed this far in STEM may have a strong math/science self-concept keeping them in their field.

Furthermore, it is possible that within our unique sample of participants many of them had already committed to attend graduate school, resulting in similar reported likelihood of persistence between men and women. This suggests that women who persist to this point in the STEM pipeline have already encountered some of the biases against them and persisted nonetheless, making it less likely for them to leave. Also worth consideration is the notion that simply committing to participate in a study about graduate school may have led the participants to acknowledge their interest in graduate school, potentially increasing the likelihood of reporting higher persistence in the short term.

Finally, it may be that the procedure of the study created a supportive intervention for the female undergraduates, leading to increased likelihood of persistence. Because we created dyads between women interested in graduate school and graduate students in their field, these women may have gotten advice and

reassurance that they otherwise would not have. The constraints of the study effectively forced the undergraduate women's interest in graduate school to be taken seriously by the graduate student, resulting in attention that they may not have been used to receiving. It is possible that for women, having a positive interaction with a graduate student goes a long way for the decision to attend graduate school. While this is speculative, interactions between graduate students and undergraduate women as an intervention to improve female retention in STEM would be worth looking into in the future.

Conclusions

The fact that many of the predictions of the current study were not supported could indicate hopeful news for women who aspire to work in STEM fields. The lack of gender differences for reported likelihood of persistence in STEM suggests that among STEM undergraduates who express interest in going to graduate school, women and men report similar thoughts and plans. Additionally, by facilitating potentially helpful conversations about graduate school, we may have inadvertently produced an intervention that helps encourage women to report wanting to persist in STEM. However, it is worthwhile to again note that the sample in this study consisted of students already likely to persist and, therefore, may not be generalizable to students interested in STEM at large. Only future research will be able to explain whether or not this is the case.

APPENDIX 1: Measures

Measure 1: Comparative effort

Compared to other students who are applying to graduate school in this field, how much EFFORT do you believe will you have to expend in graduate school? Likert 1 (much less effort) to 5 (much more effort).

Measure 2: Self-reported natural ability

To what extent is YOUR success in your field dependent on your natural ability? Likert 1 (not at all dependent) to 5 (entirely dependent).

Measure 3: Inverse relationship between effort and ability

In YOUR FIELD OF STUDY, people who have to put forth more effort have less natural ability. Likert 1 (strongly disagree) to 5 (strongly agree).

Measure 4: Belief in importance of natural ability to field

IN GENERAL, to what extent is success in your field dependent on natural ability? Likert 1 (not at all dependent) to 5 (entirely dependent).

Measure 5: Domain motivation

For each of the following statements, please indicate how strongly you agree or disagree using the scale provided. Likert 1 (strongly disagree) to 5 (strongly agree).

I would describe my major as very interesting. (1)
I have had a lot of experience with my major. (2)
Doing work in my major is important to me. (3)
My major does not hold my attention at all (reverse coded). (4)
I feel that I do well in my major. (5)
I enjoy doing work in my major very much. (6)
I think my major is valuable. (7)
Work in my major is fun to do. (8)
It is important to me to do well in my major. (9)
During the work I do in my major I think about how well I am doing. (10)
I think my major is a boring (reverse coded). (11)
I think my major is hard (reverse coded). (12)
I become very absorbed with work in my major while I am doing it. (13)
My talents are important in doing work in my major. (14)
I care very much about how well I do in my major. (15)
I feel I have a lot of choice in how to do work in my major. (16)
My major is useful. (17)
I feel doing work in my major is an enriching experience. (18)
I think it was a waste of time to do work in my major (reverse coded). (19)
After doing work in my major for awhile, I felt pretty competent about my abilities. (20)
Doing work in my major is a worthwhile way to spend my time. (21)
I would describe work in my major as very enjoyable. (22)
Work in my major gives me the opportunity to learn something new. (23)
I would like to do work related to my major in the future. (24)
I expect to receive excellent grades on the coursework in my major. (25)

Measure 6: Grad ratings

In the following section, you will respond to some questions related to the conversation you just had with the undergraduate student. Since the questions sound similar to each other, important DIFFERENCES look like THIS.
How QUALIFIED do you believe the undergraduate is for graduate school? Likert 1 (not at all qualified) to 5 (completely qualified).
How PREPARED do you believe the undergraduate is for graduate school? Likert 1 (not at all prepared) to 5 (completely prepared).
How SUCCESSFUL do you believe the undergraduate will be in graduate school? (Likert 1 (not at all successful) to 5 (extremely successful).

Measure 7: Future persistence

For each of the following statements, please indicate how strongly you agree or disagree using the scale provided. Likert 1 (strongly disagree) to 5 (strongly agree).
I have seriously considered leaving my field of study. (1)
I am satisfied that I chose the right field of study. (2)
I intend to pursue a graduate degree in my field of study. (3)
I wonder if I really want to have a career in my field of study. (4)
I expect to someday have a job in my field of study. (5)
I have clear plan in mind for the path I will take in my field of study. (6)
I am unlikely to leave my field of study. (7)

APPENDIX 2: Tables

Table 1: Descriptive statistics.

	Overall		Men		Women	
	Mean	SD	Mean	SD	Mean	SD
Natural Ability	2.60	0.91	2.50	0.90	2.69	0.92
Domain Motivation	4.26	0.33	4.17	0.32	4.34	0.31
Belief in Importance of Natural Ability to Field	2.85	0.82	2.87	0.88	2.83	0.78
Comparative Effort	4.10	1.50	3.81	1.58	4.40	1.38
Inverse Relationship Between Effort and Ability	2.61	1.30	3.02	1.41	2.16	1.01
Future Persistence	3.57	0.32	3.48	0.35	3.62	0.28
Graduate Student Ratings	3.55	0.93	3.48	0.97	3.63	0.90

Note: Domain Motivation and Inverse Relationship Between Effort and Ability were measured on a 6-point scale; Belief in Importance of Natural Ability to Field, Natural Ability, Comparative Effort, Future Persistence, and Graduate Student Ratings were all rated on a 5-point scale.

Table 2: Natural ability predicting likelihood of future persistence.

	Moderated			Unmoderated		
	b	SE	*p*	b	SE	*p*
Intercept	3.62	0.04	<0.001	3.62	0.04	<0.001
Natural ability	-0.08	0.05	0.09	-0.06	0.03	0.05
Gender	-0.10	0.06	0.09	-0.10	0.06	0.09
Interaction	0.03	0.06	0.67	-	-	-
	$R^2 = 0.03$			$R^2 = 0.04$		

Note: For gender, women were coded as 0 and men as 1.

Table 3: Domain motivation predicting likelihood of future persistence.

	Moderated			Unmoderated		
	b	SE	*p*	b	SE	*p*
Intercept	3.58	0.04	<0.001	3.58	0.04	<0.001
Domain Motivation	0.43	0.12	<0.001	0.42	0.08	<0.001
Gender	-0.02	0.06	0.71	-0.02	0.05	0.71
Interaction	-0.02	0.17	0.92	-	-	-
	$R^2 = 0.17$			$R^2 = 0.18$		

Table 4: Undergraduates' natural ability predicting graduate student ratings.

	Moderated			Unmoderated		
	b	SE	*p*	b	SE	*p*
Intercept	3.63	0.12	<0.001	3.63	0.12	<0.001
Natural ability	-0.05	0.14	0.72	-0.04	0.09	0.68
Gender	-0.16	0.17	0.37	-0.16	0.17	0.37
Interaction	0.02	0.19	0.92	-	-	-
	R^2 = -0.02			R^2 = -0.009		

Table 5: Belief in importance of natural ability to field predicting likelihood of future persistence.

	Moderated			Unmoderated		
	b	SE	*p*	b	SE	*p*
Intercept	3.62	0.04	<0.001	3.62	0.04	<0.001
Belief in importance of natural ability to field	0.02	0.05	0.76	0.03	0.04	0.38
Gender	-0.09	0.06	0.13	-0.09	0.06	0.13
Interaction	0.02	0.07	0.74	-	-	-
	$R^2 = 0.001$			$R^2 = 0.009$		

Table 6: Comparative effort.

	Moderated			Unmoderated		
	b	SE	*p*	b	SE	*p*
Intercept	3.62	0.04	<0.001	3.61	0.04	<0.001
Comparative effort	-0.01	0.03	0.73	0.009	0.02	0.66
Gender	-0.08	0.06	0.16	-0.08	0.06	0.17
Interaction	0.03	0.04	0.41	-	-	-
	$R^2 = 0.001$			$R^2 = 0.004$		

Table 7: Comparative effort x inverse relation between effort and ability as predictors of reported likelihood of persistence.

	Moderated			Unmoderated		
	b	SE	*p*	b	SE	*p*
Intercept	3.59	0.05	>0.001	3.67	0.07	>0.001
Comparative effort	-0.02	0.03	0.57	0.03	0.04	0.56
Inverse relationship between effort and ability	-0.07	0.04	0.12	-0.03	0.02	0.26
Gender	-0.05	0.06	0.45	-0.06	0.06	0.36
Comparative effort x Inverse relationship	-0.01	0.03	0.68	-0.006	0.01	0.66
Comparative effort x Gender	0.05	0.04	0.29	-	-	-
Inverse relationship x Gender	0.06	0.05	0.24	-	-	-
Inverse relationship x Gender x Comparative effort	0.004	0.03	0.90	-	-	-
	R^2 =-0.003			R^2 = -0.0002		

References

Ackerman, P. L., Kanfer, R., & Beier, M. E. (2013). Trait complex, cognitive ability, and domain knowledge predictors of baccalaureate success, STEM persistence, and gender differences. *Journal of Educational Psychology*, *105*(3), 911.

Andersen, L., & Ward, T. J. (2014). Expectancy-value models for the STEM persistence plans of ninth-grade, high-ability Students: A comparison between black, hispanic, and white students. *Science Education*, *98*(2), 216-242.

Bleeker, M. M., & Jacobs, J. E. (2004). Achievement in math and science: Do mothers' beliefs matter 12 years later?. *Journal of Educational Psychology*, *96*(1), 97.

Cabrera, A. F., Castaneda, M. B., Nora, A., & Hengstler, D. (1992). The convergence between two theories of college persistence. *The Journal of Higher Education*, *63*(2), 143-164.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional role confidence and gendered persistence in engineering. *American Sociological Review*, *76*(5), 641-666.

Correll, S. J. (2001). Gender and the career choice process: The role of biased self assessments. *American Journal of Sociology*, *106*(6), 1691-1730.

Espinoza, P., da Luz Fontes, A. B. A., & Arms-Chavez, C. J. (2014). Attributional gender bias: teachers' ability and effort explanations for students' math performance. *Social Psychology of Education*, *17*(1), 105-126.

Fan, W., & Williams, C. M. (2010). The effects of parental involvement on students' academic self-efficacy, engagement and intrinsic motivation. *Educational Psychology*, *30*(1), 53-74.

Gonzalez, H. B., & Kuenzi, J. J. (2012, August). Science, technology, engineering, and mathematics (STEM) education: A primer. Congressional Research Service, Library of Congress.

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology*, *102*(4), 700–717.

Halpern, D. F., Benbow, C. P., Geary, D. C., Gur, R. C., Hyde, J. S., & Gernsbacher, M. A. (2007). The science of sex differences in science and mathematics. *Psychological Science in the Public Interest*, *8*(1), 1–51.

Hill, C., Corbett, C., & St Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. American Association of University Women. 1111 Sixteenth Street NW, Washington, DC 20036.

Jagacinski, C. M., & Nicholls, J. G. (1984). Conceptions of ability and related affects in task involvement and ego involvement. *Journal of Educational Psychology*, *76*(5), 909.

Jagacinski, C. M., & Nicholls, J. G. (1987). Competence and affect in task involvement and ego involvement: The impact of social comparison information. *Journal of Educational Psychology*, *79*(2), 107.

Kiefer, A., & Shih, M. (2006). Gender differences in persistence and attributions in stereotype relevant contexts. *Sex Roles*, *54*(11-12), 859-868.

Leslie, S.J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science*, *347*, 262–265.

Lewis, K. L., & Hodges, S. D. (2015). Expanding the concept of belonging in academic domains: Development and validation of the Ability Uncertainty Scale. *Learning and Individual Differences*, *37*, 197–202.

Miller, K., & Benson, K. (2017). The simple truth about the gender pay gap. *Retrieved from American Association of University Women:* https://www.aauw.org/research/the-simple-truth-about-the-gender-pay-gap/

National Science Board (2003). The Science and Engineering Workforce: Realizing America's Potential (NSB 03-69). Arlington, VA: National Science Foundation.

National Science Board (2016). Science and Engineering Indicators 2016 (NSB-2016-1). Arlington, VA: National Science Foundation.

Navarro, R. L., Flores, L. Y., & Worthington, R. L. (2007). Mexican American middle school students' goal intentions in mathematics and science: A test of social cognitive career theory. *Journal of Counseling Psychology*, *54*(3), 320.

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002). Math = male, me = female, therefore math ≠ me. *Journal of Personality and Social Psychology*, *83*(1), 44–59.

Phillips, K. (2014). How diversity works. *Scientific American, 311*(4), 42-47.

Sansone, C., & Harackiewicz, J. M. (1996). *Striving and feeling: Interactions among goals, affect, and self-regulation*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Smith, J. L., Lewis, K. L., Hawthorne, L., & Hodges, S. D. (2012). When trying hard isn't natural: women's belonging with and motivation for male-dominated STEM fields as a function of effort expenditure concerns. *Personality and Social Psychology Bulletin*, *39*(2), 131–143.

Smith, J. L., Sansone, C., & White, P. H. (2007). The stereotyped task engagement process: The role of interest and achievement motivation. *Journal of Educational Psychology*, *99*(1), 99–114.

Steele, J., James, J. B., & Barnett, R. C. (2002). Learning in a man's world: examining the perceptions of undergraduate women in male-dominated academic areas. *Psychology of Women Quarterly*, *26*(1), 46–50.

Stetsenko, A., Little, T. D., Gordeeva, T., Grasshof, M., & Oettingen, G. (2000). Gender effects in children's beliefs about school performance: A cross-cultural study. *Child Development*, *71*(2), 517–527.

Stipek, D. J., & Gralinski, J. H. (1991). Gender differences in children's achievement-related beliefs and emotional responses to success and failure in mathematics. *Journal of Educational Psychology*, *83*(3), 361.

Tsay, C.J., & Banaji, M. R. (2011). Naturals and strivers: Preferences and beliefs about sources of achievement. *Journal of Experimental Social Psychology*, *47*(2), 460–465.