When School Fits Me:

The Role of Regulatory Fit in Academic Engagement and Learning

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Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School of Arts and Sciences

COLUMBIA UNIVERSITY

2011
ABSTRACT

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What factors boost student motivation? Three studies were designed to test whether fit (Higgins, 2000) between students’ goals or beliefs and the message conveyed by academic tasks increases engagement and learning. Given past research (Rodriguez, Romero-Canyas, Downey, Mangels & Higgins, 2011) showing that fit between beliefs about the interdependence of the self and task framing led to better performance, Study 1 tested the hypothesis that students would be more motivated to select tasks that fit their beliefs about the interdependence/independence of the self. Results showed that students tended to select math tasks consistent with their beliefs and this subsequent selection predicted greater math performance. Though Study 1 explored how fit affects students’ choices, it did not address the learning processes that are influenced by fit. Hence, studies 2 and 3 were undertaken to investigate this issue. Study 2 specifically looked at students’ experience studying. Drawing from the persuasion literature, it was explored whether fit can impact persuasion through “feeling right” about one’s evaluative response to a persuasive message and can also increase engagement during the act of studying to enhance performance. Students were asked to focus their studying on either the persuasiveness of an article’s message or on their opinion of its proposal. Results indicated that among students who experienced regulatory fit (vs. non-fit) and focused on a science article’s persuasive message, the more positive their attitudes were about studying, the more persuasive they perceived the article to be; and the more negative their attitudes about studying, the less persuasive they perceived the
article to be. When students under fit instead focused on their opinion of the article’s proposal, regulatory fit but not study attitudes predicted perceived persuasiveness. Reading comprehension of the text, which captured their strength of engagement in the studied material, was directly enhanced by fit. While in Study 2 participants were explicitly told how to focus their attention on the task, it is also important to investigate the role of attention as students progress through a task. Study 3 tested how students naturally allocate attention during a challenging verbal task that resulted in poor performance. It was investigated whether fit between students’ achievement goals and task framing helped them correct their errors. In order to identify the attentional mechanisms that explain how fit may help, event-related potentials (ERP) were recorded. Participants completed the initial task with two blocks. One block was framed to emphasize mastery goals (e.g. effort, learning, mastery of knowledge) and another was framed to emphasize performance goals (e.g. outperforming others as to demonstrate one’s competency). For each task question, participants received performance feedback (wrong vs. right) and learning feedback (correct answer). Subsequently, participants were given a surprise retest on all items answered incorrectly from the initial task. Results showed that fit between achievement goals and task framing led to greater correction of items at retest. Furthermore, ERP analyses and structural equation modeling identified different attentional pathways through which fit led to better learning. Whereas in the performance frame model the pathway was through greater sustained attention to negative performance feedback, in the mastery frame model it was through greater processing of the correct answer. Overall, these three studies draw from different literatures to provide a more comprehensive understanding of how regulatory fit can boost student engagement and learning.
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ACKNOWLEDGEMENTS

This research was supported by a graduate research fellowship from the National Science Foundation, and grants from the National Institute of Mental Health to E. Tory Higgins (Grant 39429) and to Geraldine Downey (R01 MH069703 and MH081948).

I want to thank my research assistants at Columbia University and at Baruch College, for their excitement, hard work and dedication to this research over the past five years. I would also like to thank my fellow lab members in the Higgins, Downey and Mangels labs, for all their helpful feedback and support. To all my friends, thank you for being there always. A special thanks to Kavita Reddy and Dobromir Rahnev whom I am grateful for having met and gotten to know.

I would also like to thank my committee members Steve Stroessner, Daphna Shohamy, Jennifer Mangels, Geraldine Downey and E. Tory Higgins for their help during the dissertation process and for a stimulating and helpful discussion during the defense. Thank you to Jennifer Mangels for her support and guidance on the EEG project (VFF), to Geraldine Downey for her mentorship and feedback over the years, to Rainer Romero-Canyas for his continued guidance and friendship, and to my advisor, E. Tory Higgins, for his enthusiastic support and wisdom.
DEDICATION

For my parents, Jose & Silvia Rodriguez, and brother, Joseph Rodriguez, who have been my pillar of support, unconditional love, and infinite inspiration.
INTRODUCTION

We are what we repeatedly do. Excellence, therefore, is not an act but a habit. - Aristotle

Upon walking into a classroom, students may see quotes of famous philosophers, artists, mathematicians and scientists lining the walls, intended to motivate and inspire them to achieve. However, despite the best efforts of teachers and parents, some students are not motivated in their scholarly pursuits, which can often lead to their complete disengagement from school. In stark contrast, other students who are highly motivated may make extensive use of their educational resources in a way that sets them on a path towards success. What can account for the discrepancy in motivation? Though many factors (e.g. family environment, finances) can contribute to students’ academic circumstances, it may be that what differentiates one student’s drive from another student’s disengagement may also stem from whether or not they experience fit between their goals and beliefs, and the message promoted by their learning environment. In three studies, I test how regulatory fit, as outlined by regulatory engagement theory, can be used to boost student engagement.

Regulatory Engagement Theory and Regulatory Fit

Regulatory Engagement theory provides an account for how value is created during goal pursuit. Value is a motivational force experience that has direction (e.g. attraction to or repulsion from) and intensity (e.g. weak or strong). One particular factor that can contribute to the intensity of the motivational force is strength of engagement (Higgins, 2006; Higgins & Scholer, 2009). Engagement is defined as the state of being fully absorbed or engrossed in an activity. Because engagement relates to the intensity, rather than the direction of motivation, people can be strongly engaged in both pleasant and unpleasant goal pursuit. One important factor that can contribute to the engagement experience, and ultimately, to value creation, is regulatory fit.
According to regulatory engagement theory, regulatory fit increases engagement in an activity, as compared to situations of regulatory non-fit. Regulatory fit occurs when an individual’s motivational orientation, beliefs or goals and the strategies employed during goal pursuit fit, leading to greater strength of engagement, as compared to situations of non-fit. Strength of engagement has been indexed in a variety of ways, including performance and persistence on a task (Higgins, 2000; see Higgins, 2005 for a review; Higgins, 2006; Higgins & Scholer, 2009). Forster, Higgins and Idson (1998), for example, found that people in a fit state performed better on anagram tasks. They also persisted longer and exerted more effort, as measured by the arm pressure they exerted to complete the task. Regulatory fit can make people “feel right” about their choices or evaluations in persuasion and decision making contexts (Avnet & Higgins 2006; Cesario, Grant, & Higgins, 2004) as well as in the domain of morality (Camacho, Higgins & Lugar, 2003). Regulatory fit is distinct from other perspectives such as person-environment fit (e.g. Chatman, 1989; Kristof, 1996), which has predominately been investigated in organizational settings as the interplay between employees and their company. Whereas regulatory engagement theory directly links engagement as resulting from fit, person-environment fit does not.

Regulatory fit sustains, rather than disrupts, people’s motivational orientation. People that have a promotion focus (concern with nurturance and accomplishment), prefer eager strategies. On the other hand, people with a prevention focus (concerned with safety and security), prefer vigilant strategies. Having participants complete a task framed in either an eager vs. vigilant way leads promotion- vs. prevention-oriented people to perform better (e.g. Freitas & Higgins, 2002; Freitas, Liberman, & Higgins, 2002). Similarly, promotion and prevention people who imagine the presence or absence of positive or negative outcomes can experience fit when
the imagined outcome is consistent with their regulatory concerns (Higgins, Idson, Freitas, Spiegel, & Molden, 2003). Importantly, the effects are not due to people imagining the pleasure or pain of the outcome, but instead occur because the framing sustains their regulatory orientation (by maintaining a high level of eagerness/vigilance under fit), which increases engagement in the activity (Idson, Liberman & Higgins, 2004).

Multiple factors can contribute to any specific motivational orientation (Aaker & Lee, 2006). For example, prevention individuals who use local processing and promotion individuals who use global processing during goal pursuit experience regulatory fit, as indexed by speed of processing task-relevant stimuli and performance (Forster & Higgins, 2005). The preferred strategy of goal pursuit can also depend on the characteristics of the task at hand. For example, fun tasks such as dating games, can lead people to be more engaged when pursued in a fun vs. important manner, whereas completing financial duties leads to greater engagement when framed as an important but not as a fun task (Bianco, Higgins & Klem, 2003).

Despite the considerable number of studies that have demonstrated the importance of fit in various contexts, less research has been done on the applications of fit to educational settings. A study by Spiegel, Grant-Pillow and Higgins (2004) suggests possible implications of fit for education. Researchers found that regulatory fit predicts the likelihood of turning in a report about one’s goals for the weekend. Under fit, people were more likely to mail back the report than those under non-fit. In a related vein, regulatory fit has been linked to people reporting a greater willingness to repeat a laboratory task (identifying shapes in an object search task) in the future under fit than non-fit (Freitas & Higgins, 2002). However, many education-related questions remain unanswered: What is the role of regulatory fit in academic settings, particularly in reference to academic achievement? Does fit increase student engagement?
The current set of studies was designed to address these questions. The studies tested the effect of regulatory fit on engagement and learning within educational contexts. Understanding the role of regulatory fit in these settings may provide a better understanding for how to improve student learning.

In previous work I have explored the effect of regulatory fit within mathematics, particularly in light of the need to recruit students into science, technology, engineering, and mathematics (STEM) fields (Rodriguez, Romero-Canyas, Downey, Mangels & Higgins, 2011). In two studies I investigated whether fit is applicable to people’s cultural beliefs (e.g. beliefs about the interdependence of the self). We hypothesized that students would be more engaged in a math task when their beliefs about the benefit of math education were consistent with the framing of the task. In the first study I found that for highly interdependent individuals – people who see the self as intertwined and interrelated with others – performance on a math task was boosted when a pre-task manipulation emphasized math’s benefit to society but not when it emphasized math’s benefit to the individual self. Thus, a task that supposedly served the individual’s beliefs about the self boosted engagement (via performance). In the second study, such fit led to greater use of resources that could increase math understanding.

Building upon the above studies, which demonstrate the importance of fit in math achievement, the current studies were undertaken to explore several additional questions regarding regulatory fit and learning. In study 1 I ask: Do people select tasks that reflect their beliefs (i.e. self-selected fit), and does this selection results in greater performance? In Study 2, I draw from the persuasion literature to explore whether the same strategies that lead to greater persuasion (e.g. fit and how attention on a task is directed) also apply to understanding students’ experience studying. More specifically, I address the issue of whether fit differentially affects
students’ evaluative responses to studying and their engagement as a function of the aspects of an educational task that are emphasized during studying. Finally, in Study 3 I investigate the role of fit in challenging academic environments, and specifically for people’s ability to rebound from failure. I use electroencephalography (EEG) to provide a complementary understanding of the attentional mechanisms that underlie fit in challenging tasks.

**Study 1: Choice**

The role of regulatory fit has recently been linked to people’s cultural beliefs in math achievement settings. Highly interdependent people who perceive the self as fundamentally intertwined and interconnected with others, are more engaged in a math task when the task is framed as one in which the benefits of learning math are linked to others rather than to the individual self (see Rodriguez, Romero-Canyas, Downey, Mangels, & Higgins, 2011). In these sets of studies, participants were randomly assigned to a task that was either consistent or inconsistent with their beliefs. If given the opportunity, would people pick tasks that reflect their beliefs, and would this choice predict their subsequent engagement in the task?

There is suggestive evidence that regulatory fit may influence peoples’ preferences. For example, when estimating preferences among different products, people attended more to information that was relevant to their regulatory goals (i.e., gains or losses), unless there was external incentive to process all information (Wang & Lee, 2006). In addition, people felt better about a choice when led to imagine the choice’s outcome in a way that fit their promotion or prevention goal (Idson, Liberman & Higgins, 2004).

People also appear to prefer tasks that fit their self-beliefs (Fyans & Maehr, 1979). Recent comparisons of relatively more interdependent North Americans (those with less than high school education) with more independent peers (those with a college education) shows that
people make choices among different products that reflect their goals and values (Stephens, Markus, & Townsend, 2007). Independent participants chose products that highlighted their autonomy and independence, whereas more interdependent participants chose products that reflected similarity and connectedness. In a related vein, Iyengar, Ross & Lepper (1999) found that whereas highly independent people prefer self-made choices, highly interdependent individuals prefer other-made choices. These findings suggest that when given options between different academic tasks, people should prefer those framed in a manner consistent with their beliefs and goals.

Study 1 assessed whether people choose math tasks that fit their self-beliefs and whether they perform better when they do so. The effect of self-beliefs on preference should be evident when the individual is given the impression that they can choose between a belief-consistent or belief-inconsistent task.

Study 1 also explored whether fit extends to other beliefs, e.g. independence, the extent to which people see the self as autonomous, separate and unique from others (Markus & Kitayama, 1991). In previous work, I only found fit effects for interdependence but not independence, and argued it was the case because the frame did not emphasize aspects of independence important to the independent students in the university sample (Rodriguez, Romero-Canyas, Downey, Mangels & Higgins, 2011). Thus, Study 1 used a new independent prompt that emphasized alternate aspects associated with independence (e.g. personal uniqueness and expression).

**Hypotheses**

I expect that individuals who strongly endorse beliefs about the independent self should be more likely to choose a math task describing characteristics and values linked to independence, and those who strongly endorse beliefs about the interdependent self should be
more likely to choose a task emphasizing characteristics and values associated with interdependence. Furthermore, in both cases, fit should be associated with greater performance on the math task.

**Method**

**Participants and Procedures**

Table 1 describes participant demographics (N = 86). After completing the I/C questionnaire, participants read a (fictitious) *New York Times* article that was developed, described below. After reading the article, participants selected one of the problem sets to solve (both sets contained identical problems), were debriefed and paid $10.

**Measures**

*Collectivism/Individualism Scale* (I/C; Oyserman, 1993). Three subscales tap aspects of interdependence (interrelatedness, sense of common in-group fate, familialism) and three tap aspects of independence (personal achievement, uniqueness, personal freedom/happiness). Participants indicated agreement with each statement (1 = not at all; 4 = very much). Table 2 gives descriptives and sample items. A Sex x Ethnicity (Asian American VS. Asian VS. Others) ANOVA revealed no significant differences in scale endorsement (p’s ≥ 0.07).

*Fictitious Article.* To test whether people chose to work and engage in math problems that serve their beliefs about the interdependence of the self, a frame was needed that presented math as benefiting the individual self or one's communities. Thus, a fictitious newspaper article was created that presented research about two different types of mathematics, each associated with different life goals and career paths.

The frame emphasizing interdependence was based on a version used in previous work that was significantly correlated with the interrelatedness component of interdependence and that
had successfully led to fit (Rodriguez, Romero-Canyas, Downey, Mangels, & Higgins, 2011). The current article presented one set of math problems using similar language to the interdependence frame presented in earlier work. In addition, based on previous work (Rodriguez, Romero-Canyas, Downey, Mangels, & Higgins, 2011), the fictitious article included language that framed mathematics problems as serving an aspect of independence not obviously connected to math and science, personal uniqueness. Perhaps framing of tasks to generate fit may be more effective when the frame emphasizes some non-obvious connection between the task and the person's goals (e.g., between math and helping others).

The fictitious article (see Appendix A) described two subsets of math problems linked with different career paths and personality traits. People who did well on the personal development subset pursued personal dreams, goals and careers, stood out for their unique approach and contributions, and were creative and versatile (independence frame). People who did well on the societal development subset pursued careers that had direct benefits to society, addressed pressing societal issues, were good at resolving conflict and maintaining ties with others (interdependence frame).

**Choice.** Everyone read: "You will now have the option to pick between two different sets of math problems to complete. These are based on the article that you just read: Set A is linked to personal development and expression, and Set B is linked to societal development." Societal Development and Personal Development were counterbalanced in their association with Set A and B. 38 chose the societal development packet, and 48 chose the personal development packet. Choice did not vary significantly by sex or ethnicity.

**Math Performance.** Total correct responses was recorded as the proportion of items answered correctly for 12 multiple-choice and four open-ended GRE-type questions completed.
without calculators in 25mins (e.g., If \(af = 6\), \(fg = 1\), \(ag = 24\), and \(a \geq 0\), then \(afg = (12)\); \(M = .50\), \(SD = .25\)).

**Math Knowledge** was measured as number of college math classes. The number was higher for men and Asians/Asian Americans (Table 1, 3).

**SAT Quantitative Skills Score** (College Board, 2009) were collected through self-report at the end of the study and used as an additional control for math preparedness (Table 1).

**Results**

**Choice**

Logistic regression was used to test whether self-beliefs predicted choice of the societal or personal development frame (coded 0 or 1 respectively). A preliminary analysis in which all six subscales were entered into the model supported focusing on interrelatedness and uniqueness: none of the other subscales significantly predicted choice and thus were dropped from the model. Analyses controlled for sex, Asian ethnicity, Asian American ethnicity\(^1\), SAT scores and number of math courses taken in college. All variables were centered around their respective means.

Uniqueness predicted choosing the personal development frame, \(\beta = 2.16\), \(wald = 10.91\), \(p \leq .001\), Odds Ratio (OR) = 8.70. Interrelatedness predicted choosing the societal development frame, \(\beta = -1.22\), \(wald = 4.74\), \(p \leq .03\), OR = 3.38 (Figure 1).

**Performance**

In separate analyses based on task choice, performance was regressed on interrelatedness, uniqueness and controls. Among people who picked the societal development frame, performance was predicted by interrelatedness \((b = .14, t(30) = 2.09, p \leq .05)\) but not by uniqueness \((b = -.03, t(30) = -.21, p \leq .69)\). Among those who picked the personal development
frame, performance was significantly predicted by uniqueness \(b = .03, t(40) = 2.31, p \leq .05\) but not by interrelatedness \(b = .03, t(40) = .57, p \leq .58\) (Figure 1).

None of the results were significantly moderated by sex, ethnicity, or math knowledge.

**Discussion**

Beliefs about the interdependence or independence of the self predict choosing to work on math tasks framed as being in the service of one's beliefs and performing better on the chosen task, presumably because of increased engagement. When given a choice between two sets of math problems, participants high in interrelatedness were more likely to choose problems that had been presented as benefiting society (interdependence frame), while participants high in personal uniqueness were more likely to choose problems presented as supporting creativity and originality (independence frame). Additionally, among those who chose the societal benefit problem set, interrelatedness predicted better performance and among those who chose the personal development set, uniqueness predicted better performance.

Study 1 shows that the fit effect is, as expected, not specific to beliefs about the interdependence of the self, and that the fit effect can extend to other beliefs set (e.g. independence). Just as students high in interrelatedness performed better when a set of math problems was presented as benefiting society in previous work (Rodriguez, Romero-Canayas, Downey, Mangels & Higgins, 2011), in the current study, students who highly value personal uniqueness performed better in a set of problems that they had been led to believe served their personal goals. None of the other subscales predicted performance because the prompts did not emphasize those components of interdependence or independence.

The finding that a belief that is not typically associated with the study of math (e.g. personal uniqueness) can predict better performance in that task when those beliefs are
emphasized highlights the importance of how the frame is created. It seems that for beliefs and the task frame to result in fit effects on choice and performance, the frame may need to highlight the non-obvious ways in which the task serves personal goals. Personal freedom and valuing achievement did not produce fit with the personal benefit problem set in this study, while personal uniqueness did. The connection between personal uniqueness and mathematics is one that is not obvious, unlike that between achievement and math, or quantitative skills and careers that offer financial independence, for instance. Thus, the revelation of the "unexpected" link between mathematics and values and goals associated with personal uniqueness may have, in a sense, increased the likelihood of fit, perhaps because the novelty of the information made learning math for the sake of personal uniqueness a more accessible or salient idea.

Study 1 highlights the potential for flexible educational interventions that would benefit students with diverse values and goals. This would be particularly useful for recruiting and retaining students in disciplines currently more closely identified with some self-beliefs and not others, for example, mathematics and independence.

Whereas Study 1 provides an account for how fit affects choice, a remaining question is how fit affects the kinds of learning processes that are associated with better performance. Thus, in a follow up study, I explored how fit and the different ways students study influence engagement. To do so, I drew from the persuasion literature to test whether the same processes that have been found to be effective in persuading people are relevant in the context of studying a text.

**Study 2: Regulatory Fit and Persuasion**

There are many routes to persuasion, from attitudinal advocacy effects such as role-playing behavior, in which the very act of advocating an assigned (often counter-attitudinal)
position leads to greater attitude change consistent with the advocated message (e.g. Hovland, Janis, & Kelly, 1953; King & Janis, 1956), to message-based persuasion techniques such as argument quality, with better quality arguments eliciting greater persuasion (e.g. Petty & Cacioppo, 1984). More recently work on regulatory fit has demonstrated that fit matters for persuasion (Cesario & Higgins, 2008). In this study I explored whether the manner in which regulatory fit has been applied in persuasion contexts can also be used to understand how to increase engagement in an educational setting.

Regulatory fit has been shown to increase the extent to which people are persuaded by a message (Cesario & Higgins, 2008), with fit making people “feel right”, or more confident, about their evaluative responses to a message and non-fit making people “feel wrong”, or less confident, about their evaluative responses. In one instance this was accomplished by matching the way in which a message was delivered (e.g. nonverbal behavior, such as hand gestures) to the motivational orientation of the recipient (promotion vs. prevention). In cross-cultural work, fit between cultural beliefs about the self and the frames used to present messages promoting health behavior led readers to perceive those messages as more persuasive (Uskul & Oyserman, 2010). Fit is also more generally associated with perceiving messages as easier to process (Lee & Aaker, 2004).

Cesario, Grant and Higgins (2004) found that participants’ evaluative responses to a message can also depend in part on what aspect of a message receives attention: whether attention is directed to the persuasiveness of the message itself or to people’s own opinion of the proposal. When participants focused on the persuasiveness of the message, people’s thoughts (via a thought listing paradigm), and more specifically, the valence of those thoughts, predicted the message’s perceived persuasiveness. The more positive people’s thoughts about the message,
the more persuasive they found the message under fit than non-fit. Experiencing more negative thoughts, however, led people to be less persuaded by the message under fit than non-fit. Thus, fit served to make people feel more confident about their positive or negative evaluative reaction to the message than non-fit; i.e., fit made them “feel right” about their positive reaction or “feel right” about their negative reaction. When people instead focused on their own opinion of the proposal, rather than the message itself, thought favorability did not predict perceived persuasiveness. People were simply more persuaded under fit than non-fit. Hence, people in this circumstance “felt right” about the proposal to a greater extent under fit than non-fit.

It is argued that thought favorability is more influential when people focus on a message’s persuasiveness rather than their opinion of the proposal because valenced cognitions about the message are made more accessible in the former circumstance (Cesario, Grant, & Higgins, 2004; Clore, 1992). According to the cognitive response model (Greenwald, 1968; Petty, Ostrom & Brock, 1981), valenced cognitions can mediate the effect that a message has on persuasion such that positive cognitions which are generated from a message lead to greater persuasion and more negative cognitions lead to less persuasion. However, this only occurs when motivation is high (see Chaiken, Wood & Eagly, 1996), as may be the case when people experience regulatory fit. Thus, participants in Cesario, Grant and Higgins (2004) message-persuasiveness condition may have processed the strength and weaknesses of the message’s arguments in a way that elicited more positive and negative message-related thoughts. Participants who focused on their opinion of the proposal, on the other hand, simply reflected on whether or not they agreed with the proposal without considering the strengths and weaknesses of the message itself.
Hypotheses

This previous work serves as a basis for understanding whether the same processes that underlie persuasion may be used to understand the manner through which students come to be engaged with a text as they are studying; whether they focus on the effectiveness of the message text or on their opinion of the proposal. In the proposed study, I sought not only to extend Cesario, Grant and Higgins (2004) study to an educational setting but also to explore its relation to education-relevant measures of engagement (e.g., reading comprehension performance).

Rather than use a thought listing paradigm, participants’ attitudes towards studying will be assessed as a proxy for the kinds of thoughts that may be elicited as students’ experience the act of studying. Consistent with Cesario, Grant and Higgins (2004), I argue that students’ study attitudes will surface when they study a message for its effectiveness. Students who have positive study attitudes are likely to respond positively to studying (e.g. “studying is wise and thus this text is effective”), whereas people with negative study attitudes are likely to respond negatively to studying (e.g. “studying is foolish and thus this text is ineffective”). Furthermore, fit should lead students to “feel right”, or more confident about their positive or negative evaluations than students under non-fit. Among students who instead focus their studying on whether or not they agree with the proposal and the general position that it advocates, fit (regardless of study attitudes) should predict students’ feeling right about the proposal.

Although students’ positive and negative evaluations and confidence in their evaluations may differ as a function of their study attitudes, fit, and study focus, what should predict student engagement in the material is regulatory fit. Regulatory engagement theory argues that the valence of one’s evaluation is independent of the strength of engagement experienced (Higgins,
Thus, individuals with both negative and positive attitudes can be equally engaged under fit, which predicts that learning performance will be greater under fit than non-fit.

**Method**

**Participants and Procedures**

Table 1 describes participant demographics ($N = 86$). The study was described as a reading preferences and study habits experiment. After completing the regulatory fit induction, participants read a compiled encyclopedia article on the topic of octopuses’ intelligence. The article described evidence suggesting that octopuses are highly evolved and intelligent animals. Prior to reading the article, participants were given a set of instructions that instructed them to study a text about which they would later be asked questions. Instructions also contained key experimental manipulation (see below). After reading the article, participants answered some filler questionnaires, and proceeded to take a multiple-choice test assessing their reading comprehension of the text. After participants finished the tasks, they were debriefed and paid $5.

**Octopus Text.** Participants read an interactive text on the topic of octopus’ intelligence entitled: “Behind the Mind of an Octopus”. The article was presented one paragraph at a time. Interspersed within some paragraphs, were optional hyperlinks that if clicked on, provided individuals with more information about a related topic. Participants had unlimited time to read through the text. See Appendix B for a text excerpt.

**Framing Instructions.** All participants first read that they would be asked to study an article for which they would subsequently be asked questions. Following the general instruction, participants were randomly assigned to one of two conditions listed below.
In the condition where the study focus was on *Message Persuasiveness*, participants (N = 44) read:

You will be given an encyclopedia article to read about the controversial topic of octopuses’ intelligence and asked how persuasive you found the text to be. As you are reading the article, think about how the article is written and its strengths and weaknesses: essentially, how effective is it?

In the condition where the study focus was on participants’ *Opinion of the proposal*, participants (N = 42) read:

You will be given an encyclopedia entry on the controversial topic of octopuses' intelligence and asked what your attitude toward the topic is. As you are reading the article, think about your opinion of the topic and your stance on it: essentially, do you agree or disagree with the topic of octopuses' intelligence?

**Measures**

*Regulatory Fit Induction* (RFQ; Freitas & Higgins, 2002). The purpose of the regulatory fit induction is to create situations of regulatory fit or non-fit by either matching or mismatching one’s strategy to the induced regulatory focus. Participants are first asked to list either something they ideally would like to do (promotion) or something they believe they ought to do (prevention). After indicating a goal, participants list up to 8 strategies they could use to “make sure everything goes right” (eager) or “avoid anything that could go wrong” (vigilant). Thus, this measure produces promotion regulatory fit (promotion focus, eager strategy), prevention regulatory fit (prevention focus, vigilant strategy), promotion regulatory non-fit (promotion focus, vigilant strategy), and prevention regulatory non-fit (prevention focus, eager strategy).

People were randomly assigned to regulatory fit or non-fit. The number of people in each
condition were as follows: Prevention fit (N = 22), promotion fit (N = 24), prevention non-fit (N = 24) and promotion non-fit (N = 19).

**Study Attitudes - Cognition Scale** (Tykocinski, Higgins & Chaiken, 1993). 3 items tapped into people’s cognitions about studying. Participants rated the extent to which they thought studying is bad/good, unimportant/important, and foolish/wise, using a 7-point Likert scale ($M = 6.39, SD = .72, \alpha = .52$).

**Frequency of Studying Behavior.** (Tykocinski, Higgins & Chaiken, 1993). Participants reported the extent to which they had engaged in studying in the past (during the previous semester) on a scale 0 (almost never) to 7 (very often); $M = 5.47, SD = 1.59$. Frequency of study behavior was assessed to ensure that less positive study attitudes were not necessarily linked to less studying behaviors.

**Text Persuasiveness.** A persuasiveness index was created based on participants responses to two items: the extent to which they found the text to be persuasive and convincing on a scale from 0 (not at all) to 6 (extremely) ($M = 4.58, SD = 1.12, \alpha = .74$).

**Reading-Comprehension Task.** Participants completed 10 multiple-choice questions based on the article they had previously studied (e.g. “Maze and problem solving experiments suggest that octopuses have what capability?” (Short & long-term memory); $M = .68, SD = .19$).

**Results and Discussion**

**Data Analytic Considerations**

For all analyses, text opinion, text persuasiveness and reading comprehension scores were regressed on the following variables: Fit (1 = fit, 0 = non-fit), Focus (1 = opinion of proposal, 0 = message persuasiveness), study attitudes, and all possible 2 and 3 way interactions.
All variables were centered around their respective mean. Although not included in the final analyses, all findings below held when controlling for the frequency of study behaviors.

**Text Persuasiveness.** There was a main effect of fit, which reflected the fact that people were more persuaded under fit than non-fit condition ($b = .54$, $t(82) = 2.31, p \leq .02$), and a main effect of focus such that people were more persuaded when they focused on their opinion of the proposal than when focused on the message persuasiveness ($b = .44$, $t(82) = 1.89, p \leq .06$). The Fit X Study Attitudes interaction was significant ($b = .82$, $t(78) = 2.58, p \leq .01$), with more positive attitudes toward studying predicting greater text persuasiveness under fit ($b = .44$, $t(39) = 2.30, p \leq .03$) but not under non-fit ($b = -.38$, $t(39) = -1.48, p \geq .15$). None of the other two-way interactions were significant, $p$’s $\geq .89$. Finally, the Fit X Focus X Study Attitudes interaction was significant ($b = -1.65$, $t(78) = -2.60, p \leq .01$).

To unpack the three-way interaction, separate regressions were conducted for each focus condition. Fit and study attitudes were entered in the first level, and their interaction in the second. Within the *message persuasiveness* condition, the interaction between Fit X Study Attitudes was significant ($b = 1.63$, $t(40) = 3.43, p \leq .001$). Subsequent simple slope analysis (Aiken & West, 1991) indicated that in the fit condition, more positive study attitudes was associated with greater persuasiveness ($b = .82$, $t(40) = 2.44, p \leq .02$). In the non-fit condition, however, more positive study attitudes was associated with less persuasiveness ($b = -.81$, $t(40) = -2.42, p \leq .02$) (Figure 2). This suggests that participants with more positive study attitudes were more likely to have positive reactions to the activity of learning about, i.e., studying, the intelligence of octopuses, but whereas in the fit condition they “felt right” or confident about their positive reactions and thus felt the text was effective, in the non-fit condition they “felt
wrong” or less confident about their positive reactions and thus felt there must be something wrong with the text.

Within the opinion of the proposal condition, the interaction between Fit X Study Attitudes was not significant \((b = -.03, t(38) = -.06, p \geq .95)\), nor were the simple slope for study cognitions in the fit condition \((b = -.08, t(38) = -.46, p \geq .37)\) nor in the non-fit condition \((b = .06, t(38) = .18, p \geq .86)\). However, there was a marginally significant fit effect, such that fit generally predicted greater persuasion than non-fit \((b = .52, t(39) = 1.88, p \leq .068)\) (Figure 2).

**Reading Comprehension.** None of the 2 or 3-way interactions between focus, fit or study attitudes were significant, \(p\)’s \(\geq .09\). However, there was a significant main effect of fit \((b = .08, t(82) = 1.96, p \leq .05)\), such that people in fit did better on the reading comprehension task than those in non-fit (Figure 3). Interestingly, further inspection revealed a marginally significant correlation between persuasion and reading comprehension, such that greater perceived persuasiveness was associated with greater performance, \(r = .20, p \leq .06\).

**Conclusion**

Findings from Study 2 demonstrate that under fit, when people focused on the persuasiveness of a message, study attitudes (e.g. cognitions) was associated with the extent to which they found the text to be persuasive. The more positive students’ attitudes about studying, the more persuaded they perceived the text to be under fit but not non-fit. Among people who focused instead on their opinion of the proposal, study attitudes did not interact with fit. Rather, people under fit were more persuaded than people under non-fit. These findings are a conceptual replication of the findings of Cesario, Grant and Higgins (2004) but they extend them to the domain of learning from texts and to the case of study attitudes impacting responses to reading the text rather than the quality of arguments impacting responses to a persuasive message. The
extent to which students find the text to be persuasive under fit seems to reflect the extent to which they “feel right” or are confident in their evaluative responses to studying (and thus, the text), particularly as compared to non-fit. These findings also generally support research that finds that people’s feelings can be used as sources of information when making evaluative judgments (see Clore, 1992), so long as they are not made aware of the feeling’s source (e.g. see Clore, Schwarz, & Conway, 1994). The study also found that reading comprehension was better under fit than non-fit, and that more generally, the more students were persuaded, the better they did on the task. This is a new finding that has important implications for education.

In addition to the expected predictions, another interesting pattern that emerged was that under non-fit, when people focused on the message persuasiveness, positivity of people’s cognitions predicted less text persuasiveness. As suggested earlier, perhaps the sense of “feeling wrong” about one’s positive thoughts while learning about the intelligence of octopuses led people to infer that the text itself was not very effective. This in turn suggests the intriguing possibility that when students have a negative attitude towards studying an intervention might be to create a non-fit prior to reading a text in order that they would “feel wrong” about their negative thoughts and decide that the text itself was quite effective.

One potential concern that arises from looking at people’s study attitudes is the possibility that the favorability of their attitudes may influence the frequency with which they study, with people with more positive study attitudes studying to a greater extent than those with less positive study attitudes. However, as indicated in the methods, on average, people reported studying quite frequently in the past semester ($M = 5.47$ on a 7 point scale). Thus, it seems that students acknowledge the importance of studying for achievement, and is consistent with the
student population at Columbia, who tend to be high achieving. Notably, persuasion and engagement findings still significantly hold after controlling for frequency of studying behavior.

In sum, the findings of this study extend the work conducted in persuasion to an educational context, and demonstrate that fit can impact both the persuasiveness of a text and learning its material. Indeed, findings show that fit can contribute to learning independent of individuals’ personal attitudes about studying. This suggests that fit could be used to enhance learning even for students who do not have positive study attitudes. It may be the case that engaging students through fit may help to change their valuation of the study experience over time. If studying is seen as an obstacle to overcome (Higgins & Scholer, 2009), and students are able to successfully overcome such an obstacle, it may be that their attitudes about and valuation of studying may become more positive with repeated exposure. Future research should explore this possibility.

In study 3, the role of regulatory fit in challenging academic environments was explored, to see if fit helps students rebound from failure. I used a paradigm that provided students with continuous feedback about their performance in order to see if they would correct their errors on a subsequent incidental learning test. Unlike Study 2 where students’ attention was explicitly directed, Study 3 allowed students to naturally allocate attention on an academic task and measured attention via electroencephalography.

**Study 3: Rebound from Failure**

Mastery and performance goals encompass two goal types originally identified as being important for students’ educational outcomes (Dweck, 1986; Elliot, 1997; Nicholls, 1984). The achievement goal literature is vast on this area and has traditionally highlighted the overall benefit of mastery goals, which place emphasis on learning, effort and challenge. Endorsing a
mastery orientation has been linked to positive outcomes, such as persistence, greater performance and deeper processing of study material (Elliot, McGregor, & Gable, 1999), and an incremental, malleable view of intelligence (Vandewalle, 1997). Performance goals, on the other hand, which stress the importance of proving one’s ability or capacity to achieve in comparison to others, have more traditionally been perceived as being detrimental to achievement. Some studies have found that performance goals are linked to negative outcomes like superficial processing of information (Elliot, McGregor & Gable, 1999), depression (Sideridis, 2005), evaluation anxiety (Elliot & McGregor, 1999), self-handicapping (Urdan, 2004), and a fixed view of intelligence (Vandewalle, 1997).

How do mastery-oriented and performance-oriented students perceive difficult academic tasks where failure is possible? People with mastery orientations persist on challenging tasks (Elliot & Dweck, 1988) and this is thought to be the case because they do not associate failure with one’s level of ability but instead perceive it to be a learning experience. It has been argued that people with performance goals, however, can view challenge as threatening, and ultimately disengage from difficult tasks, especially given their perception that failure reflects limited capacity (Elliot & Dweck, 1988). Thus, it appears that individuals with performance goals would be particularly vulnerable when presented with a difficult academic task.

Although much research suggests that performance goals are maladaptive, other studies have found performance goals to be linked to persistence, effort, challenge appraisals, and facilitated performance (Elliot, Shell, Henry, & Maier, 2005; Lopez, 1999; McGregor & Elliot, 2002). To address these mixed results, studies have found that performance goals are adaptive when coupled with either perceptions of high self-competency (Elliot & Dweck, 1998), or an approach orientation (as opposed to an avoidance orientation) (Elliot, 1999; Elliot et al., 2005).
The benefits of an approach orientation have also been linked to mastery goals. Although many studies have documented the benefits of mastery-approach goals, the addition of mastery-avoidance goals to the achievement goal framework is recent; thus, less is known about their academic consequences. While they are considered to be less adaptive than mastery-approach goals, some work suggests that mastery-avoidance goals do not hurt performance, perhaps because of their mastery focus (Elliot & McGregor, 1999). Furthermore, they may not be hurtful when the desire to improve one’s competency is salient (Elliot & McGregor, 1999), as may occur when students revisit their mistakes. However, previous work has generally examined how students fail and persist on new, untested material (Elliot & Dweck, 1988). In these cases, mastery (approach) goals predict good academic outcomes. It is unknown whether students would persist and learn on items they had previously failed to learn. It may be that students with mastery-avoidance goals excel on these kinds of tasks.

We explore the possibility that performance-approach goals will boost achievement under regulatory fit, and that mastery-avoidance goals will boost achievement under fit, for a task in which students must revisit their past errors. I investigated this possibility in light of two other theories. According to a mastery goal perspective, endorsement of mastery goals is always more adaptive for achievement than endorsement of performance goals (Dweck & Leggett, 1988). On the other hand, Elliot and McGregor’s 2 x 2 achievement goal framework implies that mastery-approach goals are comparable to performance approach goals, which are both generally more adaptive than mastery-avoidance or performance-avoidance goals (Elliot & McGregor, 2001).

Additionally, I explored the neural underpinnings of rebound from failure by examining how attention is allocated as a function of goal and context using electroencephalography (EEG) recordings.
Electroencephalography and Achievement

EEG is a non-invasive technique that measures brain activity elicited from the scalp. EEG provides a direct and accurate recording of the temporal course of voltage changes caused by sensory, motor or cognitive events (Friedman, Cycowicz, & Gaeta, 2001), in the form of event-related potentials. One particular event related potential that can account for students’ experiences as they progress through challenging academic tasks is the late positive potential (LPP). The LPP is a positive-going potential that captures a form of sustained attention to information that is motivationally-relevant (Cuthbert, Schupp, Bradley, Birbaumer, & Land, 2000). It is also sensitive to emotional up- or down-regulation of the response to this information (Hajcak, MacNamara & Olivet, 2010). The LPP occurs maximally at central/parietal sites, is elicited 300 to 450 ms after stimulus onset and can be sustained up to or above 1000 ms (Cuthbert et al., 2000).

Based on an evolutionary perspective that argues that emotion can drive attention when survival is on the line, the LPP was originally thought to capture motivationally-relevant attention due to research showing its emergence to pleasant and unpleasant but not neutral stimuli (e.g. Bradley et al., 2003; Hajcak, Macnamara, & Olvet, 2010; Lang et al., 1998, Morris et al., 1998; Sabatinelli, Bradley, Fitzsimmons, & Lang, 2005; Schupp et al., 2000). Though most of the work on the LPP has been conducted using unpleasant (e.g. sharks, mutilations) and pleasant events (e.g. sports, nudes), the LPP is conceptualized more broadly as processing of motivationally-relevant stimuli. In situations where performance is on the line, even perceptually simple performance feedback is motivationally-relevant. Indeed, a recent study found that the LPP was associated with heightened attention to negative feedback in a challenging math problem solving task (Mangels, Good, Whiteman, Maniscalco, & Dweck, 2011). Interestingly, in
that study, the LPP was related to poor learning, and less efficient use of learning resources (i.e. tutor). Research in emotion regulation shows the LPP response is reduced when using cognitive reappraisal techniques, such as reinterpreting emotional stimuli as less intense (Hajcak & Nieuwenhuis, 2006; Moser, Hajcak, Bukay, & Simons, 2006). These reappraisal techniques have been thought to work by changing the meaning of the stimuli (Foti & Hajcak, 2008; Hajcak & Nieuwenhuis, 2006) or changing its relative importance (Schupp et al., 2007) and is consistent with the notion that the LPP may be sensitive to people’s motivations.

Electrophysiological studies are beginning to examine how different achievement goals bias attention to performance and mastery aspects of a learning environment. Research on an earlier but related component, the P3, which captures an orienting response to unexpected or novel stimuli (e.g. high confidence error), suggests that performance-oriented individuals may be more vulnerable to negative performance than mastery-oriented individuals. Mangels and colleagues (2006) used a feedback-based paradigm in which participants received performance feedback (i.e. green asterisk and high tone if correct vs. red asterisk and low tone if incorrect) and learning feedback (i.e. correct answer) after answering individual items. To capture incidental learning, participants were subsequently surprise retested on all the items they had previously answered wrong. The researchers found that endorsement of performance goals predicted a greater orienting response to negative performance feedback than did endorsement of mastery goals. This orienting response also predicted worse performance on a surprise retest of all incorrect items. Thus, it would seem more generally that endorsement of performance goals as compared to mastery goals can disrupt and harm learning in challenging situations. It is unknown, however, whether endorsement of performance goals would lead to the same troubling academic outcomes if the learning environment fostered performance goals.
In the current study, I used a feedback-based paradigm, based on similar paradigms used by Mangels and colleagues (2003, 2006, 2011) to ask: how do people progress through a challenging academic task as a function of their achievement goals and the message conveyed by the task? In the study, the LPP’s response to performance feedback in a challenging verbal task was investigated, given its role in motivated attention. In addition to looking at performance feedback, I also tested the extent to which people process learning feedback. Successful encoding of verbal information (e.g. learning feedback) has been shown to modulate sustained, negative-going waveforms over inferior posterior and fronto-temporal sites starting at approximately 200 ms after the onset of a word stimulus (Butterfields & Mangels, 2003; Mangels et al., 2006; Mangels, Picton, & Craik, 2001). In previous feedback-based studies (Mangels et al., 2006), successful encoding at these temporal sites was indexed as the relative difference in negativity elicited for later remembered and forgotten items (known as the “difference due to memory,” Paller & Wagner, 2002).

Previous work has found that mastery goals differentially modulated fronto-temporal learning-related activity, whereas activity over more posterior sites was similar in both performance and mastery oriented students. The more frontal activity seen in mastery oriented students is likely to have arisen from more semantic, meaningful processing of the learning feedback. The processing of performance-oriented students appeared to stop at more perceptual, and putatively “shallower” levels of processing (Mangels et al., 2006). On one hand, it may be that environments that emphasize mastery rather than performance lead students to process information crucial to learning to a greater extent, particularly after a failure experience. However, in previous studies, either individual differences in achievement goals were measured but no task goal was explicitly emphasized (Mangels et al., 2006) or task goals were emphasized
but the individual’s goals were not assessed (Mangels et al., 2011). Thus, an untested possibility is that individuals with performance goals may process learning feedback in a comparable level to mastery individuals when under regulatory fit.

Hypotheses

Given the literature suggesting the benefits of endorsing performance-approach goals, I hypothesize that people’s performance-approach goals will predict greater correction on a retest for items that they had previously answered incorrectly only on a performance-framed task. On a task that is framed to emphasize mastery goals, however, I expect instead that people’s mastery-avoidance goals will predict greater error correction. It is theorized that in situations in which one has failed to learn, individuals with mastery-avoidance goals will be motivated to correct their errors. Although there is not much work linking mastery-avoidance goals to beneficial academic outcomes, it may be that these benefits arise in situations in which individuals are provided with an opportunity to revisit and correct their past errors (Elliot & McGregor, 1999).

However, these fit effects should only emerge for items where people experience a minimal level of interest or investment, as is the case when they have provided an answer. Failing to provide answers may instead reflect situations in which people have very little knowledge or interest in the topic.

In addition to behavioral results, and based on previous work (Mangels et al., 2011), structural equation modeling (SEM) was used to test the interrelation of EEG and behavioral variables in each framing in order to obtain a more comprehensive understanding of the mechanisms underlying rebound from failure. To do so, I used AMOS software to conduct maximum likelihood parameter estimations on resulting variance-covariance matrices.
In the performance frame, given the importance that is placed on indicators of ability/competency, I expect that endorsement of performance-approach goals will predict greater sustained attention to incorrect responses, as signaled by the LPP. Despite the saliency of negative performance feedback for people who endorse performance goals, I do not expect that the LPP will hurt processing of learning feedback or retest performance for items that were encountered in the performance-framing block. Why? Perhaps adopting an approach orientation to the task boosts overall motivation to continue with the task, whereas an avoidance motivation steers students away from the task. It may also be the case, however, that the LPP does not hurt learning if people are indeed experiencing greater engagement in the task. Greater engagement may be sustaining attention to information in a way that aids learning.

In the mastery frame, mastery-avoidance goals should not predict greater sustained attention to negative performance feedback, and if anything, people endorsing these goals should attend less to this information given their greater concern with learning than performance. Similar to Mangels et al. (2006), endorsement of mastery goals in the current study should be linked to greater processing and encoding of learning feedback in a manner that boosts retest correction in the mastery-framing block.

**Method**

**Participants and Procedures**

Table 1 describes the demographics of the participants (N = 24). All subjects were prescreened 1-14 days prior to the EEG study. Participants met inclusion criteria for participation (18–28 years old, right-handed, fluent English speakers, normal or corrected-to-normal vision/hearing, and no history of neurological disorders). During prescreen, participants also completed a packet of questionnaires that contained the achievement goal questionnaire (Elliot &
McGregor, 2001). Two participants were excluded from the analysis because they performed at ceiling on the incidental learning task (described below) and two individuals were excluded because of excessive noise in their EEG recordings (e.g. sweat potentials, muscle artifacts).

On the day of the experiment, participants were informed that the researchers were interested in identifying stimuli for use in future psychology studies. After participants provided verbal and written consent, experimenters proceeded to equip them with the EEG cap, and seated them 60 cm away from a PC computer monitor located within a private booth. Participants were provided with ear-bud headphones and began the first test, which consisted of two blocks of general knowledge questions. After each block, participants were given a short questionnaire that contained manipulation check items regarding the purpose of the block. After task completion, experimenters removed the EEG cap, and allowed participants a couple of minutes to freshen up. Participants were subsequently escorted back to their computer booth and asked to complete a retest on the computer. After the retest, participants were fully debriefed and paid $10/hour, for a minimum of $40 and maximum of $50.

**Stimuli.** A pool of 400 questions was assembled drawing from various academic domains, including literature, natural and physical sciences, geography, and history. Items were normed with a separate student population for difficulty and familiarity (95% of participants rated questions’ answers as familiar). Stimuli were imported into Presentation, version 14.1 (Neural Behavioral Systems, 2010) for use in first test and retest.

**First Test.** The task included two blocks each consisting of 100 questions. Prior to each block, participants viewed a set of instructions with the framing manipulation (see below). To ensure that participants received the main instructions, a pre-recorded female voice read the instructions aloud. Additionally, half-way through each block, an instruction reminder was
introduced as a momentary break, and presented for 20 s (with no audio). The presentation order of instruction set was counter-balanced by participant.

For each general knowledge item, participants typed a one-word response. If participants were unsure of their answer and could not make an educated guess, they were asked to enter “XXX,” which signaled an omit response. After submitting a response, participants were asked to indicate their confidence in their response on a 7-point scale from 1 (you are absolutely sure your answer is wrong) to 7 (you are absolutely sure your answer is right). Following confidence ratings, participants were presented with performance feedback information (which was preceded and followed by a crosshatch, presented for 1.5 s). A green asterisk (displayed for 1 s) paired with a high tone was presented if participants were correct, and a red asterisk (displayed for 1 s) paired with a low tone was presented if participants were incorrect. Following performance feedback, participants were shown learning-relevant feedback, which consisted of the correct answer, displayed for 2.5 s.

In order to make the task challenging, each block was independently titrated at 30% accuracy, based on a mathematical algorithm that the Presentation software used to randomly select questions based on their normed difficulty level (e.g. participants were presented with an easier question if the previous item was wrong, and a harder question if the previous item was correct). Neither first-test performance nor the proportion of omits varied by framing block (first test: Performance frame $M = .32$ ($SD = .05$), Mastery frame $M = .32$ ($SD = .05$), $t(23) = .35, p ≥ .73$; Proportion of omits: Performance frame $M = .19$ ($SD = .14$), Mastery frame $M = .20$ ($SD = .13$), $t(23) = -.48, p ≥ .64$).

Similarly, confidence for items answered correctly at first test did not vary by frame (Performance frame corrects: $M = 5.19$ ($SD = .50$), Mastery frame corrects: $M = 5.17$ ($SD = .44$),
\(t(23) = .23, p \geq .82\), nor did they vary for items answered incorrectly (Performance frame incorrects: \(M = 3.30 (SD = .55)\), Mastery frame incorrects: \(M = 3.32 (SD = .57)\)), \(t(23) = -.13, p \geq .90\).

**Framing Instructions.** Participants read and simultaneously heard over headphones the following instructions:

In the *Performance Framed* block:

The following question set consists of questions that are being considered for inclusion in future studies. They have been drawn from a pool of previously established questions. In order to determine whether to use them for future studies, we will assess your accuracy on these questions. In answering these questions, it is important that you use the feedback to get a sense of your accuracy on the task. Since we are interested in determining the appropriateness of these questions for a college population over time, we will directly compare your individual performance to that of other university students who are also participating in this study. Please try your best to answer these questions.

In the *Mastery Framed* block:

The following question set consists of questions that are being considered for inclusion in future studies. For this section, we are chiefly interested in how people learn to solve different kinds of questions over time, rather than in their accuracy. This part of the study is exploratory – and thus, we are interested in determining the types of questions that people find useful and learn the most from. In answering these questions, it is important that you use the question feedback to get a sense of what you are learning from the question set. Think about the questions that you find to be especially interesting and from which you learn the best. Please try your best to answer these questions.

**Retest.** Approximately 10 minutes after cap-removal, participants were once again seated in front of the computer and presented with a retest of all items that they had answered incorrectly from both frames. Items were randomly interspersed, as to avoid participants being able to identify from which block items were drawn. Mean performance on retest, excluding omits, did not differ by frame (Performance frame retest \(M = .77, SD = .16\); Mastery frame retest \(M = .78, SD = .13\), \(t(23) = -.38, p \geq .71\). Retest performance for omits, did not differ by frame
either (Performance frame retest $M = .63$, $SD = .20$; Mastery frame retest $M = .64$, $SD = .17$, $t(22) = -.16$, $p \geq .87$).

**ERP Recording and Data Reduction.** Continuous EEG was recorded during the first test from 64 sintered Ag/AgCl electrodes with an A/D conversion rate of 500 Hz and band-pass of DC-100 Hz. Impedance was kept below 11 kΩ. EEG was initially referenced to Cz and converted to an average reference off-line. PCA-derived ocular components were used to compensate for blinks and other eye movement artifacts. Artifacts not captured by other filters were manually removed and interpolation of electrodes did not exceed 10% of total electrodes. Off-line, EEG was cut into 1100 ms epochs starting 100 ms prior to the onset of the performance or learning feedback. Following baseline correction, I excluded epochs containing excessive noise ($\pm 120$ mV), applied 0.15 Hz high-pass and 35 Hz low-pass, zero-phase filters, and then averaged these epochs to create the ERPs.

For performance feedback, retention of non-omit trials approximated 27 correct trials, 41 incorrect trials, and 16 omit trials in each block. Retention did not vary by block ($p$’s $\geq .78$). For learning feedback, some participants had low trial counts for uncorrected retest items where they had attempted an answer at first test, thus, rather than look at difference due to memory (DM), an average was computed that collapsed across later corrected and uncorrected items and that accounted for trial count. The amplitude of this waveform reflects the relative contributions of the neural processes associated with corrected vs. uncorrected item for a given person. Similarly to the DM effect, for this average, greater negativity should reflect greater successful encoding.

The analysis of the LPP was focused on the period 450-1000 ms after stimulus onset, at its CPz and Pz maxima. Learning feedback analyses were focused on the right frontal (F8, FT10,
and T8), right posterior (TP8, TP10, CB2, and O2), left frontal (F7, FT9, and T7), and left posterior (TP7, TP9, CB1, and O1) sites for the 200-400 ms and 400-1000 ms epochs.

**Measures**

*Achievement Goal Questionnaire* (Elliot & McGregor, 2001). Participants completed the achievement goal questionnaire during the prescreen. The achievement goal questionnaire contains four subscales that assess individuals’ endorsement of achievement goals along both achievement goal type and the approach/avoidance dimension. Participants rated the extent to which they agree with each statement on a scale of 1 (not at all true of me), to 7 (very much true of me) (Mastery-approach: “I want to learn as much as possible from my courses”, $M = 5.49$, $SD = 1.18$, $\alpha = .90$; Mastery-avoidance: “I worry that I may not learn all that I possibly could in my courses”, $M = 4.22$, $SD = 1.24$, $\alpha = .76$; Performance-approach: “It is important for me to do better than other students”, $M = 5.26$, $SD = 1.30$, $\alpha = .79$; Performance-avoid: “I just want to avoid doing poorly in my courses”, $M = 4.89$, $SD = 1.57$, $\alpha = .72$).

*Manipulation Check Items*. After each block, participants were asked to rate the extent to which they agreed (on a scale “1” not at all, to 6 “very much”) that the purpose of the block was to: “Identify which questions you find useful and learn the most from” (Mastery Item) and “Determine your accuracy in comparison to other university students participating in the study” (Performance Item).

**Behavioral Results**

**Manipulation Checks**

After each block, participants’ responses to the two manipulation check questions assessed the extent to which they thought the purpose of the instructions was to assess performance and/or mastery. Two participants were missing values in 1 one of their blocks, and
thus the sample mean was used to supplement their responses in that block. Paired t-tests revealed that participants perceived that the performance frame was more about performance ($M = 5.52$, $SD = .71$) than it was about mastery ($M = 3.70$, $SD = 1.49$; $t(23) = 5.15$, $p \leq .001$). In the mastery frame, however, participants were just as likely to perceive the block to be about mastery ($M = 4.21$, $SD = 1.41$) and about performance ($M = 4.17$, $SD = 1.40$; $t(23) = -.09$, $p \geq .93$), regardless of the order in which the blocks were tested. Thus, to account for participants’ perceptions of task instructions, a difference score between these two manipulation check items was computed for each frame and included in the behavioral analyses as a control.

**Data Analytic Considerations**

Item correction in each frame served as the main behavioral dependent variables. Omit and non-omit cases were separately analyzed, as they could hold different motivational significance for participants. Omits may reflect domains in which the participant has little knowledge and/or curiosity, as well as situations where the feedback outcome is already determined by their answer (they are aware that they have answered incorrectly). With non-omit trials, on the other hand, participants may be more interested in receiving feedback since they provided an answer. They may also be more interested in the domain in general.

Each behavioral analysis controlled for first time performance in that block and the manipulation check difference score. All variables were centered around their respective means.

**Omit Item Correction in the Performance Frame.** None of the goals significantly predicted retest correction: Performance-approach goals ($b = .05$, $t(16) = 1.63$, $p \geq .12$; performance-avoidance $b = -.01$, $t(16) = -.18$, $p = .86$; mastery-approach $b = .01$, $t(16) = .20$, $p \geq .85$; mastery-avoidance $b = .06$, $t(16) = 2.05$, $p \geq .09$).
**Omit Item Correction in the Mastery Frame.** Performance-approach significantly predicted correction in the mastery frame: \( b = .06, t(16) = 2.22, p \leq .05 \). None of the other goals predicted retest correction (Mastery-avoidance: \( b = -.01, t(16) = -.56, p \geq .58 \); mastery-approach \( b = .02, t(16) = .60, p \geq .56 \); performance-avoidance \( b = -.02, t(16) = -.84, p \geq .41 \)).

**Non-Omit Item Correction in the Performance Frame.** Performance-approach goals significantly predicted greater retest performance (\( b = .07, t(17) = 2.64, p \leq .02 \)). However, performance-avoidance was not associated with item correction (\( b = -.01, t(17) = -.45, p \geq .66 \)). As expected, neither mastery-approach nor mastery-avoidance predicted retest correction in the performance frame (mastery-approach \( b = -.01, t(17) = -.42, p \geq .68 \); mastery-avoidance \( b = .03, t(17) = 1.15, p \geq .37 \) (Figure 5).

**Non-Omit Item Correction in the Mastery Frame.** Mastery-avoidance goals significantly predicted greater correction in the surprise retest (\( b = .03, t(17) = 2.09, p \leq .05 \)) but mastery-approach did not (\( b = .01, t(17) = .67, p \geq .51 \)). Neither performance-avoidance nor performance-approach significantly predicted retest performance in the mastery frame (performance-avoidance \( b = -.01, t(17) = -.56, p \geq .58 \); performance-approach \( b = .03, t(17) = 1.70, p \geq .09 \) (Figure 5).

Given the behavioral results, ERP analyses were confined to items that exclude omit trials, and looked first at general frame effects and then used structural equation modeling (SEM) to identify possible mechanisms underlying the behavioral results.

**EEG Frame Effects and Structural Equation Modeling**

**Performance Feedback**

To explore the role of the LPP in each frame, I collapsed across central/parietal electrodes (CPz & Pz) for incorrects and corrects in each frame, which were significantly
correlated in the sample, \( r = .46, p \leq .03 \). A 2 (Performance: correct vs. incorrect) x 2 (Frame: Performance vs. Mastery) ANOVA for the 450-1000 ms epoch revealed only an effect of accuracy, \( F(23,1) = 23.00, p < .001 \), with corrects eliciting a more sustained LPP (\( M = 3.78, SD = 1.55 \)) than incorrects (\( M = 3.00, SE = 1.61 \)), \( t(23) = 4.59, p \leq .001 \). Even for the 450-600 ms epoch, where visual inspection suggested that there was a frame effect for negative feedback, the overall frame effect was not statistically significant, \( F(1,23) = 1.04, p \geq .32 \), nor did it emerge when the analysis was restricted to incorrect responses or to Pz (Figure 6).

**Learning Feedback**

A 2 (Hemisphere: right vs. left) x 2 (Frame: performance vs. mastery) x 4 (electrode: F7/F8, FT9/FT10, T7/T8, TP7/TP8) ANOVA was conducted for each time period (200-400 and 400-1000 ms) for frontal sites. Effects of electrode that did not interact with frame are not reported. For the 200-400 ms epoch, the waveforms were more negative-going over the left hemisphere overall, \( F(1,23) = 6.91, p \leq .05 \). There was also a marginal Frame x Hemisphere interaction, \( F(1,23) = 3.62, p \geq .07 \), resulting from the left frontal activity being more negative (\( M = -1.69, SD = 1.47 \)) than right frontal activity (\( M = -.87, SD = 1.49 \)), under performance framing only, \( t(23) = 2.14, p = .04 \). There were no significant effects during the 400-1000 ms epoch (Figure 7).

A 2 (Hemisphere: right vs. left) x 2 (Frame: performance vs. mastery) x 4 (electrode: O1/O2, Cb1/Cb2, TP9/TP10, TP7/TP8) ANOVA for each time period (200-400 and 400-1000 ms) for posterior sites was also conducted. In the 200-400 ms epoch, there was a significant main effect of hemisphere, such that the waveforms were also more negative-going over the left hemisphere, \( F(1,23) = 19.50, p < .001 \). There was also a marginal main effect of frame, with a more negative-going waveform in the mastery frame, \( F(1,23) = 3.85, p \leq .06 \). These main effects
were modulated by a marginal Frame x Hemisphere interaction, \( F(1,23) = 3.82, p \leq .06 \). Post-hoc t-tests indicated that the interaction was driven by a right-hemisphere lateralization of the frame effects, with the negativity being greater in the mastery frame (\( M = -3.65, SD = 2.08 \)) than in the performance frame (\( M = -3.08, SD = 2.36 \)), \( t(23) = 2.30, p \leq .03 \). There were no significant effects during the 400-1000 ms epoch (Figure 7).

Given the learning feedback findings, I collapsed electrodes in the right frontal (F8, FT10, and T8), right posterior (TP8, TP10, CB2, and O2), left frontal (F7, FT9, and T7), and left posterior (TP7, TP9, CB1, and O1) sites for the 200-400 ms and 400-1000 ms epochs separately.

**Structural Equation Modeling (SEM)**

SEM was used to identify the mechanisms underlying the performance-approach effect in the performance frame and the mastery-avoidance effect in the mastery frame. Each model started with a base model that included values from all principle ERP effects (LPP, fronto-temporal and posterior negativities), and relevant behavioral effects and covariates (first test accuracy, manipulation check). With the exception of goals, parameters used in each frame-specific model used only the values specific to that frame (e.g. LPP in the performance frame). To attain goodness-of-fit in each model (RMSEA ≤ .05), a stepwise approach was used to exclude relationships that were not significant. See Figure 8 for visualizations of the best-fit models. Although not displayed, the direct path from goals to retest was no longer significant when including the ERP mediators.

**Performance Frame Model.** In the performance frame model (Figure 8), performance-approach goals predicted greater sustained attention to negative outcomes (LPP 450-1000 ms), consistent with an attentional bias toward performance-relevant information (Mangels et al., 2006, 2011). However, this did not have a negative effect on learning. Rather, it appears to have
motivated engagement with the learning feedback, as indexed by a significant relationship between the LPP during feedback and negative-going right frontal inferior negativity (200-400 ms) during learning feedback. This early right frontal negativity predicted successful error correction on the surprise retest.

**Mastery Frame Model.** In the mastery frame model (Figure 8), endorsement of mastery-avoidance goals predicted reduced sustained attention to negative outcomes, and was consistent with a greater valuation of learning than performance information. This effect was moderated by the participant’s belief that performance was still being stressed under this framing (i.e. Manipulation check). The LPP to performance feedback was decoupled from subjects’ response to learning feedback as it did not predict learning-relevant activity. Instead, greater negativity to learning feedback at 200-400 ms for left frontal temporal sites predicted retest performance in the mastery frame.

**Non-fit Models.** To assess whether the best-fit models capture fit, I tested the performance model in the mastery frame, by changing all the components (except for goal) to reflect the mastery frame. Similarly, I tested the mastery model in the performance frame. Neither of these models had goodness-of-fit (RMSEA ≥ .05). For standardized betas in each model, see Table 4a (performance model) and 5a (mastery model). For model testing, see Table 4b (performance model) and 5b (mastery model).

**Discussion**

The purpose of Study 3 was to explore the interplay of achievement goals and context in the face of challenge. Behavioral results indicate that the more that people endorsed performance-approach goals, the more non-omit retest items they corrected from the performance frame. In the mastery frame, mastery-avoidance goals predicted greater correction
of non-omit retest items. Overall, behavioral results support a regulatory fit perspective by demonstrating that pursuing tasks that emphasizes a message that is consistent with one’s goals leads to greater engagement and learning.

EEG was used to better understand the processes through which people with performance-approach and mastery-avoidance goals experienced greater engagement in the performance frame and mastery frame, respectively. Structural equation modeling suggests that these two pathways are distinct. Performance-approach individuals up-regulate their emotional responses to negative performance feedback. This up-regulation leads to deeper processing of learning feedback as indexed by a right fronto-temporal negativity, which in turn predicts greater retest performance in the performance frame. The direct link between goal and retest performance was not significant, indicating that the designated pathway provides a mechanism through which performance-approach goals leads to greater engagement in the performance frame.

Mastery-avoidance individuals, on the other hand, may either down-regulate their emotional responses to negative performance feedback, or attend less to the feedback given their valuation of learning. Regardless, however, their processing of performance feedback is independent from the factors that lead to greater correction in the mastery frame. What does predict retest performance is the extent to which participants process the learning feedback, as indexed by the left fronto-temporal negativity. Thus, greater engagement in the mastery frame stems directly from their engagement with learning feedback independently of their response to performance feedback. The poor fit of the non-fit models suggest that these mechanisms are not general frame strategies but specific to the interplay between goals and task environment.
EEG findings are consistent with previous work on hemisphere lateralization of semantic and emotional processing. Whereas processing of emotional stimuli is associated with right hemisphere activity, processing of semantic non-emotional stimuli is linked to left hemisphere activity (Dillon, Cooper, Grent-’t-Jon, Woldorff, & LaBar, 2006; Ortigue, Michel, Murray, Mohr, Carbonnel, & Landis, 2004). Perhaps performance-approach individuals are fueled by their emotional responses to negative feedback, experiencing a “hot” emotional response (Metcalf & Mischel, 1999) akin to irritation (in an “I’ll show them” manner) that leads them to process learning feedback more deeply under fit. Despite their negative valence, agitation-related emotions are engaging (Higgins, 2006), and may be one way through which individuals experience fit. Mastery-avoid people, however, may instead adopt a “cool,” distant approach, by experiencing negative feedback as less emotional (Metcalf & Mischel, 1999). For them, processing verbal information at the exclusion of an emotional response boosts learning.

Current work demonstrates that performance goals serve adaptive functions for achievement when the environment conveys performance goals. Interestingly, findings emerged on an incidental learning task that participants were unaware would occur. Furthermore, the study finds that the benefits are specific to performance-approach and not performance-avoidance goals, which is consistent with past literature. A recent meta-analysis argues that the benefits of performance-approach may stem in part from emphasizing a normative component (e.g. wanting to do better than others) that is consistently linked with better performance whereas performance scales with an underlying appearance-based component (e.g. concern with trying to look good to an audience), or an evaluative component (e.g. concern with outperforming others in the presence of an audience) are associated with negative outcomes (Hulleman, Schrager, Bodmann & Harackiewicz, 2010). Hence, the current study’s performance framing, which
emphasized a normative component, may have been particularly effective in producing fit with performance-approach goals.

It is also possible that performance-approach findings may have been due to a greater sense of confidence or competency, as suggested by Dweck and Elliot (1988). In a follow up analysis, performance-approach goals did not predict people’s confidence ratings in either frame, and behavioral results continued to hold even after adding confidence ratings for correct and incorrect items as covariates. Thus, though it may be that students with these goals are feeling highly competent, it does not predict why they are excelling in the performance frame.

Why were mastery-approach goals not predictive of performance in the mastery frame? The link between mastery goals and academic performance is not always evident (e.g. Anderman & Midgley 1997; Harackiewicz, Barron, Tauer, Carter, & Elliot, 2000; Wolters, 2004). Inconsistencies have been attributed to wording differences across versions of mastery scales (Hulleman, Schrager, Bodmann & Harackiewicz, 2010), while other work has found that the link emerges when the task is challenging or the material is personally valued (Grant & Dweck, 2003). Findings from this study may have been due to the version of mastery scale used, which emphasized goal-relevant language that is not linked to performance (Hulleman, Schrager, Bodmann & Harackiewicz, 2010). Nonetheless, our mastery-avoidance findings provide some of the first empirical evidence that the endorsement of these goals can benefit learning, but only under specific circumstances, such as when students are given an opportunity to correct their past errors.

Fit findings only occurred when people were at least minimally interested or knowledgeable in the question. Omit items may have represented more difficult items that students knew little about, and which they could not retain after just one exposure. Perhaps
revisiting these omit items may have helped students to learn them under fit. Unexpectedly, performance-approach goals predicted greater correction of omits in the mastery frame and mastery-avoidance suggested greater correction of omits in the performance frame. If indeed people were less knowledgeable about or interested in these items, then perhaps task framing had less of an impact on these items and instead the strength of students’ predominant goals directed their correction of these items.

The study suggests that achievement goals are not always harmful or beneficial, but rather that fit matters. What occurs, however, if a situation demands for a particular kind of goal (e.g. a competitive tournament in which performance goals are optimal)? Adapting to the situation and self-regulating one’s goals may be an important coping strategy through which students achieve. Future work should explore how priming goals when the task at hand is either consistent or inconsistent with the primed goal may influence learning, particularly when rebounding from failure. In a related vein, it is unlikely that students endorse mastery goals at the exclusion of performance goals, or vice-versa. Rather, individuals may endorse and juggle multiple goals (see Shah, 2005). Research by Barron & Harackiewicz (2001) have begun to explore this, by suggesting that endorsing both a performance and mastery goal (multiple goal perspective) may be better for achievement than simply endorsing a single goal. Future research should explore how endorsement of multiple achievement goals may influence engagement and learning in challenging academic environments.

**General Discussion**

Studies provide support for the role of regulatory fit in an educational domain by demonstrating that fit leads to greater engagement in academic tasks. In study 1, a fit between people’s cultural beliefs (beliefs about the interdependence/independence of the self) lead people
to choose a task that was consistent with their beliefs. This selection was also subsequently associated with better performance. In study 2, standard persuasive strategies (e.g. focus on the text message persuasiveness vs. focus on opinion of the proposal) were associated with students perceiving a science text to be more persuasive under fit when they focused on the persuasiveness of the message they were studying and they had positive attitudes toward studying, consistent with their “feeling right” about their positive responses to studying the message. What mattered for performance was simply fit (vs. non-fit), consistent with their being engaged more strongly in studying the text. In study 3, using a general knowledge paradigm, fit helped students rebound from challenging circumstances (e.g., correcting errors after having performed poorly on a test). This is especially evident among students who endorse goals that have previously been argued to be maladaptive in difficult academic circumstances, as is the case with performance goals and mastery-avoidance goals. Furthermore, through EEG I find some initial support that fit may work by boosting processing of learning feedback in the case of mastery-avoidance goals and by up-regulating attention to negative outcomes in the case of performance-approach goals.

The findings of these studies add to the growing work on regulatory fit and its possible utilization in classrooms to improve academic attitudes and engagement. This might be particularly important to consider in light of students who experience their academic environment as being one that does not serve their needs, as may occur for performance-oriented individuals in mastery settings. Though the long term effects of fit are less documented, it’s possible that drawing people into challenging domains that they might have otherwise avoided (e.g. math, science, difficult tasks) may provide a first step in changing their perceptions or evaluations of such domains. Indeed, overcoming obstacles may strengthen engagement, and
change people’s evaluation of the domain (Higgins & Scholer, 2009), ultimately making it more likely that these students will participate more actively in these domains in the future.

Do people retain information better in the long run under fit than non-fit? Findings from Study 3 suggest this possibility, with fit leading to greater processing of learning feedback associated with encoding processes (via early temporal negativity). Previous work by Butterfield and Mangels (2003) found that people had better memory on a retest for items that they had previously been invested and engaged in (e.g. high confidence errors), an effect which although reduced, was still evident after a delay. Given that fit increases people’s engagement on the task, it may be the case that people would be more likely to remember the information after a delay.

Though in the current studies I do not find that non-fit hurts engagement, previous work suggests that it does (Rodriguez, Romero-Canyas, Downey, Mangels & Higgins, 2011). For example, people in non-fit failed to use necessary resources to aid in their understanding of math problems they had previously erred on, thus denying themselves the opportunity to improve. Future work may want to continue to explore the manner through which non-fit leads to people’s underutilization of academic resources. Recent work on stereotype threat found, for example, that whereas some people may engage more superficially with an academic resource by skimming through the material, others disengage from the resource all together (Mangels, Good, Whiteman, Maniscalco, & Dweck, 2011). Understanding these processes may provide insight on how to address these maladaptive strategies. On the flipside, it may be noteworthy to explore the possible benefits of non-fit. Are there circumstances under which it would help to be in non-fit? It may be more adaptive to disengage from certain activities or tasks that are counter-productive (e.g. procrastination, rumination, persisting on an incorrect strategy to solve a problem). Being
able to disengage from these problematic situations may be an important skill through which to successfully navigate one’s academic experiences.

These findings add to the accumulating evidence that small, simple interventions based on social psychological science may have the potential to help combat social problems (Walton & Dweck, 2009) such as the academic achievement gaps in North America (cf. Cohen, Garcia, Purdie-Vaughns, Apfel, & Brzustoski, 2009). As some studies have shown (Walton & Cohen, 2007) such interventions can have substantial long-term benefits on engagement and academic performance. The regulatory fit approach can be used to build simple interventions. This approach is different from other social-psychological approaches in that it does not prescribe a particular self-view or a specific frame. Instead, it highlights the benefit of emphasizing the utility of the task at hand in serving the individual's beliefs and values. The resulting boost in engagement increases the likelihood of individual success and, in the aggregate, of societal benefit.
References


By JAY PIXIE

While they may have sat on opposite sides of the classroom in school, it just may be that artists and performers actually have something very much in common with engineers and scientists of this world: they are good at math. People with higher math scores showed that they can be especially skilled at achieving life success at either an individual or societal level, based on what kind of problem they scored well in, new studies published by Harvard University researchers revealed.

“For years people have suspected that certain math skills are associated with skills in other areas,” said Dr. Elizabeth Spelle, Harvard University’s chief investigator. “Now we’ve found that developing certain math abilities is tied to some important societal skills on one end, while developing other kinds of math abilities is tied to important individual skills. These differentiated math abilities are clearly related to benefits in either individual or societal settings.”

Participants’ math abilities in college strongly correlated with their personality traits, and also with their future career choices three years later, researchers found.

Scores on two different sets of math problems predicted two very different career paths: one geared towards personal development and expression, and the other geared towards societal development.

In the first set of math problems, high-scorers were found more likely to pursue personal dreams, goals and careers, including those which were unusual or esoteric.

“Many of them are visual and performing artists, writers, stylists, and musicians on one hand, and scientists and engineers on the other. Even for more practical jobs like accounting, individuals who scored high on these math problems stand out for their unique approach and contributions,” remarked Dr. Spelle.

The findings suggest that excelling at this first type of math problems was linked to certain personality traits as well, among them, creativity and versatility.

According to Dr. Spelle, “They tend to be the kinds of people who come across as ‘thinking outside of the box.’ They are self-determined in doing what they want to do, are successful at overcoming individual hardships and obstacles, in order to accomplish personal goals. They are also innovative and versatile, often having an extensive range of hobbies, and they like to try new things.”
Many also tended to use a portion of their income towards travel, personal development and self-expression, the research found.

Alternatively, success on the second group of math problems pointed toward an entirely different kind of career path and personality-type among participants: group-oriented and issue-based.

High-scorers in the latter group tended to pursue careers that have direct benefits for society: a large percentage worked in economics, business, medicine, education, policy and environment-related jobs; others were likely to use their expertise to address pressing societal issues in research and science.

“They are driven by concerns that affect society and help others through their career and life goals. These individuals were also good at resolving conflict with others, worked well in team settings, had extensive social networks and maintained strong ties with others,” Spelle said.

Spelle and her colleagues found that the many in the latter group contributed some of their income to organizations, groups and communities that they belong to, as well as to programs that have been shown to effectively increase societal productivity and success.

These math-based relationships predicted success over and above traditional measures of academic success and career choice, such as GPA and college major, the studies showed. The research was conducted among 2400 participants nationwide.

Overall, Dr. Spelle said, the findings “are exciting, and so far suggest that peoples’ skills and math abilities are related in some way. There is no denying the link between developing either societal or individual skills to these kinds of math skills. The exact nature of the link – whether it’s due to cognitive processes, personality characteristics, or some kind of combination, will be the subject of further research, but with these results it’s clear that some kind of significant interaction is taking place.”

How to understand the nature of these connections is the challenge at hand. In collaboration with the Center for Biological & Computational Learning at MIT, Dr. Spelle and her colleagues are now working to identify the underlying personality and mathematical characteristics of these special kinds of math abilities and how they are tied to their consequences.

“This research is promising for both those of us who seek to contribute to issues concerning others in our society, as well as for those of us who would like to hone in on individual growth and development – particularly if this is possible through different fundamental math skills. Although we are still ironing out some details, for now, what remains clear is that these different math problems are indeed linked to very different but very important outcomes for both the self and for others.”
Appendix B

Behind the mind of an Octopus

The octopus is a cephalopod of the order Octopoda. Structurally, octopuses have two eyes and four pairs of arms and like other cephalopods are bilaterally symmetric. Octopuses have hard beaks, with their mouths at the center point of their arms, and most octopuses have no internal or external skeleton, allowing them to squeeze through tight places, such as openings no bigger than one of their eyes (Stewart, 1997). In addition to their unique physical configuration, a feature that is thought to distinguish Octopuses from other invertebrates is their intellectual capacity. According to experts, octopuses are likely more intelligent than any other order of invertebrates (Hamilton, 1997).

[Paragraph 1 of 10]

The exact extent of Octopuses' Intelligence and learning capability is much debated among biologists, but maze and problem-solving experiments have shown that they do have both short- and long-term memory (Zimmer, 2008). However, their short life spans limit the amount they can ultimately learn. For example, some species live for as little as six months. Larger species, such as the North Pacific Giant Octopus, may live for up to five years under suitable circumstances. Often, reproduction is a cause of death: males can only live for a few months after mating, and females die shortly after their eggs hatch (Stewart, 1997).

[Paragraph 2 of 10]

Would you like to read about the main cause of death among octopuses?

- Yes
- No

Often, reproduction is a cause of death: males can only live for a few months after mating, and females die shortly after their eggs hatch. They neglect to eat during the (roughly) one month period spent taking care of their unhatched eggs, but they don't die of starvation. Endocrine secretions from the two optic glands are the cause of genetically-programmed death (and if these glands are surgically removed, the octopus may live many months beyond reproduction, until she finally starves).
Footnotes

1 In Study 1 participants provided information on country of birth and residence. Based on classifying Asian /Asian American participants by whether they were born abroad or in the USA, two separate dummy variables for ethnicity were created and included as controls in the analyses. For each dummy variable, Asian (or Asian American) ethnicity was coded as 1 and all other groups were coded as 0.

2 36 Participants were excluded from the analysis because they could not correctly remember the main manipulation instructions, which were probed several minutes after the manipulation implementation. Thus, given that they served more so as control participants, they were not included in the analysis.

3 In a one way ANOVA, promotion and prevention fit did not differ on reading comprehension performance ($p = .72$) and were thus collapsed across. Similarly, promotion and prevention non-fit did not differ from each other ($p = .58$), and thus were collapsed across.
Table 1: Sample Demographics: Studies 1 – 3

<table>
<thead>
<tr>
<th></th>
<th>Study 1 (N = 86)</th>
<th>Study 2 (N = 86)</th>
<th>Study 3 (N = 24)</th>
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<tbody>
<tr>
<td>Age</td>
<td>19.2 (1.19)</td>
<td>20.5 (2.90)</td>
<td>20.5 (2.32)</td>
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<td>% Female</td>
<td>71%</td>
<td>72%</td>
<td>63%</td>
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<td>SAT Quantitative Reasoning</td>
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<td>-</td>
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<tr>
<td>Number of Math Classes Taken in College</td>
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<td>-</td>
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<td>Ethnic Groups in Sample</td>
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<tr>
<td>African/African American</td>
<td>10.5%</td>
<td>10.5%</td>
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<td>Asian/Asian American</td>
<td>33.7%</td>
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<td>Hispanic/South or Central American</td>
<td>8.1%</td>
<td>8.1%</td>
<td>20.8%</td>
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<tr>
<td>Other</td>
<td>9.3%</td>
<td>11.6%</td>
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Table 2: Means (SD), Sample Items, and Alphas from the I/C Scale for Study 1

<table>
<thead>
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<th>I/C Subscales</th>
<th>Study 1</th>
<th></th>
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<tr>
<td></td>
<td></td>
<td>Mean (SD)</td>
<td>α</td>
<td></td>
</tr>
<tr>
<td>Interrelatedness</td>
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<td></td>
</tr>
<tr>
<td>&quot;To know who I am, you must see me with members of my group&quot;</td>
<td>2.57 (.50)</td>
<td>.62</td>
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<td></td>
</tr>
<tr>
<td>Common in-group fate</td>
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<td></td>
</tr>
<tr>
<td>&quot;I have respect for the leaders of my religious, national, or ethnic groups&quot;</td>
<td>2.11 (.67)</td>
<td>.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Familialism</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I often turn to my family for social and emotional support&quot;</td>
<td>3.13 (.69)</td>
<td>.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal achievement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;To know who I am, you must examine my achievements and accomplishments&quot;</td>
<td>3.01 (.51)</td>
<td>.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal uniqueness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;I am different from everyone else, unique&quot;</td>
<td>3.47 (.46)</td>
<td>.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal freedom/happiness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Individual happiness and the freedom to attain it are central to who I am&quot;</td>
<td>3.20 (.53)</td>
<td>.66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: ANOVA for Math Familiarity by Sex and Ethnicity for Study 1

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD) Number of College Math Classes</td>
<td>1.10 (1.19)</td>
<td>1.60 (1.32)</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>Non-Asian</td>
</tr>
<tr>
<td></td>
<td>1.79 (1.37)</td>
<td>0.96 (1.09)</td>
</tr>
</tbody>
</table>

Sex: $t(83) = 2.00, p \leq .05$, 
Ethnicity: $t(83) = 3.13, p \leq .002$,

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD) SAT Quantitative Reasoning</td>
<td>701.48 (73.57)</td>
<td>748.00 (68.68)</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>Non-Asian</td>
</tr>
<tr>
<td></td>
<td>769.31 (33.90)</td>
<td>687.37 (75.01)</td>
</tr>
</tbody>
</table>

Sex: $t(83) = 2.77, p \leq .007$, 
Ethnicity: $t(83) = 4.92, p \leq .001$,

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD) Math Performance</td>
<td>.44 (.22)</td>
<td>.59 (.26)</td>
</tr>
<tr>
<td></td>
<td>Asian</td>
<td>Non-Asian</td>
</tr>
<tr>
<td></td>
<td>.63 (.21)</td>
<td>.40 (.22)</td>
</tr>
</tbody>
</table>

Sex: $t(83) = 3.26, p \leq .002$, 
Ethnicity: $t(83) = 4.84, p \leq .001$, 
Table 4a: Standardized Betas for Performance-Approach Goals and ERP Effects in the Performance Frame (Fit) and Mastery Frame (Non-fit) in Study 3

<table>
<thead>
<tr>
<th></th>
<th>Performance Frame</th>
<th>Mastery Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance-Approach Goal to LPP</td>
<td>$.66 (p ≤ .004)</td>
<td>$.62 (p ≤ .001)</td>
</tr>
<tr>
<td>LPP to Learning 200-400ms Right Frontal</td>
<td>-.57 (p ≤ .001)</td>
<td>-.32 (p ≥ .11)</td>
</tr>
<tr>
<td>Learning 200-400ms Right Frontal to Retest</td>
<td>-.43 (p ≤ .01)</td>
<td>-.43 (p ≤ .002)</td>
</tr>
<tr>
<td>First Test Performance to LPP</td>
<td>.07 (p ≥ .48)</td>
<td>.04 (p ≥ .79)</td>
</tr>
<tr>
<td>First Test Performance to Retest Performance</td>
<td>.39 (p ≤ .02)</td>
<td>.63 (p ≤ .001)</td>
</tr>
</tbody>
</table>

Notes:
- LPP above references the 450-1000ms epoch at the Pz & CPz composite for incorrect non-omit trials
- Retest only consists of non-omit trials
Table 4b: Model Testing of the Performance Model in the Performance and Mastery Frame in Study 3

<table>
<thead>
<tr>
<th></th>
<th>Performance Frame</th>
<th>Mastery Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>4.63</td>
<td>6.67</td>
</tr>
<tr>
<td>DF</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>$P$</td>
<td>.46</td>
<td>.25</td>
</tr>
<tr>
<td>$\chi^2$/DF</td>
<td>.93</td>
<td>1.33</td>
</tr>
<tr>
<td>CF1</td>
<td>1.00</td>
<td>.95</td>
</tr>
<tr>
<td>NF1</td>
<td>.88</td>
<td>.84</td>
</tr>
<tr>
<td>RMSEA</td>
<td>&lt;.001</td>
<td>.12</td>
</tr>
<tr>
<td>Pclose</td>
<td>.50</td>
<td>.28</td>
</tr>
<tr>
<td>AIC</td>
<td>24.27</td>
<td>26.67</td>
</tr>
</tbody>
</table>
### Table 5a: Standardized Betas for Mastery-Avoidance Goals and ERP Effects in the Mastery Frame (Fit) and Performance Frame (Non-fit) in Study 3

<table>
<thead>
<tr>
<th></th>
<th>Mastery Frame</th>
<th>Performance Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery-Avoidance Goal to LPP</td>
<td>-.33 ($p \leq .065$)</td>
<td>-.35 ($p \leq .05$)</td>
</tr>
<tr>
<td>LPP to Learning Feedback</td>
<td>.18 ($p \geq .30$)</td>
<td>-.05 ($p \geq .79$)</td>
</tr>
<tr>
<td>Learning 200-400ms Left Frontal to Retest</td>
<td>-.34 ($p \leq .05$)</td>
<td>.02 ($p \geq .42$)</td>
</tr>
<tr>
<td>First Test Performance to LPP</td>
<td>.24 ($p \geq .17$)</td>
<td>.31 ($p \geq .08$)</td>
</tr>
<tr>
<td>Manipulation Check to LPP</td>
<td>.34 ($p \leq .056$)</td>
<td>-.19 ($p \geq .57$)</td>
</tr>
<tr>
<td>First Test Performance to Retest</td>
<td>.68 ($p \leq .001$)</td>
<td>.41 ($p \leq .03$)</td>
</tr>
<tr>
<td>Learning 400-800ms Left Frontal to Retest</td>
<td>.16 ($p \geq .34$)</td>
<td>-.16 ($p \geq .47$)</td>
</tr>
</tbody>
</table>

**Notes:**
- LPP above references the 450-1000ms epoch at the Pz & CPz composite for incorrect non-omit trials
- Retest only consists of non-omit trials
Table 5b: Model Testing of the Mastery Model in the Mastery and Performance Frame in Study 3

<table>
<thead>
<tr>
<th></th>
<th>Mastery Frame</th>
<th>Performance Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>8.20</td>
<td>20.92</td>
</tr>
<tr>
<td>DF</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>P</td>
<td>.83</td>
<td>.07</td>
</tr>
<tr>
<td>$\chi^2$/DF</td>
<td>.63</td>
<td>1.61</td>
</tr>
<tr>
<td>CF1</td>
<td>1.00</td>
<td>.56</td>
</tr>
<tr>
<td>NF1</td>
<td>.80</td>
<td>.46</td>
</tr>
<tr>
<td>RMSEA</td>
<td>&lt; .001</td>
<td>.16</td>
</tr>
<tr>
<td>Pclose</td>
<td>.86</td>
<td>.10</td>
</tr>
<tr>
<td>AIC</td>
<td>38.20</td>
<td>50.92</td>
</tr>
</tbody>
</table>
Figure 1. Interrelatedness and Uniqueness Predicting Math Task Choice and Proportion of Correct Responses in Study 1

(a) Interrelatedness Predicting Selection of Societal Development Task (Choice = 0), and Among Those Who Selected Societal Development Task, Interrelatedness Predicting Proportion of Correct Responses

\[ \beta = -1.22, \text{ wald} = 4.74, p \leq .03, \text{ OR} = 3.38 \]

Interrelatedness \( b = 2.16, t(30) = 2.09, p \leq .05 \)
Uniqueness \( b = -.41, t(30) = -.41, p \geq .69 \)

(b) Uniqueness Predicting Selection of Personal Development Task (Choice = 1), and Among Those Who Selected Personal Development Task, Uniqueness Predicting Proportion of Correct Responses

\[ \beta = 2.16, \text{ wald} = 10.91, p \leq .001, \text{ OR} = 8.70 \]

Interrelatedness \( b = .46, t(40) = .57, p \geq .58 \)
Uniqueness \( b = 2.52, t(40) = 2.31, p \leq .03 \)

Notes: Variables for choice and performance are mean-centered. Performance graphs depict predicted values computed 1.5SD above/below the mean for interrelatedness and uniqueness.
a) Within the Persuasiveness Condition, Study Attitudes Interact With Fit to Predict Persuasiveness

Notes: Variables are mean-centered. Graph depicts predicted values computed $1.5\text{SD}$ above/below the mean for study attitudes, in each condition.
b) Within the Opinion of Proposal Fit Predicts Greater Persuasiveness Irrespective of Study Attitudes

![Graph showing persuasiveness vs study attitudes for fit and non-fit conditions]

Main effect of Fit: $b = .52, t(39) = 1.88, p = .068$
Study attitudes X Fit: $b = -.03, t(38) = -.06, p = .95$
Simple slope of Study Attitudes in Fit: $b = -.08, t(38) = -.46, p = .37$
Simple slope of Study Attitudes in Non-fit: $b = .06, t(38) = .18, p = .86$

Notes: Variables are mean-centered.
Figure 3. Fit Predicts Reading Comprehension in Study 2

Notes: Graph depicts regression values for fit predicting performance, controlling for focus and study cognitions. All variables in the graph, except for fit, are centered around their respective means.
Figure 4. Sequence of Events for First Test and Retest in Study 3
Figure 5. Achievement Goals Predicting Retest Performance in Each Frame in Study 3

a) Performance-Approach Predicts Greater Retest Performance in the Performance Frame

Simple Slopes in Performance Frame:

**Performance-Approach:** $b = .07, t(17) = 2.64, p \leq .02$

Performance-Avoidance: $b = -.01, t(17) = -.45, p \geq .66$

Mastery-Approach: $b = -.01, t(17) = -.42, p \geq .68$

Mastery-Avoidance: $b = .03, t(17) = 1.15, p \geq .37$

Notes: Graphs in Figure 5a and 5b depict predicted values computed 1.5SD above/below each scale mean. When computing each predicted value, all other scales were centered around their respective mean. Results control for first-test performance in the respective frame, and the manipulation check difference score.
b) Mastery-Avoidance Predicts Greater Retest Performance in the Mastery Frame in Study 3

Simple slopes in Mastery Frame:
Performance-Approach: $b = .03, t(17) = 1.70, p \geq .09$
Performance-Avoidance: $b = -.01, t(17) = -.56, p \geq .58$
Mastery-Approach: $b = -.01, t(17) = .67, p \geq .51$
Mastery-Avoidance: $b = .03, t(17) = 2.09, p \leq .05$
Figure 6. Frame Effects: The LPP Response to Performance Feedback at First Test in Study 3

Notes:
- Head maps illustrate the difference in LPP activity elicited by framing (Performance – Mastery) at Pz (in green) following performance feedback to incorrect answers.
- The 450-600 ms head map suggests a more positive going LPP in the performance frame relative to the mastery frame. This frame effect attenuates from 600-1000 ms. The same non-significant pattern can be seen in the LPP waveform at Pz (450-600 ms), where the frame effect was most pronounced.
Figure 7. Frame Effects: Temporal Negativity Activity and Learning Feedback in Study 3

Notes:
- Head maps illustrate the *difference* in temporal negativity activity elicited by framing (Mastery – Performance) at FT9, FT10, Cb1, and Cb2 (in green).
- Individual electrodes (e.g., FT9, FT10, Cb1, Cb2) display temporal negativity waveforms for each frame.
- Importantly, for both head maps and individual waveforms, the temporal negativity displayed consists of the relative contribution of later corrected vs. forgotten retest items. More negativity is presumed to reflect more successful encoding.
- The 200-400 ms head maps indicate marginally more negative left frontal activity 200-400 ms in the performance relative to the mastery frame (visually this is displayed as more positivity in the mastery than the performance frame). These frame effects are no longer significant from 400-1000 ms.
- Head maps also show marginally more negative right posterior activity 200-400 ms for the mastery frame relative to the performance frame. This effect is most visually pronounced at Cb2. These frame effects, although no longer significant, remain visible from 400-1000 ms in both the right-hemisphere head map and at Cb2.
Figure 8. Best Fit Models Displaying the Relationship of Behavioral and ERP Effects in Each Frame in Study 3

Notes:
- The figures above represent the optimized models derived from SEM analysis (AMOS 5) of a model that initially included values from all principle ERP effects (LPP, fronto-temporal and posterior negativities), as well as relevant behavioral effects and controls (first-test accuracy, manipulation check). With the exception of goals, which were measured prior to testing, parameters in each frame-specific model used only the values specific to that frame (e.g., LPP in the performance frame). Although not displayed, the direct path from goals to retest were no longer significant when including the ERP mediators.
- Under performance-oriented framing, endorsement of a performance-approach goal predicted greater sustained attention and arousal to negative outcomes (LPP; 450-1000 ms), consistent with an attentional bias toward performance-relevant information (Mangels et al., 2006, 2011). Paradoxically this did not have a negative effect on learning. Rather, it appears to have motivated
engagement with the learning feedback, as indexed by a significant relationship between the LPP during performance feedback and a negative-going right frontal inferior negativity (200-400 ms) during learning feedback. This early right frontal negativity predicted successful error correction on the surprise retest.

Under mastery-oriented framing, greater endorsement of a mastery-avoidance goal was associated with reduced sustained attention and arousal to negative outcomes, consistent with a greater valuation of learning than performance information. This effect was moderated by the participant’s belief that performance was still being stressed under this framing (i.e. Manipulation Check). In the mastery frame, the LPP to accuracy feedback was decoupled from subjects’ response to learning feedback; it did not predict learning-relevant activity. In this frame, rebound from failure was predicted only by an early (200-400 ms) left frontal negativity.