Encouraging Realistic Expectations in STEM Students: Paradoxical Effects of a Motivational Intervention

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Dedication

To Roman, my love and inspiration, and to my daughter Alexia who was born a day after this thesis was submitted- thank you for letting me finish.

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Abstract

University students in STEM disciplines are expected to successfully deal with academic stress while maintaining the well-being and motivation required to achieve superior performance. These students are at risk of overconfidence which can lead to disengagement when students are inevitably faced with disappointment. The present study evaluated the effects of a longitudinal motivational intervention encouraging downgrading expectations (Heckhausen, Wrosch, & Schulz, 2010) for pre-medicine university students (N = 52) on self-reported expectancies (academic expectations and optimism), academic emotions (enjoyment and anxiety), psychological well-being (illness symptoms and depression), and academic achievement (sessional GPA). Contrary to study hypotheses, results showed students in the intervention condition to report higher expectations and optimism on post-test measures, as well as lower GPAs over five academic semesters following the intervention. These paradoxical effects highlight the importance of tailoring previously successful motivational programs to the unique psychological needs and aptitudes of students in STEM disciplines.

Keywords: Motivational intervention, STEM, downgrading expectations

Résumé

Les étudiants universitaires dans les disciplines de STEM sont censés de traiter le stress académique en préservant leur bien-être et la motivation nécessaire pour obtenir un rendement supérieur. Ainsi, ces élèves sont à risque d'être trop confiants, ce qui peut provoquer un désengagement lorsque les élèves rencontreront des expériences décevantes. Cette étude a évalué les effets d'une intervention qui encourage un déclassement de leurs attentes auto-déclarées à long terme (Heckhausen, Wrosch, et Schulz, 2010) pour les étudiants universitaires pré-médecine (n = 52) concernant leurs réussites scolaires et leur optimisme, les émotions académiques (jouissance et l'anxiété), le bien-être (symptômes des maladies et la dépression), et la réussite scolaire (AMP). Les résultats ont révélé que, contraire à les hypothèses, les élèves de la condition d'intervention ont démontré des attentes scolaires et des niveaux d'optimisme plus élever, ainsi que les AMP inférieurs pendant une période de plus de cinq semestres académiques après avoir reçu l'intervention. Ces effets paradoxaux soulignent l'importance d'adapter les programmes de motivation éprouvées aux aptitudes et besoins psychologiques spécifiques des élèves dans des disciplines de STEM.

Mots clés: intervention de motivation, STEM, déclassement d'attentes

Introduction

The transition to university is both exciting and stressful for most new students. As most entering university students are emerging adults (Arnett, 2000), adaptation to the university lifestyle can include academic as well as developmental demands; students face challenges such as heightened competition, pressure to succeed academically, increased expectations for independence and maturity, and the need for successful adjustment to unfamiliar tasks and environments. These and other transition-related demands and responsibilities can become an obstacle to students' abilities to succeed, and sometimes bright and motivated students experience academic failure due to their inability to successfully adjust to this new lifestyle (Perry, 1991). This can lead to a "paradox of failure" in which students who are capable of succeeding in university experience disappointing outcomes due to unsuccessful adaptation, and consequently disengage and drop out of university (Perry, Hall, & Ruthig, 2005). This phenomenon is especially prevalent among STEM (science, technology, engineering, and mathematics) students, as these degree programs are particularly demanding and costly (Rask, 2010), putting students at increased risk of loss of interest as well as for overconfidence (an overestimation of one's abilities within a constrained environment; Armor & Sackett, 2006) both of which can lead to disengagement either from the program or university (Perez, 2012).

According to Heckhausen, Wrosch, and Schulz's (2010) motivational theory of life-span development, these trends can be explained, in part, by the motivational strategies that university students use in reaction to failure experiences (either perceived or objective), especially during transitional periods. Maintaining one's motivation is especially difficult in the face of developmental transitions (Hall, 2012), during which the individual is expected to adjust to their new environments, assess their abilities, and accurately evaluate the interaction between their

abilities and environmental constraints and opportunities. For example, Morrison, Sansosti, and Headley (2009) have demonstrated that when university students with disabilities take the time to learn about support services in their universities, and are able to advocate for themselves in order to receive the needed support, both their performance in university and overall well-being compared positively to those of other students with disabilities who were unaware of these services. This demonstrates that when one is transitioning to a new environment it is important to a) recognize one's abilities, b) become familiarized with one's environments, and c) identify the most adaptive ways in which one's abilities can interact with the environment in order to achieve the desired results.

Following this rationale, the present study aims to provide first- and second-year university students in STEM programs, who are at risk of overconfidence, motivational content about how to adaptively react to academic failure experiences (e.g., personally disappointing achievement outcomes, failure to gain admission to a desired program). Following a review of literature on STEM disciplines, academic overconfidence, and other factors that affect students' motivation in higher education, previous research highlighting the trends and outcomes involving motivational interventions as administered in higher education will be presented. An in-depth review of Heckhausen et al.'s (2010) motivational theory of life-span development will then be provided, due to it informing the present study, and research in which this theory was applied to overconfident students and in other context where participants benefitted from changes in control perceptions will be discussed (e.g., transitioning to university, aging, and transitioning from school to work). Finally, the present study will be outlined in which the effects of a motivational intervention designed to inform students of the benefits of adaptive downgrading of academic

expectations, so as to reduce overconfidence and encourage realistic expectations (Forsterling & Morgenstern, 2002), was evaluated on self-report and institutional achievement outcomes.

Literature Review

Challenges in STEM Disciplines

One of the most important decisions in one's academic career is choosing a major. Not only does one's major dictate which domains and topics they will spend most of their time learning about, but undergraduates also view their choice of major as critical to their identity, well-being, and future career (Galotti, 1999). For students in science, technology, engineering, and mathematics (STEM) disciplines, this decision is often accompanied by heightened competition and academic stress, while having to maintain the emotional, physiological, and psychological health needed to achieve the expected superior performance (Wai, Lubinski, Benbow, & Steiger, 2010). These demands are among the reasons why natural science students (particularly females; Lee, 2011) are more likely to change their major to a non-science major (Daempfle, 2003; Rask, 2010), and therefore opt out of a science career.

Since college is a critical period when many potential scientists are lost, institutional and national efforts are being placed on retaining students in STEM disciplines (Perez, 2012). Some of the most cited reasons for opting out of STEM disciplines are loss of interest or new interest in a non-science field (Seymour & Hewitt, 1997), and difficulties in achieving academic success within STEM majors as reflected by both absolute GPA and grades relative to peers (Rask, 2010). In a sample of 5,320 high achieving students (graduating in the top 10% of their class), Strenta, Elliot, Adair, Matier, and Scott (1994) found that of those initially interested in natural science majors, approximately 44% ultimately majored in a non-science major, or opted to leave university altogether. In this sample, grades in college science courses significantly predicted

attrition from science majors. Due to these academic pressures which can often lead to physical and psychological distress, even those students who are classified both by their teachers and by aptitude tests as having high ability for science disciplines often leave science majors (Webb, Lubinski, & Benbow, 2002).

Motivational constructs such as interest, perceptions of ability, and expectations are crucial predictors students' decision to either remain in or drop out of STEM disciplines (Perez, 2012). Therefore, it is important that students in STEM disciplines not only have the ability to maintain the physical and psychological health needed to achieve success in their chosen major, but also that their perceptions of ability and their expectations will be adaptive in reflecting the reality of the challenging context in which these students find themselves (Moore & Healy, 2008). Although this is important for all students, this is of particular significance for students in challenging STEM programs as pursuing unattainable goals can result in unnecessary disengagement (Wrosch, Scheier, Miller, Schulz, & Carver, 2003), performance declines (Perez, 2012; Rask, 2010), and impaired psychological well-being (Seymour & Hewitt, 1997; Wrosch et al., 2003) due to the high cost involved (e.g., time invested in studies, personal and social sacrifices, etc.). An inability to accurately assess one's skills within a given context (with its attached environmental demands), and especially an overestimation of one's abilities, can lead to inflated expectations for the future (Armor & Sackett, 2006), that if not met, can erode STEM students' motivation and engagement. Such overconfidence is defined and discussed in the next section.

Academic Overconfidence

Overconfidence in higher education settings has been found to have adverse implications for students' motivation, performance, and well-being. Although some level of optimism is

adaptive for maintaining students' motivation (Krypel & Henderson-King, 2010), overly optimistic expectations about one's academic performance can have various detrimental personal as well as achievement consequences for a student's academic future. For example, Stone (2000) argues that overconfidence hinders self-regulated learning, as students are not accurately calibrated in their perceptions of what they know and don't know (i.e., they tend to perceive their knowledge as more extensive than it is), and neglect to develop self-regulation skills (e.g., reflection, self-monitoring, setting realistic goals) that are crucial for academic success.

Numerous descriptive studies have demonstrated that overoptimistic expectations may be adaptive in the short term in preserving students' motivation and self-esteem, but destructive for students' long-term goal attainment (Klein & Helweg-Larsen, 2002; Nowell & Alston, 2007; Robins & Beer, 2001). In two studies designed to examine whether over-optimism can be adaptive in academic contexts, Robins and Beer (2001) assessed 868 undergraduate students' self-enhancement tendencies concerning a specific task (an experimental group problem solving task) and throughout their undergraduate studies (i.e., at six time points over four years) and found that self-enhancing beliefs about one's performance were associated with narcissism, lack of social approval, and ego involvement. Individuals who felt particularly invested in the task (i.e., high ego involvement) were more likely to inflate their self-perceptions and inaccurately evaluate their own performance on the task. Moreover, high ego involvement was accompanied by a threat of failure, with self-enhancement used as a defensive strategy to maintain self-worth and self-esteem (Lobel & Teiber, 1994).

Robins and Beer (2001) found that individuals with a tendency to enhance their subjective performance ratings explained their success in terms of high ability rather than effort, whereas failure was not attributed to ability. This finding points to the defensive nature of

individuals who hold unrealistically high expectations, and the fragility of their self-worth. More specifically, self-enhancing students were found to disengage from their studies over time (i.e., to decrease their ego involvement); a strategy likely intended to maintain their self-worth upon realizing they failed to live up to their expectations. During the course of their four-year degree, the self-esteem of "self-enhancers" was adversely affected by their university experiences and they were less likely to graduate than their non-enhancing counterparts. Hence, using a longitudinal study and a cross-sectional experimental study, the authors found academic overconfidence (ego involvement) to have significant consequences for motivation and persistence.

In a review of 22 studies focusing on academic overconfidence, Klein and Helweg-Larsen (2002) found that an optimistic bias can lead students to view themselves as less at risk of academic disappointment and failure relative to their peers. Therefore, these students do not foresee the need for cognitive strategies to maintain their motivation in the event of failure, which can lead to loss of motivation and disengagement in the course of their studies. These findings pertain particularly to poor-performing students who tend to have grossly miscalibrated ability perceptions and be overconfident about their future academic performance (Kruger & Dunning, 1999). This type of disengagement due to the unattainability of one's academic goals has negative implications not only for academic achievement but also for students' physical health (e.g., illness symptoms) and psychological well-being (e.g., negative emotions, life satisfaction; Wrosch et al., 2003).

In challenging degree programs, students' level of optimism has a direct and profound impact on their expectations and emotions, and consequently, their behavior. Krypel and Henderson-King (2010) found that optimistic students report less stress and more adaptive

academic coping strategies than their pessimistic counterparts. Moreover, optimism was found to prevent these students from devaluing education and help them maintain a positive attitude toward the challenges and responsibilities of higher education. According to Robins and Beer (2001), very high optimism corresponds to a tendency to deny information that threatens one's self-worth that has psychological benefits such as greater motivation and psychology well-being. However, this enhanced self-esteem may not be long lasting, as research on overconfidence shows individuals' subjective perceptions of their performance and objective indicators to often be poorly correlated, making these students more susceptible to disappointment (Burson, Larrick, & Klayman, 2006). The difficulty in accurately assessing one's own abilities is especially evident in the "above average effect"; the tendency for the average individual to believe that their abilities and performance are above average (Kruger & Dunning, 1999).

Burson, Larrick, and Klayman (2006) argue that although overoptimistic predictions can be observed in many students, unskilled performers are especially at risk of making such predictions. For these students, both their poor performance and their inaccurate evaluations of their performance can be explained by examining their metacognitive skills. When students lack metacognitive skills, they are less able to reflect on their learning strategies, modify them adaptively to accommodate the task at hand, and to evaluate whether they have performed well – skills that are required to perform well. Kruger and Dunning (1999) designed four studies to explore the relationship between competence, metacognitive ability, and self-assessment across different tasks and domains. They found that across studies, participants who scored in the bottom quartile tended to overestimate their ability and performance relative to their peers, demonstrating that unskilled performers were the most miscalibrated when it came to self-assessment. Moreover, when they were given the opportunity to evaluate the performance of

their peers, participants in the bottom quartile were less able to gauge the competence of others than were their top quartile counterparts, and failed to gain insight into their own performance after observing the performance of their more competent peers. Finally, to establish the link between these results and metacognitive skills, the authors provided some of the participants in the bottom quartile with training to improve their metacognitive skills and logical reasoning that helped these students become better calibrated in their self-assessment as compared to their peers who did not receive the training.

Similar to metacognitive skills, task difficulty is another factor that plays a role in the accuracy of students' self-assessment and predictions. Moore and Healy (2008) argue that students don't always have enough information (or the metacognitive abilities) to accurately estimate their own performance, abilities, or chances of success. When it comes to other students' performance, students have even less information to form an accurate assessment. Consequently, students will often regress to basing their estimates concerning their own performance and that of others on their own prior experience (e.g., their high-school performance), particularly when completing performance-oriented tasks and when additional sources of information are limited.

As task difficulty (and therefore uncertainty) increases, students will tend to overestimate their performance compared to that of their peers. For instance, Burson, Larrick, and Klayman (2006) found that lower accuracy of performance estimates were associated with tasks that were higher in difficulty, particularly for poor performing students and in demanding, natural science domains (e.g., STEM disciplines). In a study of economics students, for example, participants demonstrated significant overconfidence with respect to their expected performance on exams, with 44% of 524 participating students exhibiting overconfidence about their future exam grades

(Nowell & Alston, 2007). Once again, this inability to predict grades was particularly pronounced for poor performing students, particularly unsuccessful students who spent more time studying (e.g., expected higher grades than were received due to the high level of effort invested). As previously discussed, this finding points to the role of metacognition in both academic success and over-optimism: Time spent studying corresponded directly to the the overestimation of success and was not affected by disappointing outcomes on several exams. These results imply a direct link between overconfident students' academic expectations and the amount of effort invested in their studies, with effort operationally defined as the quantity of time spent studying as opposed to the quality of study strategies used.

Finally, individuals tend to expect their futures to be more pleasant than their present, as well as than the futures of others. For example, although students tend to overestimate the prevalence of negative life events (e.g., failing at medical school), they also generally underestimate the likelihood of these events happening to them (Moore & Healy, 2008). Whereas such biases can preserve students' motivation in the face of adversities, they also allow students to maintain an unrealistic view of how their present actions influence the overall trajectory of their academic performance. Armor and Sackett (2006) examined students' performance expectations in task-expectant conditions (students expected to complete the task described to them) and hypothetical conditions (students did not expect to complete the task described to them). Findings showed that students who expected to complete the task exhibited more realistic expectations than students who did not expect to complete the task, who instead were found to overestimate their actual performance by large margins thereby weakening the correlation between their estimations and their actual performance. This implies that overconfidence biases are influenced not only by metacognitive abilities and task difficulties, but

are also situated within contexts; individuals tend to be more overly optimistic when predictions are made about tasks from which they are more "psychologically distant."

To understand these and other overconfidence findings from a developmental psychological perspective, Hall, Perry, Chipperfield, Clifton, and Haynes (2006a) provide an in-depth examination of how motivational beliefs are related to overconfidence in post-secondary students. In a longitudinal field study of 373 first-year university students spanning one academic year, Hall et al. (2006a) evaluated how perceptions of control (described in more detail below; Heckhausen & Schulz, 1995) influenced students' academic development in terms of cognitive, affective, and achievement outcomes. The authors found students' beliefs regarding motivational strategies involving both primary control (modifying one's behaviour to achieve goals) and secondary control (modifying one's cognitions to adapt to environmental constraints) to differentially predict academic outcomes depending on students' initial performance (for more on this dual-process model of control, see The Motivational Theory of Life-Span Development section to follow).

Primary-control beliefs were more prevalent among students who experienced success at the start of the year, and were positively related to higher levels of end-of-year academic achievement (i.e., GPA), motivation, and positive affect (i.e., pride, happiness). For unsuccessful students, the endorsement of both primary and secondary control as effective motivational strategies led to optimal academic development with respect to students' performance, motivation, and academic emotions (higher positive emotions). However, initially unsuccessful students who were high in primary control and low in secondary control were notably overconfident in their academic expectations and at greater risk of academic failure (course grades, cumulative GPA), decreased motivation (i.e., more likely to drop courses), and lower

positive affect relative to their peers. This finding thus contributes to existing research on overconfidence in students in suggesting that miscalibrated beliefs regarding future academic success may be evidenced by a corresponding lack in motivational strategies specific to academic failure.

To summarize, the recent research literature on overconfidence in academic settings suggests that unsuccessful students in challenging degree programs (such as STEM disciplines) are at risk of developing and maintaining unrealistic, overly optimistic expectations even after having received feedback about their performance (Armor & Sackett, 2006; Burson et al., 2006; Nowell & Richards, 2007). Consequently, these students may not possess valuable metacognitive, self-regulatory skills such as being able to optimally adapt their study strategies after disappointing experiences (e.g., believing that more time studying will guarantee better grades), or accurately evaluate their performance to assess whether changes are required. In addition, the information that is available to students about their academic performance might not be properly used to predict future events (e.g., getting accepted to a medical program), leading poor performing students to continue holding unrealistic beliefs about eventual academic success. Lastly, overconfident students might neglect back-up (i.e., secondary control) strategies for maintaining their motivation in the face of disappointing experiences (Hall et al., 2006a). Maintaining such beliefs in the face of failure can be detrimental not only to students' academic achievement and careers, but also to their motivation as well as and psychological and physiological well-being (Haynes, Ruthig, Perry, Stupnisky, & Hall, 2006; Robins & Beer, 2001). To better understand the scope of motivational variables that have been found to predict learning, persistence, achievement, and well-being in university students, the following section provides a review of current topics in research on motivation in higher education.

Motivation in Higher Education

Research in the field of motivation in education began in the 1940s with the study of motivation as the search for equilibrium by satisfying needs activated in the body, so as to keep arousal levels to a minimum (Weiner, 1990). Motivational psychologists at that time were concerned with what energizes a resting organism to a state of activity, and focused primarily on basic needs (e.g., food), as well as how learning took place when those needs were used as incentives. The study of motivation was therefore confounded with the study of learning, as learning was often interpreted as an indicator of motivation. In the 1960s, there was a shift in the study of motivation from biological mechanisms toward cognition (Marx, 1960). Researchers began to concentrate on human motivation and related constructs such as emotions (e.g., fear, anxiety), achievement strivings and outcomes (i.e., success and failure), and expectancies, as well as individual differences in motivation-related constructs. According to Weiner (1990), this represented a major shift in focus that would lead to increased emphasis on cognition in motivational research in the 1980s and 1990s, with emerging concepts like attributions, self-concept, and goals dominating the study of motivation in education during those years.

The study of cognition and the focus on individual differences are at present the predominant areas of research in the field of academic achievement motivation. According to Pintrich (2003), five types of motivational constructs are most commonly explored as predictors of student learning and success: self-efficacy and competence perceptions, interest and intrinsic motivation, task values, achievement goals, and causal attributions and control beliefs. The following sections provide an overview of current theories concerning each of these constructs, followed by a discussion of findings regarding the outcomes of motivational interventions for

post-secondary students aimed at enhancing each factor individually or in combination (e.g., value and interest).

Theories of Motivation in Higher Education

Self-efficacy and competence beliefs. Self-efficacy refers to the perceived abilities and competencies of an individual for learning and achieving goals at a desired level. Self-efficacy perceptions can be both the antecedent of achievement (e.g., a student who holds high self-efficacy beliefs is more likely to utilize various self-regulation strategies and consequently achieve better outcomes) or the consequence of achievement (e.g., achievement outcomes can influence a students' competence perceptions; Schunk & Pajares, 2009). Self-efficacy is commonly found to be associated with higher motivation, learning, and achievement in students, as well as to predict approximately 25% of the variance in academic achievement (Schunk & Pajares, 2009; Walker, Greene, & Mansell, 2006) and better adjustment in first-year college students (Chemers, Hu, & Garcia, 2001). Self-efficacy beliefs can also be influenced by the theory of intelligence that a student holds. Dweck and Master (2009) argue that a student's motivation is largely determined by the self-theories they hold concerning the nature of intelligence; those who believe that intelligence is a stable trait that cannot be modified (i.e., entity view of intelligence) are less likely to persist through difficulties, seek help when it is needed, and stay motivated in the face of setbacks. They believe that both their successes and failures are a consequence of their ability, and therefore are concerned with demonstrating high ability, or avoiding the appearance of low ability, in situations where they are being evaluated. On the other hand, students who believe that intelligence is fluid and can be changed through effort (i.e., incremental view of intelligence) are more likely stay optimistic and motivated in the

face of failure, seek help to improve their competencies, use adaptive learning strategies, and persist toward desired outcomes.

Interest and intrinsic motivation. The second family of motivational constructs involves interest and intrinsic motivation. Schiefele (2009) distinguishes between individual and situational interest, with individual interest being a stable, dispositional attraction of an individual to specific subjects or domains, and situational interest representing a more malleable psychological state of engagement in an activity that is created by the features of the context. Hidi and Renninger (2006) suggest a four-phase model of interest development. In Phase 1, interest is elicited when the individual sees value in the specific task or activity (triggered situational interest). In Phase 2, the student may choose to engage in a task repeatedly over time after a situational interest has been triggered and the student finds short-term value in the task or experiences enjoyment during the activity (maintained situational interest). After continuous engagement, the activity is expected to begin to become more permanently significant and of personal value to the individual (emerging individual interest; Phase 3). Continuous engagement with the task, increased knowledge and expertise, as well as positive affect can then lead to a stable, persistent interest by the individual in the learning activity (developed individual interest; Phase 4). In this model, situational factors first "catch" the individual's attention (due to being pleasant or enjoyable), with subsequent interest and/or value perceptions being later sustained by factors such as instructor and course ratings (Riconscente & Seli, 2012) and task qualities (i.e., "hold" factors; Durik & Harackiewicz's, 2007) that develop into enduring individual interest (Wigfield & Cambria, 2010). Both individual and situational interest are understood to contribute to students' intrinsic motivation, namely when an "activity is undertaken for its own sake, for the inherent satisfaction in doing the task" (Pintrich, 2003, p. 674).

Interest influences achievement outcomes by shaping students' cognitions and behaviours such as attention, goals, and learning strategies (Hidi & Renninger, 2006; Riconscente, & Seli, 2012). University students who report higher situational interest in a subject (e.g., psychology) at the beginning of the semester are more likely to perform well in those classes and express an interest in pursuing a degree in that domain (i.e., maintained situational interest; Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Hulleman, Godes, Hendricks, & Harackiewicz, 2010).

Expectancy-value theories. As previously mentioned, thinking of a specific task or activity as having personal value can increase motivation and achievement. Wigfield and Eccles (2000) developed a model of achievement motivation in which both expectancy and value play a role in shaping students' motivation. In this model, the combination of students' expectations for performance outcomes and their value beliefs is assumed to predict motivational and behavioural outcomes by affecting task choice and persistence (i.e., optimal engagement in a task is predicted by high personal relevance or utility combined with an expectation of success). Value beliefs are defined in terms of four components: interest, utility, importance, and cost. Interest value is similar to individual interest, as defined in the previous section; utility value is defined in this model as the usefulness of the activity to the individual and/or their future; importance or attainment value refers to the degree to which performing well on the task is central to the individual's identity or sense of self-worth; and cost refers to the perceived negative consequences associated with engaging in the activity.

More recently, Pekrun modified this model and elaborated on the expectancy component to have it reflect multiple types of perceived control, to better reflect the various ways in which students appraise the relationship between their actions and achievement outcomes (Pekrun,

2006; Wigfield & Cambria, 2010). This model addresses both student motivation and emotions, and takes into account both value and various types of control appraisals as important determinants of motivation. Pekrun (2006) distinguishes between three kinds of control beliefs, the first being *situation-outcome expectancies* in which the individual has no agency in this relationship, and the situation will inevitably produce a specific outcome. In contrast, *action-outcome expectancies* involve the beliefs that specific actions of the individual will produce certain outcomes. Finally, *action-control expectancies* reflect beliefs about whether the individual can conduct those behaviours (i.e., actions) that help them achieve desired results (similar to self-efficacy).

As control beliefs involve students' perceptions of whether they can successfully regulate their behaviour, they are assumed to produce behavioural outcomes when combined with activity and outcome values. More specifically, if a student assesses their level of action control as sufficient to attain an outcome, and also value the outcome, motivation will increase and the student will pursue the goal. In contrast, when action control and task value are not present, the student should experience lower motivation and behavioural engagement. For example, Pekrun, Goetz, Daniels, Stupnisky, and Perry (2010) found that control and value were negatively associated with academic boredom, a deactivating emotion that contributes to attention problems, decreases in intrinsic motivation (interest value), and poor performance. This finding was replicated across cultures (i.e., German and Canadian students) and research methodologies.

For students in STEM disciplines, both utility value and cost play a role in students' persistence in the face of difficulties (Harakiewicz et al., 2012; Perez, 2012). Those who reported perceiving their classes to be of higher utility value, were more likely to persist in the major and even undertake more mathematics classes than their counterparts in the control group. Cost has

been found to significantly predict attrition from STEM majors, with students who perceived the cost of majoring in STEM disciplines to be high reporting stronger intentions to leave their discipline at the end of the semester (Perez, 2012). These findings are in line with assertions in both Pekrun's and Wigfield's models that value beliefs predict choice behaviour (e.g., course enrollment, attrition), whereas expectancy or control beliefs predict achievement outcomes.

Achievement goals. Goals are significant in the study of student motivation, as they give students purpose or meaning when engaging in an activity. Goal orientations refers to the general attitudes or approaches students demonstrate in relations to their learning, competence, and achievement that provide direction for their future behaviour (Maehr & Zusho, 2009). Researchers initially distinguished between two goal orientations: a mastery goal orientation focused on learning, acquiring competence, expertise, and satisfying interest, and a performance goal orientation that emphasizes demonstrating competence and abilities by achieving and outperforming others (Senko, Hulleman, & Harackiewicz, 2011). By the 1990s, researchers noticed contradictory effects of having a performance goal orientation, and these achievement goals were further differentiated into approach and avoidance goals (Elliot & Harackiewicz, 1996; Schwinger & Stiensmeier-Pelster, 2011). Students who hold a performance-approach goal orientation are concerned with demonstrating their competence and outperforming others, while those holding a performance-avoidance goal orientation attempt to avoid looking incompetent. Similarly, mastery-approach goals include the desire to learn and gain competence, while mastery-avoidance goals involve avoiding missing out on opportunities to learn, and not reaching one's standards of competence.

Although mastery-avoidance goal orientation has been neglected in the literature (Senko et al., 2011), research on motivational effects of the remaining three goal orientations has yielded

mixed results (Deevers, 2010; James & Yates, 2007; Pintrich, 2003; Putwain & Symes, 2011; Wigfield & Cambria, 2010). Past research has focused on the benefits of mastery goals on motivation, emotions, and achievement, and perhaps even more commonly on the maladaptive outcomes of performance goals, especially performance-avoidance (Ames, 1992; Dweck & Leggett, 1988; Maehr & Zusho, 2009). Today, researchers are arguing in favour of the multiple goal perspective: Rather than investigating the effects of each goal individually, researchers now consider how multiple goals in specific educational contexts (e.g., depending on the instructional approach, task demands, etc.) combine to produce achievement outcomes (James & Yates, 2007; Pintrich, 2003). For example, a descriptive study of students' and teacher's goal orientations by Deevers (2010) found that teachers' achievement goal endorsement influenced students' goal orientations such that students were likely to adopt the goal orientation of their teacher. This finding implies that goal orientation is malleable and may be context-specific, depending on the cues from their environment as to which goal orientation is most adaptive in that context.

James and Yates (2007), however, offer alternative explanations for this relationship between teachers' and students' goal orientations. In their article reviewing goal theory applications in elementary, secondary, and post-secondary educational settings, the authors concluded that although a relationship clearly exists, this relationship is not well-researched or well-defined in terms of its directionality. Although there was a positive correlation has been found between students' goal orientation and their perceived classroom goal structures (Lyke & Kelaher Young, 2006, as cited in James & Yates, 2007), the directionality of this relationship is still not clear and no experimental studies in this regard have been conducted in higher education students. Although it is certainly plausible that teachers' goals orientations should influence students' goals, it is also conceivable that students themselves influence the dynamics of the

classroom and therefore the teacher's goal orientation (reverse causality). Moreover, it is possible that students' initial goal orientation influences the way students perceived teachers' goals and how they interpreted potential cues in the learning environment.

Adaptive attributions and control beliefs. Students' attributions and control beliefs pertain to views that they hold about the causes of success and failure. Students who believe that they have more control over their learning behaviours, and therefore learning outcomes, generally perform at a higher level than those who hold lower control beliefs (Pintrich, 2003). As for attributions, Weiner (1985) proposes that students try to make sense of their experiences, especially ones which are negative, surprising, and/or important by engaging in causal searches. In these searches, students try to determine the causes for the particular event, especially in terms of their locus of causality (whether the causes are internal or external to the individual), stability (whether the cause is subject to change over time), and controllability (whether the cause can or cannot be controlled by the individual). Thus, Weiner's proposed model involves a 2 x 2 x 2 taxonomy that aims to account for the variety of explanations students provide for their success and failure experiences. Those who adopt attributions that are internal, unstable, and personally controllable (e.g., effort) tend to demonstrate motivational and achievement benefits, whereas students who hold internal, stable and uncontrollable attributions (e.g., ability) or external, unstable, and uncontrollable attributions (e.g., luck, test difficulty) are more likely to have miscalibrated expectations, negative academic emotions, and lower grades (Hall, 2006b; Weiner, 2010).

Many motivational interventions have been designed based on the theories of motivation presented above so as to evaluate the effects of these motivational constructs on psychological, physiological, and behavioural outcomes in both social science and STEM student populations.

Reviews outlining the specific content of these interventions, as well as empirical findings concerning their benefits and limitations for post-secondary students, are described in the following section.

Motivational Interventions in Higher Education

Self-theories interventions. Research on interventions to improve self-efficacy and self-theories has aimed to change students' maladaptive views of their abilities by designing learning activities (e.g., challenging activities that can be successfully completed given proper guidance; Betz & Schifano, 2000) and provided adaptive feedback (e.g., emphasizing effort- rather than ability-based views of intelligence). Glenn (2010) argues that although praising effort rather than fixed intelligence has proven effective in facilitating incremental beliefs among school-aged children (as opposed to strengthening the link between self-worth and intelligence), the same has not been consistently found in a higher education contexts. Nonetheless, higher levels of incremental beliefs are generally associated with greater academic enjoyment and achievement, especially for post-secondary students facing intelligence-related stereotype threats (Aronson, Fried, & Good, 2002; Betz & Schifano, 2000). Stereotype threat is a state of anxiety about potentially confirming a stereotype about one's social group (e.g., as per race, gender).

In a study of African-American university students, Aronson et al. (2002) found that students who experienced stereotype threat benefitted from an intervention targeting their self-theories in terms of their cognitions (i.e., attitudes toward intelligence), emotions (i.e., academic enjoyment), and grades. Similarly, Betz and Schifano (2000) found females in STEM disciplines to demonstrate higher confidence and improved attitudes toward participating in STEM-related activities (i.e., solving engineering problems alongside males) following an intervention encouraging incremental beliefs. In both studies, the effects of the interventions on students'

attitudes were mediated by students' self-worth, such that the interventions improved students' self-worth that, in turn, positively affected their educational attitudes and the effect of the stereotype threat on their future success. However, students who hold incremental beliefs, but whose self-worth is tied to their academic performance, have also been found to not differ from students with entity beliefs in terms of academic achievement outcomes or their views on the role of effort in academic success (Niiya, Brook, & Crocker, 2010). Therefore, although the self-theory model is effective for younger students (Jones, Wilkins, Long, & Feihong, 2012; Margolis & McCabe, 2006), post-secondary students do not seem to consistently reap the benefits that Dweck and Master (2009) suggest are associated with an incremental view of intelligence.

Value-enhancing interventions. Other motivational researchers attempt to enhance student motivation by increasing interest through the facilitation of utility value (the perception of a task or an activity being useful for other aspects of the individual's life; Eccles, 2005), with such interventions having been shown to predict greater situational and maintained situational interest among university students both in experimental and natural settings. As Hulleman et al. (2010) discovered, this was especially true for students who performed poorly in a psychology class. In two studies involving a total of 425 university students from introductory psychology courses, the authors attempted to increase student interest on either a math task, or in students' psychology class, by administering a writing exercise elaborating on the utility value of the activity for students' everyday life. The intervention triggered both situational interest (in the specific task) and maintained situational interest (as indicated by students' intention to engage in the activity in the future), particularly for those students who reported low expectations of success on the task. For these students, interest in the subject matter mediated the direct effects of perceived utility value on achievement outcomes. That is, students who perceived the math

task or psychology class to be relevant for their lives after the intervention (controlling for utility value at Time 1) became more interested in the activity and achieved better outcomes (e.g., final grades in the course).

Although these results demonstrate the positive effects of value and interest-oriented interventions on academic achievement, Durik and Harackiewicz's (2007) findings warrant further consideration of this assumption by highlighting how initial student interest moderates the effects of such interventions. By using "catch" and "hold" factors to trigger and maintain student interest on a math task, the authors hoped to initiate and maintain situational interest and thereby increase self-reported interest and involvement on a math task. What they found, however, was that students who started the task with low individual interest benefited from the stimulus-rich learning environment that the "catch" factors created, but a personal utility emphasis (i.e., "hold" factor) undermined their involvement and perceived competence. Individuals who began the task with high individual interest, on the other hand, reported dampened task involvement, interest, and competence valuations when "catch" factors were present, but high interest and better performance in the presence of "hold" factors. Similarly, work by Clinton and Van den Broek (2012) found that students who were initially more interested in the topic of a reading passage were able to recall more information and make more inferences about the reading, regardless of levels of prior knowledge or intervention condition (i.e., reading only vs. reading coupled with a think aloud protocol).

Moreover, Shechter, Durik, Miyamoto, and Harackiewicz (2011) found that in addition to initial levels of interest, students' culture and the proximity of the task utility moderated the effects of utility value interventions on students' interest and motivation. In a sample of 458 university students across two studies (301 Western students, 157 from Asian descent), the

authors discovered that Asian students with low initial interest in a math task benefitted from a utility value intervention in terms of their interest in the task. In contrast, Western students with low initial interest, as well as students with high initial interest, did not benefit from the intervention. Furthermore, when informed about the usefulness of a math technique for either their university classes (proximal utility) or a graduate school admission test (distal utility), students of Asian descent reaped the largest motivational benefits upon learning that the new technique could help them reach long-term goals such as acceptance into a graduate program (i.e., worked harder, found the new technique more interesting, felt more competent, and performed better). Western students, on the other hand, became more interested in the task when they learned that it could help them achieve more proximal goals, such as improving their grades in statistics courses.

These findings imply that although interest was, once again, associated with more enjoyment, higher competence perceptions, and better performance, interventions that aim to increase student motivation by facilitating value and interest have to date been domain-specific (thus enhancing motivation related to a task or a domain but not in general; Harackiewicz et al., 2008; Hulleman et al., 2010), and have not been tailored to the students' initial levels of interest (Nieset, 2008; Shechter et al., 2011; Thoman, Sansone, Fraughton, & Pasupathi, 2012). Moreover, the directionality of the relationship between interest and performance has been found to be reciprocal, with students who demonstrate better exam performance at the beginning of the semester reporting higher interest in the course later in the semester (Harackiewicz et al., 2008). Therefore, interventions that aim to facilitate student interest may do so not only by directly manipulating situational interest, but also by indirectly increasing interest by improving achievement outcomes. In sum, because of the specificity of findings produced by motivational

interventions aimed to increase interest and intrinsic motivation, it is difficult to generalize findings and draw uniform conclusions about best practices in increasing motivation through interest-enhancing interventions. The one common finding across these studies, however, is that when interest is present, students benefit in terms of their enjoyment, motivation, and performance.

Value-oriented interventions employed with higher education students have focused mainly on increasing students' perceptions of utility value (i.e., usefulness) in an attempt to enhance student motivation (Acee & Weinstein, 2010; Harackiewicz, Rozek, Hulleman, & Hyde, 2012). Unlike the interventions discussed above, however, these following interventions did not aim to increase *subject interest* by encouraging perceptions of utility value. Instead, the rationale for these interventions was simply that students would perceive their studies as useful for their lives or for a future goal, such as pursuing a career in the field, and consequently become more motivated to pursue their studies. For example, Acee and Weinstein (2010) attempted to increase the utility value of university students' introductory statistics course by providing them with a handout outlining strategies for developing positive attitudes toward the subject, enjoying the course, and using the information learned in the course in other courses and everyday life. The authors found, both immediately following the intervention and two weeks later, that participants in the treatment group perceived their class as more valuable for their lives, and were also more motivated than their control counterparts to engage in statistics-related activities (i.e., other university courses) in the future.

Harackiewicz et al. (2012) also demonstrated that value interventions can be effective even when not administered directly to the student. To address the issue of decreased enrolment in STEM majors, the authors administered a 15-month long utility value intervention to parents

whose children were completing the transition from high school to university. The intervention addressed issues such as the value of STEM disciplines for their children's future, and encouraged parents to communicate these values to their children. As a result, students whose parents participated in the intervention increased their participation in elective STEM courses in high school (prerequisites for STEM college programs) and reported increased willingness to major in STEM disciplines in university. In sum, these findings underscore the importance of perceiving one's academic pursuits as valuable in showing the positive effects of value-enhancement programs on academic emotions, motivation, and performance. However, although such programs are beneficial in increasing motivation and improving performance, the gains associated with these interventions are limited due to their domain specificity (e.g., psychology or statistics courses) and do not address overall student motivation in higher education contexts.

Goal-orientation interventions. Studies of achievement goals in higher education students to date have been inconclusive as to which goals, or goal combinations, are most adaptive in higher education. Instead, most empirical studies are descriptive in nature and focus on the relationships between students' existing goal orientations and academic motivation, emotions, and performance (Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Putwain & Symes, 2011; Senko & Miles, 2008). However, some interventions have been developed to study the effects of promoting specific goal orientations in university students while completing a learning task. For example, Barron and Harackiewicz (2001) encouraged 154 psychology students to adopt either a mastery or performance goal orientation when solving a novel math task. The authors discovered that adopting performance-approach goals was not as maladaptive as hypothesized, with the promotion of competition-oriented goals leading to better task performance. However, the effects of the goal intervention conditions were moderated by

students' personality characteristics, namely, achievement motivation (i.e., the individual's desire to achieve excellence and to outperform others). Students who were low in achievement motivation benefited from being assigned to the mastery-orientation condition, whereas students who were high in achievement motivation benefitted more from the performance-orientation condition. These two groups also demonstrated higher task engagement and performance relative the other two groups (low achievers in the performance-orientation condition, high achievers in the mastery-orientation condition), who were more likely to disengage from the task.

Despite such achievement benefits, it is possible that performance-oriented students (including both performance-approach and performance-avoidance types) might demonstrate maladaptive motivational patterns when faced with challenging tasks due to their preoccupation with demonstrating competence and low intrinsic motivation (Elliot & McGregor, 2001). More specifically, these students are likely to prefer to give up or self-handicap rather than look incompetent (Schwinger & Stiensmeier-Pelster, 2011), and develop negative self-perceptions as a result of disappointing performance outcomes (Maehr & Zusho, 2009). Mastery goals, on the other hand, have been consistently shown to be beneficial in corresponding to greater motivation (e.g., self-efficacy, persistence), positive academic emotions (e.g., course enjoyment), and more adaptive self-regulation (Barron & Harackiewicz, 2001; Mesa, 2012; Shell & Husman, 2008). For example, Hoyert and O'Dell (2006) evaluated the effects of promoting mastery goals in 188 struggling students from an introductory psychology course, and found students in the intervention condition to exhibit greater persistence and higher course grades following the intervention, as compared to baseline levels. However, because of their focus on understanding and gaining competence, the extent to which these students may also perform well on measures of long-term academic achievement, as compared to their performance-oriented counterparts, is

unclear (Senko & Miles, 2008). As such, it is possible that students in demanding STEM programs that emphasize performance and competition may not experience improved motivation and achievement from motivational interventions that promote adaptive goal orientations.

Given these potential limitations of interventions focused on promoting single goal orientations, interventions in which a multiple goals perspective is encouraged may be particularly relevant for higher education settings. Given the focus in post-secondary education on not only learning and competence, but also on maintaining superior performance to ensure the attainment of goals (e.g., graduate school, scholarships, career), programs similar to those previously used in secondary educational contexts may prove useful for university students (Linnenbrink, 2005). Theorists argue that combining performance and mastery approaches can be particularly adaptive such that achievement goals both originate from within the student (as opposed to being externally facilitated) and are focused on outperforming others (Elliot & McGregor, 2001; Harackiewicz et al., 2002; Pintrich, 2000). However, despite the growing consensus among motivational theorists on the various benefits of adopting the multiple goals perspective, there is still no agreed upon intervention for university students aimed at facilitating motivation and performance through the promotion of combined goal orientations.

Attributional Retraining. The final group of motivational interventions to be discussed are those that aim to promote the use of adaptive causal attributions to explain poor academic performance, and are referred to as "attributional retraining." In order to promote adaptive attributions in post-secondary students, extensive research has been done on the motivational, emotional, and achievement consequences of attributional retraining interventions (Forsterling & Morgenstern, 2002; Perry, Hechter, Menec, & Weinberg, 1993). Attributional retraining (AR) interventions are designed to reframe students' explanations about the causes of (primarily

unexpected and negative) experiences or outcomes, by replacing maladaptive attributions with more motivationally adaptive attributions (e.g., effort versus ability). Hall, Hladkyj, Perry, and Ruthig, (2004) examined the effects of an AR intervention on emotions, motivation, and achievement in 203 university students as moderated by their use of elaboration learning strategies (low levels assumed to indicate at-risk students). Findings indicated that regardless of students' frequency of using elaboration learning strategies, all students benefitted from the AR intervention in terms of their motivation, positive affect (i.e., enjoyment) and performance (i.e., course grades). However, only students with high elaboration levels were found to apply these AR strategies to all their courses and also showed significantly higher levels on cumulative achievement outcomes (year-end GPAs).

Similar positive effects of an AR intervention were found by Haynes, Daniels, Stupnisky, Perry, and Hladkyj (2008) on 336 first-year university students. In this study, motivation was operationalized in terms of students' goal orientations, with a greater mastery orientation indicating higher motivation. The authors found that among the No-AR participants, motivation generally decreased over time (6 months post-intervention). For those in the AR condition, the intervention appeared to have differential effects on mastery vs. performance motivation, with the intervention increasing mastery motivation but having little effect on performance motivation. Moreover, it was found that mastery motivation mediated the effects of AR on students' performance (i.e., GPA), such that AR predicted mastery motivation that, in turn, predicted better academic performance. Struthers and Perry (1996) also examined the interaction between university students' existing motivational profile (i.e., attributional style) and an AR intervention, and discovered that AR enhanced the motivation of students who made maladaptive

(i.e., unstable and uncontrollable) attributions, with these students also showing higher course grade, as compared to controls.

Haynes, Perry, Stupnisky, and Daniels (2009) argue that higher education settings are particularly appropriate for the application of AR treatments, as they involve a transition into a novel setting (i.e., high school to university) during which it is possible to incorrectly perceive one's success in the new environment as largely determined by external factors. Numerous studies have supported this assertion and demonstrated that AR, when applied in higher education settings, can produce long-term benefits for students' motivation (Hall et al., 2004; Hall, Perry, Goetz, Ruthig, Stupnisky, & Newall, 2007; Haynes et al., 2008; Struthers & Perry, 1996), positive emotions (Hall et al., 2004, 2007), and performance (Hall et al., 2005, 2006b; Haynes et al., 2006; Ruthig et al., 2004). These positive effects can help explain why attributional retraining programs are perhaps the most commonly evaluated motivational programs in higher education settings, and hence are more extensively reviewed in this paper relative to the preceding motivational programs.

Despite the demonstrated benefits that AR can produce for many students, AR interventions are not uniformly effective for all students due to the aptitude x treatment interaction (ATI; Cronbach & Snow, 1977). An ATI can be observed when an educational intervention produces differential effects for students based on their personal attributes. For example, Perry, Stupnisky, Hall, Chipperfield, and Weiner (2010) administered AR to students whose initial test performance in an introductory psychology course was high, average, or low, and found that although the intervention facilitated adaptive attributions for all students, it especially helped students with initial average and low performance in terms of both their course-specific and global performance outcomes. Students' use of elaborative learning

strategies is another student characteristic found to produce an ATI in AR interventions. Students who frequently use elaborative learning strategies are better able to incorporate new information into their exiting knowledge (Hall et al., 2004). High elaborators benefit more globally from AR interventions (i.e., performance benefits beyond the specific course in which AR was administered; Hall et al., 2004) than low-elaborators. Moreover, a follow-up study by Hall et al. (2007) found high-elaborating students to benefit most from a more specific AR treatment in which they are asked to elaborate on the AR premise in a cognitive manner, as opposed to an emotional manner which exclusively benefitted low-elaborators (Hall et al., 2007).

AR and academic overconfidence. Of relevance to the present study on overconfidence in STEM students, several research studies have focused on using AR to improve academic emotions, motivation, and achievement in overconfident post-secondary students. Attributions are especially important after failure experiences as many overly optimistic students do not expect to encounter such experiences, and therefore do not adequately consider how to best interpret failure so as to maintain their motivation (Moore & Healy, 2008). In a study of 236 first-year university students from an introductory psychology course, Ruthig, Perry, Hall, and Hladkyj, (2004) found that for overly optimistic students, AR led to improved GPAs following the intervention, as well as lower test anxiety, and lower course withdrawal. Without AR, overly optimistic students demonstrated the lowest GPA and highest voluntary withdrawal of all groups in the study (i.e., high optimism AR/No AR, low optimism AR/No AR). These findings once again reiterate the importance of holding realistic expectations for future performance, but also maintaining motivation by holding adaptive beliefs about the roles of effort and ability in academic success.

Such beliefs are vital during transitional periods, when individuals are not able to base their expectations on past experience. In these contexts, overly optimistic expectations may be illusory and therefore difficult to achieve. Haynes et al. (2006) explore how AR methods interact with optimism levels in 225 psychology students within the context of the "first year experience," which is defined as the transition from high school to university or another post-secondary setting (Perry, 1991). Because in this context students' expectations are not based on extensive experience, the authors hypothesized that holding overly optimistic expectations would put students at risk of developing maladaptive motivational strategies and poor achievement. Providing these students with an AR intervention proved beneficial in several ways. First, it enhanced first-year, overly optimistic students' effort attributions and perceptions of control, and positively affected their cumulative GPA for both the introductory psychology class and for all other classes taken during the academic year. Overly optimistic students who did not receive AR increasingly (over the course of two academic quarters) attributed their performance to causes beyond their personal control (e.g., ability, course difficulty, instruction quality). These results were not found, however, for low-optimism students in the No AR condition, suggesting that in academic transitions, lower levels optimism might be more adaptive than high optimism.

Second, overly optimistic students who received the AR intervention significantly outperformed all other groups in terms of their course grade and overall GPA. This finding suggests that perhaps optimism can be adaptive and even beneficial in novel settings if it is based on internal factors that are within the students' control, such as effort. Lastly, overly optimistic students who did not receive the AR intervention demonstrated more maladaptive cognitions (i.e., explaining their performance using attributions that are beyond their personal control) and low achievement relative to low-optimism students in the No-AR group. This finding is

surprising given that low-optimism students are known to be at risk for decreased motivation, poor performance, and attrition (Perry et al., 2005). Moreover, this finding is especially alarming as students who believe that their academic performance is beyond their control ultimately assume less responsibility for their poor achievement, and suffer a loss of motivation, negative academic emotions, and consequently potential declines in performance and disengagement (Struthers & Perry, 1996).

Finally, in a follow-up study to Hall et al. (2006a) described above (see Academic Overconfidence section), Hall et al. (2006b) expanded our understanding of the consequences of overly optimistic beliefs during academic transitions by focusing on the effects of an AR intervention that encouraged both controllable attributions (persistence) and secondary-control strategies (positive reappraisal) for 225 overconfident university students over one academic year. Overconfidence was defined as students' having high primary control (beliefs in effort, persistence) combined with low secondary control (failure-related coping strategies) following initial poor performance. For students who did not receive AR, those who maintained this overconfident profile received year-end grades that were 17% lower than they expected, as compared to unsuccessful students who used both primary- and secondary-control strategies, whose expectations were on par with their achievement (accurately calibrated). Overconfident students who received the AR intervention also endorsed fewer uncontrollable attributions, increased their use of positive reappraisal as a secondary-control strategy, and received a final grade approximately 10% (or one full letter grade) higher than their No-AR counterparts.

Once again, it appeared that maintaining high primary control and low secondary control was maladaptive in fostering students' feelings of invulnerability to failure, and further, that AR could reverse these effects by encouraging the use of controllable attributions after failure

experiences. Moreover, greater reliance on secondary control strategies was also found for initially unsuccessful students who were high in primary control and low on secondary control. On a post-test measure of secondary control (positive reappraisal of negative events), these students were no longer significantly different than their peers classified as high in secondary control. These and previously described findings (Haynes, 2006; Klein & Helweg-Larsen, 2002; Ruthig et al., 2004) emphasize the importance of calibrating expectations to performance, maintaining realistic beliefs about one's personal control over academic achievement, and the link between these cognitions and academic motivation.

Limitations of AR programs. Other studies have demonstrated that this ATI does not only fail to show benefits for certain students, it can actually indicate significant negative effects for specific student populations. When the interaction between students' self-esteem levels and AR was assessed, for example, Hall, Jackson, Goetz, and Musu-Gillette (2011) found that students with low self-esteem who received AR aimed at reframing attributions regarding job interviews to have a 32% higher rate of employment relative to controls, as well as more adaptive and internal attributions for failure (e.g., effort). However, students with high self-esteem who received the treatment were more likely to endorse external attributions, and were about half as likely to obtain a job offer, compared to their control counterparts. In this ATI, the intervention helped students who were at-risk of not obtaining employment, but backfired for students with high self-esteem. Similarly, Hall, Musu-Gillette, Perry, Nett, and Goetz (2010) have found that when administering AR interventions to both high- and low self-esteem students, the treatment predicted positive performance changes on an exam immediately following the intervention for low self-esteem students, but not on end-of-year grades or students' overall GPA. The implications of these ATIs are that although AR treatments are typically beneficial in

producing long terms benefits after a short intervention session for at-risk students, they need to be applied with caution given potential limitations or drawbacks for some students.

In summary, despite the demonstrated motivational, emotional, and achievement benefits of AR for specific student populations (e.g., those with low initial performance), this intervention has also been found to have unanticipated limits as well as negative consequence for specific students depending on their psychosocial dispositions (e.g., learning strategy preference, self-esteem levels). As described above, low elaborators benefit motivationally from participating in AR interventions, but these benefits are not found to generalize beyond the specific course in which the intervention was administered (Hall et al., 2004). Similarly, students with low self-esteem benefit from AR on short-term measures of employment and achievement (i.e., evaluated within a few months after the intervention; Hall et al., 2010, 2011) but do not show similar benefits on more long-term measures such as year-end course grades or cumulative GPA (Hall et al., 2010). Finally, recent findings are particularly discouraging in showing AR methods to have a substantial negative effect on students with high self-esteem on both employment and achievement outcomes (Hall et al., 2010, 2011). Therefore, AR interventions are not uniformly beneficial, nor do they produce long-term effects for all students. Thus, despite significant motivational benefits of AR programs, efforts to determine best practices for using this intervention to improve university students' motivation and performance, so as to also prevent maladaptive responses, are ongoing.

Given the critical importance of control beliefs (e.g., primary/secondary control) and personally controllable attributions in motivational intervention research, it is critical to better understand the role of perceived control on student motivation. As alluded to in multiple studies presented above, perceptions of personal control can be evaluated from a dual-process

perspective in which both primary and secondary components are considered (Rothbaum, Weisz, & Snyder, 1982), with this perspective being particularly relevant to the present research questions due to its potential to account for academic overconfidence in university students from a motivational perspective (Hall et al., 2006a). According, a review of Heckhausen et al.'s (2010) motivational theory of lifespan development is provided below so as to more clearly elaborate on the theoretical basis of the present study.

The Motivational Theory of Life-Span Development

In order to thoroughly understand the motivational theory of life-span development as proposed by Heckhausen, Wrosch, and Schulz (2010), it is important to begin by discussing the construct of perceived control and how it affects individuals' choices of motivational strategies. Heckhausen and Schulz (1995) propose that the manner in which individuals choose to interact with their environment largely depends on how much control they perceive to have over it. Individuals who perceive themselves as having personal control over their environment (i.e., that they can influence changes within it) tend to use motivational strategies to improve the situation and modify their behaviour to achieve their goals. This type of control belief, and the corresponding motivational strategies, are referred to as primary control (Rothbaum et al., 1982). For example, after a non-satisfactory grade on an exam, a student who believes that they can improve their performance are likely to use strategies that involve investing more hours studying and expanding their domain-specific knowledge before the next exam, in an attempt to obtain an improved outcome. On the other hand, individuals who perceive less control over the environment are more likely to change their cognitions in an attempt to reconcile the differences between environmental outcomes and their expectations (i.e., secondary control; Morling & Evered, 2006; Rothbaum et al., 1982). For example, after a non-satisfactory grade on an exam, a

student who attributes the results to factors beyond their personal control (e.g., luck or test difficulty) might attempt to find the "silver lining" (Hall et al., 2006a) or downgrade the importance of that exam, or the course in general, to come to terms with the disappointing reality. When secondary control motivational strategies are used adaptively, they serve to maximize primary control striving in major domains of functioning (e.g., work, health) across the life-span (Heckhausen et al., 2010).

Although most human beings have the potential to influence various aspects of their environment through their actions, they are limited both in resources and time (Heckhausen & Schulz, 1995). Therefore, individuals need to be selective about which goals they pursue, as well as when and how to pursue them. To determine this, individuals need to consider factors such as available opportunities, the limits of their abilities, time constraints, and long-term consequences of goal pursuit (Heckhausen et al., 2010). These processes can be better understood when considering the concepts of *selection* and *optimization*: Selection refers to choosing appropriate goals toward which motivational resources can be invested, whereas optimization refers to the potential for the chosen goals to afford opportunities for primary control over the life-span (Heckhausen et al., 2010; Morling & Evered, 2006). As individuals age, there is a decrease in primary control due to increased physical, cognitive, and environmental limitations. Therefore, individuals should aim throughout their lives to select goals that will optimize their primary control in the long term. An adaptive goal is one that a) is congruent with opportunities for control (the goal needs to be realistic within the individual's current developmental ecology; cf., calibration), b) can open doors for the pursuit of other goals (and therefore personal development), and c) should help maintain a diversity of goals that the individual is able to pursue (Heckhausen et al., 2010).

Although the selection of optimizing goals is important during every life stage, it is especially crucial during transitional periods, as unsuccessful adjustment to new or changed life circumstances can have detrimental health and well-being consequences (Heckhausen et al., 2010). Therefore, secondary control strategies are not always subordinate to primary control strategies, but can be adaptive when used in combination with primary control strategies to accommodate specific low-control situations (Morling & Evered, 2006, 2007; Skinner, 2007). One example of such a situation is the experience of failure. Heckhausen et al. (2010) argue that failures occur at any stage of development and when they do, the individual ought to *compensate* motivationally for the failure in order for mastery to continue to develop. Compensatory primary control involves strategies such as seeking help or increasing resources in an attempt to achieve better results in the future. Compensatory secondary control strategies, on the other hand, involve cognitive responses such as disengaging from the goal by devaluing it or downgrading its importance, or self-protective strategies such as finding the "silver lining," comparing oneself to those whose performance was worse, or focusing on successes in other domains.

Therefore, when resources are limited following a failure experience, or when control is lost entirely, compensatory secondary control strategies can be most adaptive for personal development, even if these strategies do not specifically aim to increase primary control (Heckhausen et al., 2010; Morling & Evered, 2006; Skinner, 2007). In a review of secondary control literature, Morling and Evered (2006) demonstrated that secondary control is in fact a separate construct from primary control as well as perceived control, and therefore can be adaptive under certain circumstances even if it does not increase primary control. It is instead conceptualized as a way in which individuals cope with loss of control (Skinner, Edge, Altman, & Sherwood, 2003) so as to prevent the distress associated with such losses.

Empirical Support for Secondary Control as an Adaptive Motivational Strategy

Numerous studies have explored the effects of using primary and secondary control strategies in during challenging developmental transition phases and in other situations where loss of control is inevitable (e.g., developmental deadlines; Heckhausen & Schulz, 1995). More specifically, the research literature to date in which Heckhausen's model has been empirically investigated has focused on three main contexts where loss of control is experienced: aging and its inevitable impact on personal control, the transition from school to work, and the transition to higher education.

Aging and loss of control. Concerning the adaptive self-regulation of motivational strategies in response to health-related challenges in later life, a nine-year longitudinal study by Hall et al. (2010) with 143 old adults (ages 73-98) examined the effects of both primary and secondary control strategies on health, life satisfaction, and mortality (Hall et al., 2010). In line with Heckhausen et al.'s theory (2010), the authors found that older adults with acute and reversible health problems (e.g., heart attack, stroke) benefitted from primary control strategies (goal engagement; e.g., persistence) in terms of survival. In contrast, older adults with irreversible, chronic conditions (e.g., heart disease, arthritis) demonstrated better health when using secondary control strategies involving goal disengagement (downgrading goal importance). Moreover, it was found that participants' motivational strategies also interacted with age: Young-old adults (< 80 years old) benefitted more from goal engagement whereas old-old adults (> 80 years old) benefitted from goal disengagement. These results thus underscore the importance both persistence (primary control) and realistic aspirations (secondary control, calibration) as potentially adaptive motivational strategies in response to environmental opportunities and constraints. Although individuals strive for primary control throughout their

lives, secondary control can be adaptive and even necessary following disappointing events and in response to diminished abilities (e.g., chronic illness).

To successfully deal with such concrete developmental deadlines, Heckhausen (1997) conducted a cross sectional study to investigate similar motivational strategies used by three age groups (young, ages 20-35; middle aged, ages 40-55; old, ages 60 and over) in response to age-appropriate developmental challenges. For younger adults, it was most adaptive to adopt gain-striving rather than loss-avoiding goals related to finances, family, and work. Middle-aged adults were less optimistic than young adults about the probability of goal attainment, and demonstrated more flexibility in goal adjustment, reporting more loss-avoiding and less gain-striving goals than young adults. Finally, it was most adaptive for older adults to be aware of their developmental constraints, disengage from goals that focus on maximizing personal growth (i.e., in the domains of work, finance, and family), and instead endorse goals that aim to minimize or avoid losses (in domains such as health, community, and leisure). Therefore, older adults were found to endorse more loss-avoiding goals, more flexibility in goal adjustment, and less gain-striving goals relative to middle-aged and young adults.

These two seminal studies by Hall et al. (2010) and Heckhausen (1997) provide comprehensive accounts of the motivational strategies used to cope with the challenges individuals face as they age, by focusing on perceived loss of control (i.e., probability of goal attainment) and actual (i.e., physical) control losses in older adulthood. Similar findings have been observed numerous additional studies, all of which demonstrate that old adults benefit from adopting motivational strategies involving secondary control (e.g., downgrading aspirations) in terms of their effect on goal attainment (Heckhausen & Schulz, 1998; Wrosch, Heckhausen, & Lachman, 2000) and physical as well as psychological well-being (Hall et al., 2010; Wrosch et

al., 2000, 2007a). These results further imply that enduring goal pursuit in the face of physical and environmental constraints can detrimental to the individual's motivation and well-being, whereas selective and compensatory motivational strategies involving secondary control may not only be more appropriate, but essential in such situations.

Transition from school to work. Another developmental phase in which Heckhausen's theory has been explored is the transition from school to work. During this transition, students are expected to identify a position that is both attractive to them and is in line with their training and education, and then successfully pursue it. Haase, Heckhausen, and Koller (2008) examined 362 German students during the transition from school to work, contrasting the motivational strategies of students in high-opportunity versus low-opportunity situations (e.g., females obtaining an apprenticeship in a male-dominated workplace). Results showed that that primary control (i.e., goal engagement, persistence) was important for career goal attainment and well-being (e.g., subjective well-being, positive affect) when goal attainment opportunities were limited, as was the case for females. For males who typically had better employment opportunities, goal engagement was not essential for attaining an apprenticeship, but proved beneficial for well-being. Interestingly, goal engagement before graduation predicted increases in apprenticeship attainment and positive affect after graduation for both genders. That is, regardless of the existing opportunities, students who began preparing for the developmental challenge in advance were the most successful in accomplishing it.

Heckhausen and Tomasik (2002) further supported these results by assessing 470 German students completing the transition from education to employment. Students were assessed five times in intervals of two months during the 10th grade to examine whether expectations for the type of job they wanted to attain (their "dream job") changed as the

developmental deadline approached. Findings showed that the social prestige of the desired job was in fact downgraded as proximity to the deadline increased, suggesting that students began to match their vocational aspirations to their school achievement. However, this calibration was evident more so in females, who realized that their opportunities were more limited regardless of their academic achievement. Thus, these studies reveal that it is important to recognize the opportunities and constraints faced by young adults when approaching a developmental deadline, who are required to adjust both their actions and expectations to these real-world limitations in order to successfully pursue their developmental goal of employment.

Beyond employment expectations, graduating students' occupational choices have developmental implications for their social and financial growth. In line with the trends found for the previously described transitional contexts, Tomasik, Hardy, Haase, and Heckhausen (2009) assessed 414 German high-school students during the transition from school to work. Findings showed that although primary control strategies were adaptive after graduation, maintaining these strategies after repeated failure to find work was maladaptive as it prevented students from adjusting their job aspirations, and consequently led to disengagement from job pursuit. Whereas students often aim for positions that are beyond their reach shortly after graduating, maintaining this attitude was found to represent an obstacle to future employment opportunities as the social prestige of an apprenticeship was found to correlate negatively with its accessibility (miscalibration). When an appealing work position was not obtained shortly after graduation, it was found to be most adaptive for students to turn to secondary control motivational strategies, namely downgrading aspirations.

Similar findings have been found in other preliminary German studies suggesting that although engagement is generally adaptive for individuals with limited work-related prospects,

such as for women (Haase et al., 2008), downgrading aspirations can also be beneficial after an initial period of failure in job attainment, or when the social prestige of the job is associated with its limited accessibility (Heckhausen & Tomasik, 2002; Tomasik et al., 2009). Taken together, these studies reiterate the importance of both primary control (persistence) and secondary control strategies (downgrading aspirations) during transition periods, where personal control can often be compromised by social and normative factors. As the stressful nature of transition phases makes it difficult for the individual to recognize the control opportunities that do exist, individual's perceptions of control and subsequent control strategies become critically important in accounting for successful adaptation in these situations (Heckhausen et al., 2010).

Transition to higher education. Of particular relevance to the present study with post-secondary students in STEM degree programs is a study by Hall (2008) that examined self-regulation of primary and secondary control strategies in 568 students during the transition from high school to higher education. Findings showed that students increased their primary control motivational strategies (e.g., persistence, effort) after experiences of success (i.e., getting a good grade), and after poor performances, demonstrated an increase in secondary control (e.g., positive reappraisal, finding the "silver lining"). If students expected their actions (e.g., studying for an exam) to lead to specific consequences (e.g., getting a good grade) but were disappointed, they were able to maintain their ability to persist in the future if they used secondary control strategies to re-evaluate the quality and quantity of the actions needed to achieve their goals. Thus, students' ability to alternate between primary and secondary control based on calibrated (accurate) perceptions of performance outcomes was shown to positively impact their academic motivation. That is, in order to optimize their motivational resources, students needed to recognize when a goal was within their reach, and when it was unattainable, and abandon

pursuits of unattainable goals. It is therefore assumed that benefits of primary and secondary control on academic emotions, motivation, and performance for first-year university students, as previously discussed concerning Hall et al. (2006a, 2006b), are primarily due to their ability to adaptive shift between these motivational strategies based on their grades.

Similarly, a study conducted by Wrosch, Miller, Scheier, and Brun de Potent (2007) with 81 undergraduates showed students' ability to disengage from unattainable goals, and re-engage in modified attainable goals, to predict fewer health problems (e.g., cold symptoms, sleep efficiency). Whereas poor goal disengagement tendencies were conversely associated with greater emotional upset, adaptive goal reengagement tendencies buffered the negative effects of failure to disengage from an unattainable goal on emotional well-being. Finally, there was a significant interaction effect between goal disengagement and goal reengagement on changes in life satisfaction: Problems with goal disengagement predicted decline in life satisfaction, but only among participants who scored low in goal reengagement.

These results are consistent with an earlier study by Wrosch et al. (2003), who examined the self-regulation of goal striving among 115 American university students. Study findings showed that disengagement from an unattainable goal significantly predicted lower levels of intrusive thoughts and perceived stress, and high levels of self-mastery. In addition, adaptive goal reengagement was associated with higher levels of subjective well-being, suggesting that students who were able to both disengage from unattainable goals and reengage in new goals perceived felt less stressed as well as more satisfied and efficacious. In contrast, students who reported difficulties disengaging from unattainable goals, and failed to reengage in new goals, showed low levels of self-mastery and high levels of perceived stress. Similarly, a study on student health by Hall, Chipperfield, Perry, Ruthig, and Goetz (2006c) with 888 first-year

university students found primary control strategies to predict more positive perceptions of overall health and illness symptoms for males, with a similar positive relationship being found for secondary control and self-rated health among females. Secondary control (i.e., positive reappraisal) was found to predict better objective health outcomes for both genders (e.g., missed classes due to illness) once again underscoring the importance of this motivational strategy for physiological well-being in post-secondary students. These findings demonstrate that using secondary control strategies in academic settings contributes to better psychological adjustment (Hall 2008; Hall et al., 2006a) and physiological health, both of which are important factors in maintaining students' motivation and achievement in university in general, and in challenging degree programs in particular (Wai et al., 2010).

Finally, Tomasik and Salmela-Aro (2012) investigated how German students cope with a developmental deadline associated with the transition to university. The authors studied primary and secondary control motivational strategies among 184 Finnish students who failed to pass a university entry exam. It was found that those who failed the exam and reported more compensatory secondary control strategies (e.g., disengaging from the goal, using self-protective strategies such as downward social comparisons and focusing on success in other domains) had higher levels of life satisfaction four months later. The authors argued that this association between secondary control strategies and life satisfaction is a crucial component of psychological adjustment and development not only after a developmental deadline, but across the life-span.

Thus, it can be concluded from empirical studies on primary and secondary control across the life span that it is generally adaptive to alternate between these motivational strategies in response to environmental opportunities and constraints. Whereas primary control strategies are mostly used in achievement contexts where there are few physical constraints and/or limitations

on the individual, thus allowing for successful goal pursuit, secondary control strategies instead tend to be most beneficial when loss of control is perceived or experienced by the individual, which can temporarily or permanently inhibit the individual from achieving their goals. As such, Heckhausen's theoretical model is of relevance to the present study in providing a unique dual-process perspective on achievement motivation that accounts for academic over-optimism (Hall et al., 2006a), as well as the importance of realistic expectations and downgrading aspirations (e.g., Hall, 2008; Hall et al, 2010; Heckhausen & Tomasik, 2002).

The Present Study

Research to date has primarily focused on students in social science domains (e.g., psychology), and less attention has been given to motivation in STEM students. Even fewer studies have explored the role of motivational strategies aimed at compensating for the motivational impact of personal disappointment or failure often experienced in STEM disciplines. The present study evaluates the effects of a motivational program aimed at promoting one such compensatory motivational strategy, namely downgrading personal aspirations, given the direct link between this approach and the overconfidence commonly observed in the STEM student population. Studies evaluating this motivational strategy have found downgrading aspirations to be beneficial in later life (Hall et al., 2010), during the transition to employment (Heckhausen & Tomasik, 2002), and in educational settings more generally (Forsterling & Morgenstern, 2002; Stone, 2000). Consistent with previously observed benefits of secondary control strategies during the transition to higher education (Hall et al., 2006a), the present study is similarly informed by Heckhausen et al.'s (2010) theory and investigates the effects of an exploratory motivational intervention encouraging students in

STEM degree programs to consider the importance of downgrading unrealistic expectations after disappointing academic outcomes.

This three-phase study was conducted over a two-year period, and assessed how first- and second-year students in STEM disciplines responded to an intervention that encouraged them to downgrade their overoptimistic expectations following a simulated failure experience. Outcome measures included objective achievement outcomes obtained from student records of the two years post-intervention (GPA), as well as psychosocial self-report measures including expectations, optimism, and psychological well-being. In line with Heckhausen et al. (2010), *Hypothesis 1* proposed that students in the intervention condition would demonstrate more adaptive (i.e., lower) expectations and optimism following the intervention with regards to their academic future, as compared to controls. *Hypothesis 2* proposed that students in the intervention program would also report more adaptive (i.e., higher) levels of psychological adjustment (e.g., fewer illness symptoms, lower depression) relative to controls, due to these students preserving their motivational resources by downgrading unrealistic aspirations (i.e., disengaging from unattainable academic goals, such as receiving straight As) and reengaging in more realistic goals – thus downgrading one's goals – new STEM students were hypothesized to be better adjust to the challenges of their academic program. Finally, *Hypothesis 3* proposed that due to students in the intervention condition adopting more realistic expectations and experiencing improvements in well-being, their grades (GPAs) would significantly improve, as compared to overoptimistic controls, who were assumed to continue to have maladaptive levels of overconfidence following personal disappointment or failure experiences.

Method

Data for the present longitudinal study was collected between 2007-2008 by a research team from the Department of Psychology and Social Behavior at the University of California, Irvine (UCI). All experimental protocols were approved by the UCI Institutional Review Board as per approval code HS#2007-5465, and no additional ethics approval was required by the McGill Research Ethics Board Office, as per correspondence with Lynda McNeil, Research Ethics Officer (November 4, 2011; see Appendix A for ethics documentation). The project was directed and coordinated by my thesis supervisor, Dr. Nathan C. Hall, as part of post-doctoral studies conducted under the supervision of Dr. Jutta Heckhausen (Professor, UCI).

Participants

During the 2007 winter semester, students at the University of California, Irvine were recruited from multiple introductory-level courses in the biological sciences (92.3%) and physical sciences (7.7%) through mass emails distributed by faculty deans and the directors of students affairs offices. The total sample consisted of 52 students, 61.5% of whom were women, having an average age of 18.25 (SD = .52). The majority (84.6%) of participants indicated that they were first-year students, with the remainder of participants being second-year students. Participants' ethnic backgrounds were primarily Caucasian (71.2%), with most participants indicating that English was their first language (79%). Participants' average high-school grades showed 89.1% of participants to have graduated from high school with a GPA of 85% or higher (M = 90.20, SD = 5.46), suggesting that the sample consisted primarily of high-achieving students and thus potentially at risk of academic overconfidence based on exceptional high-school achievement (Haynes et al., 2006). As an incentive for participation, participants who completed Phases 1 and 2 of the study were entered into a raffle for four iPods. Participants who

completed Phase 3 of the study were entered into an additional raffle for UCI Bookstore gift certificates ranging from $10 to $50.

Measures

The independent measures in the present three-phase study include the motivational intervention that encouraged students to consider the importance of downgrading expectations and adopting realistic expectations in response to academic disappointment, as compared to an equivalent control condition. The dependent measures included both objective outcomes (sessional GPAs) and self-report measures (expectations, optimism, well-being).

Intervention content. The intervention and control conditions were each administered to groups of 25-27 participants and consisted of three components. First, participants completed a challenging GRE-type aptitude test (Abstract Reasoning and Abilities Test, ARAT) previously used by in AR intervention research (Hall et al., 2004) as a simulated failure experience, after which they were immediately debriefed (Appendix B). This aptitude test was intended to prime failure-related cognitions and emotions in participants prior to reading the intervention handout, therefore allowing them to better retain the information presented. Second, participants were provided a short handout (specific to the experimental condition) to be completed individually. The intervention group handout outlined the benefits of downgrading one's expectations when thinking about future academic performance. For example, statements such as "anything less than the best is failure" were contrasted with more realistic alternatives such as "overly high goals can make you feel like a failure even when you succeed" (Appendix C). Participants in the control group completed a similarly formatted reading discussing medical myths vs. facts (Appendix D).

Finally, a writing exercise was administered in both the intervention and control conditions, based on elaborative learning theory (Entwistle, 2000), that required participants to summarize and discuss the main points of the handout (depth), provide several examples of the issues discussed (breadth), explain how they could apply the content in their own lives (personal structure) and share their emotions concerning academic failure (cf., Pennebaker, 1997). This writing activity was intended to provide participants an opportunity to elaborate on the benefits of downgrading expectations and cognitively consolidate the information presented in the handout with their prior knowledge on the topic. The present protocol thus included a combination of methods previously employed in AR research (aptitude test, writing exercise; Hall et al., 2004, 2007), in an attempt to provide participants with a more substantive intervention experience allowing them sufficient opportunities to cognitively process the potentially threatening intervention content concerning downgrading aspirations.

Dependent Measures. All ranges, means, standard deviations, and scale reliability measures for the dependent variables are displayed in Table 1.

Grand point average (GPA). Five sessional GPAs were obtained from the UCI Registrar's Office for Winter 2007, Spring 2007, Fall 2007, Winter 2008, and Spring 2008 semesters. The sessional GPA for each semester consisted of the mean GPA for all courses completed during that semester.

Academic expectations. Academic expectations were assessed by summing together responses from three questions: (1) "I expect to do very well overall at university this year" (Likert scale; 1= *Very Unsuccessful* to 10= *Very Successful*), as well as (2) what GPAs they expected to obtain at the end of the Winter 2007 semester (by entering a number ranging from 0 to 4.00) and (3) what GPAs they expected to obtain by the upcoming Fall 2008 semester

(cumulative GPA; range: 0 to 4.00). These items were used to evaluate both students' general expectations for academic success and specific expected academic achievement (i.e., GPA), as well as both short- and long-term expectations concerning future achievement.

Optimism. Six Likert-style items from Scheier and Carver's (1992) Life Orientation Test (LOT) questionnaire were used to assess participants' levels of dispositional optimism (e.g., "I'm always optimistic about my future", "In uncertain times, I usually expect the best") ranging from 1= *strongly disagree* to 5= *strongly agree*. This scale thus provided a dispositional and domain-general measure of expectancy, unlike the preceding measure of expected success that was specific to the academic domain.

Achievement motivation. To assess students' achievement motivation, an eight-item scale was adapted from Pintrich, Smith, and McKeachie (1989) and included items such as "I prefer course material that really challenges me so I can learn new things" (mastery goal orientation) and "If I can, I want to get better grades in my classes than most of the other students" (performance goal orientation; 1 = *not at all true of me* to 7 = *very true of me*).

Academic emotions. Two learning-related emotions were assessed using six-item, five-point Likert scales from the Academic Emotions Questionnaire (AEQ; Pekrun, Goetz, & Perry, 2005), namely enjoyment (e.g., "I enjoy learning new things"), and anxiety (e.g., "When studying the material in this course, my heart rate increases because I get anxious"; 1= *not at all true* to 5 = *completely true*). These measures evaluated students' emotional well-being specific to academics and assessed both negative and positive emotions, due to positive affect in students having not been widely researched in higher education contexts as an indicator of student well-being (Pekrun & Stephens, 2012).

Illness symptoms. An eight-item measure was used to assess how often (1 = *not at all a week* to 5 = *5 or more times a week*) during the last month students experienced each of the following illness symptoms: Sleep problems, headaches, low energy, muscle tension, fatigue, stomach pain, heart pounding, and poor appetite. Participants' total score on this measure was therefore indicative of their physical well-being at the time of assessment.

Depression. Depression was assessed using a ten-item Center for Epidemiologic Studies Depression (CES-D) scale (Radloff, 1997). Participants were asked how often (1 = *rarely or none of the time* to 4 = *most or all of the time*) during the last month they felt as described in the statements (e.g., "my sleep was restless," "I felt fearful," "I felt depressed"). Unlike the academic emotions measures that are context-specific, this measure was included to provide a more dispositional, stable, and domain-general indicator of participants' psychological well-being.

Procedure

In Phase 1 (January-February 2007), students who volunteered to participate in the study reviewed an online study consent form (Appendix E), at the end of which they entered identifying information and provided digital consent to participate by clicking the *Start the Study* button. Following consent, participants completed an online questionnaire that included demographic measures (e.g., age, gender, ethnicity, course load, high-school grade), and assessed participants' motivation (achievement motivation, academic expectations, optimism), academic emotions, and well-being using the afore-mentioned measures (illness symptoms, depression; approximately 15 minutes). Following the questionnaire, students were required to choose and attend one of two in-person sessions (Phase 2; April 2007) in which either

Table 1

Descriptive Statistics for Dependent Measures

Scale	Range	*M*	*SD*	α
GPA				
Winter 2007	0.65-4.00	3.07	0.62	
Spring 2007	1.81-4.00	3.09	0.52	
Fall 2007	1.55-4.00	3.12	0.68	
Winter 2008	0.00-4.00	3.04	0.72	
Spring 2008	1.65-4.00	3.12	0.57	
Academic expectations	6.30-14.80	12.14	1.77	
Optimism	13-29	21.90	4.17	.86
Achievement motivation				
Mastery	11-26	19.54	3.56	.74
Performance	10-28	24.51	3.89	.87
Academic emotions				
Enjoyment	14-27	19.61	3.32	.52
Anxiety	6-25	17.19	5.03	.80
Illness symptoms	10-28	16.35	5.78	
Depression	10-31	20.90	5.93	.71

intervention or control activities were administered (sessions were randomly assigned to be either experimental or control conditions; 30 minutes). Approximately four months after the experimental session, Phase 3 required students to once again complete the online questionnaire in which the same measures were administered (approximately 15 minutes). Students sessional and cumulative GPAs, as well as course load, were obtained from UCI Registrar's Office for the preceding quarter (Fall 2006) as well as the end of that quarter (Winter 2007) and for the following four quarters (Spring 2007, Fall 2007, Winter 2008, and Spring 2008).

Results

Preliminary Analyses

Initial differences. Independent-samples *t*-tests were conducted on all study variables at Phase 1 to determine if there were initial differences between participants in the control and intervention groups on any of the study variables. No significant differences were found between the groups on any of the study variables.

Correlational analyses. Correlations between all study variables (achievement and self-report) in Phase 1 and Phase 3 are presented in Table 2. Several interesting relationships were found in both phases, primarily involving depression and academic achievement (GPA). Not surprisingly, illness symptoms and depression had a strong positive relationship in both phases, highlighting the association between physical and psychological well-being in STEM students. Another relationship that remained positive and significant over time was between depression and anxiety which is not surprising as this relationship is well documented in research with college students (Gotlib, 1984). Similarly, a significant negative relationship was found in both phases between optimism and depression, suggesting that students who were more optimistic about their academic future were also less likely to have depressive symptoms. Whereas it is

possible that more optimistic students used more adaptive coping strategies that contributed to lower depression levels (see Krypel & Henderson-King, 2010), the direction of the relationship cannot be determined due to the correlational nature of the study data.

With respect to academic achievement, students' expectations for success and Winter 2007 GPA were positively and significantly correlated at the $p < .001$ level in both phases. This finding is in line with both previous literature (e.g., Chemers et al., 2001) and the study hypotheses, suggesting that students' expected and actual achievement levels should generally be similar (i.e., well calibrated). Finally, an increasingly significant and negative correlation was found between boredom and academic achievement. This finding is consistent with Pekrun et al., (2010) who demonstrated that students with higher boredom levels receive lower grades, and work by Perez (2012) who asserted that high attrition among STEM students may result from boredom after failing to keep up with their high-achieving peers.

Rationale for Main Analyses

Based on the preliminary analyses results as well as previous literature (e.g., Hall et al., 2010a), the study hypotheses were evaluated using one-way analyses of covariance (ANCOVAs) to evaluate the effects of the downgrading intervention on self-report variables (Hypotheses 1 and 2), as well as a repeated-measures ANCOVA to analyze the intervention's effects on objective performance outcomes (i.e., GPA; Hypothesis 3) across five semesters following the intervention. Although no initial differences between the experimental groups were found, literature informed covariates were chosen to control for potentially confounding variables. As per Hall et al. (2010a), covariates included baseline levels of self-report measures in Phase 1 (for all self-report variables), demographic variables such as age and gender, as well as academic variables including high school grade, and cumulative units completed (i.e., level of study) to

Table 2

Zero-Order Correlations Among Study Variables

	1	2	3	4	5	6	7	8	9	10
1. Optimism	__									
2. Expectations	.01/.07	__								
3. Illness symptoms	-.02/-.31	.12/.07	__							
4. Depression	-.42**/-.38*	.14/.25	.51**/.74**	__						
5. Enjoyment	.55**/.12	.03/.18	-.11/.17	-.34*/.12	__					
6. Anxiety	-.09/-.28	.07/-.12	.37*/.35	.48**/.38*	.03/.21	__				
7. Boredom	-.25/-.42	-.21/-.20	.29/.43	.10/.37*	-.36*/-.25	.35/.56**	__			
8. Mastery orientation	.57**/.23	-.08/.08	-.07/-.35	-.38**/-.28	.58**/.27	-.24/-.12	-.17/-.22	__		
9. Performance orientation	.14/-.12	.05/-.05	-.55**/.06	-.34*/-.01	.30*/-.01	-.15/-.24	-.21/-.11	.24/.03	__	
10. Achievement (GPA)	-.02/-.09	.71**/.65**	.04/-.06	.08/.02	.03/-.13	.04/-.30	-.36*/-.43*	.14/.03	.01/.16	__

*$p < .05$ ** $p < .001$. Correlation between study variables at Phase 1/Phase 3

control for prior academic experience and aptitude. Means and standard deviations for the experimental conditions are presented in Table 3.

Main Results

Expectations and optimism. Significant treatment effects were observed on students' expectations for academic success, $F(29) = 4.516$, $p < .05$, and general optimism levels, $F(29) = 8.049$, $p < .05$. As depicted in Figure 1, results showed students in the intervention condition to report higher post-intervention academic expectations ($M = 12.74$, $SD = .40$) compared to students in the control condition ($M = 11.36$, $SD = .48$). Figure 1 also illustrates the main effect for optimism, showing students in the intervention condition to report higher post-intervention optimism levels ($M = 22.89$, $SD = .65$) relative to controls ($M = 19.82$, $SD = .79$). These results are contrary to the anticipated results specified in Hypothesis 1, in which *lower* (better calibrated) expectations and optimism were anticipated for participants in the intervention condition.

Motivation and well-being. According to Hypothesis 2, participants in the intervention condition were expected to downgrade their expectations following the intervention, which would facilitate a more adaptive motivational profile (goal orientations) and higher self-reported health and overall well-being as compared to controls. However, this hypothesis was not supported such that one-way ANCOVAs on self-reported well-being and goal orientations did not show the intervention to significantly affect motivation and well-being outcomes: enjoyment $F(29) = 1.148$, $p = .295$; anxiety $F(29) = 1.612$, $p = .217$; illness symptoms $F(29) = 1.892$, $p = .182$; depression $F(29) = .867$, $p = .362$; performance orientation $F(29) = 1.989$, $p = .172$; mastery orientation $F(29) = .110$, $p = .743$.

Table 3

Means and Standard Deviations by Intervention Condition

	Intervention			Control			
Variable	*n*	*M*	*SD*	*n*	*M*	*SD*	*t*
Optimism	20	22.5	4.94	17	21.12	4.99	.85
Expectations	20	3.38	.323	17	3.29	.489	.69
Illness symptoms	20	18.25	7.00	17	17.12	4.39	.58
Enjoyment	20	21.25	4.23	17	19.12	5.50	1.33
Anxiety	20	16.50	5.71	17	17.35	5.23	-.47
Boredom	18	14.44	5.25	13	15.69	4.13	-.71
Mastery orientation	20	21.35	3.63	17	19.88	5.30	.99
Performance orientation	20	24.60	4.62	17	24.76	4.13	-.11
Winter 2007 GPA	20	3.01	.48	17	3.15	.49	-.28
Spring 2007 GPA	20	3.09	.39	17	3.25	.40	-.85
Fall 2007 GPA	19	2.93	.68	16	3.19	.79	-1.1
Winter 2008 GPA	19	2.87	.59	16	3.23	.59	-1.8
Spring 2008 GPA	19	2.88	.59	16	3.38	.53	-2.8*

*$p < .05$

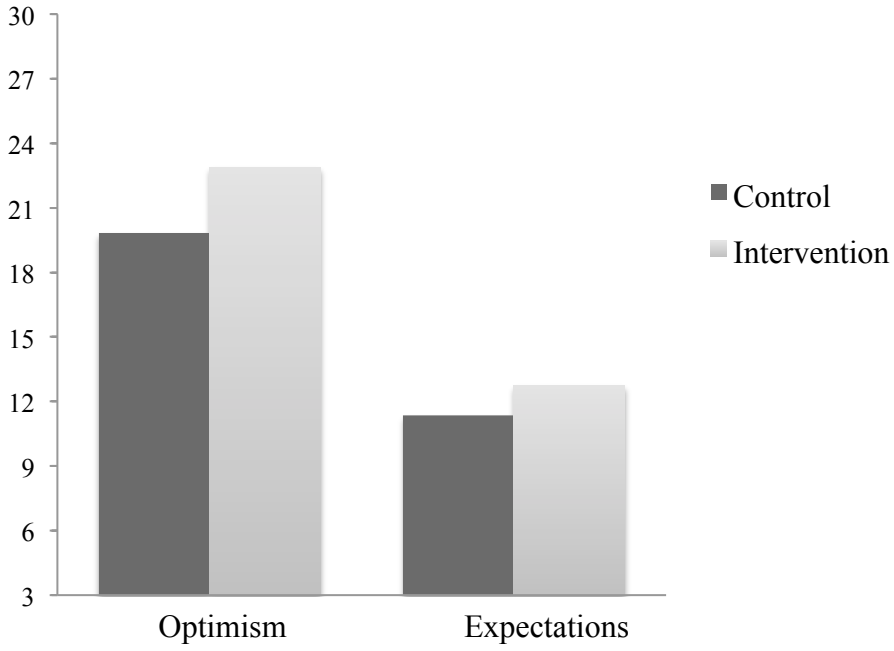

Figure 1. Effects of the downgrading intervention on students' expectations and optimism in Phase 3. Scores on the academic expectations measure range from 3-18, and score on the optimism scale range from 6-30.

Academic achievement. Hypothesis 3 proposed that as students adopt more realistic expectations, their grades (as reflected in their GPA) will improve due to sustained motivational resources, as compared to controls who were more likely to maintain academic overconfidence. A repeated measures ANCOVA revealed a significant treatment effect on participants' GPA, $F(34) = 5.875$, $p < .05$, $\eta_p^2 = .17$. As depicted in Figure 2, this significant main effect shows the intervention to have a consistently *negative* effect on GPA levels over the subsequent two-year period, with intervention participants. As such, this finding clearly contradicts both Hypothesis 3 and the existing research literature that has consistently found lowering or reevaluating

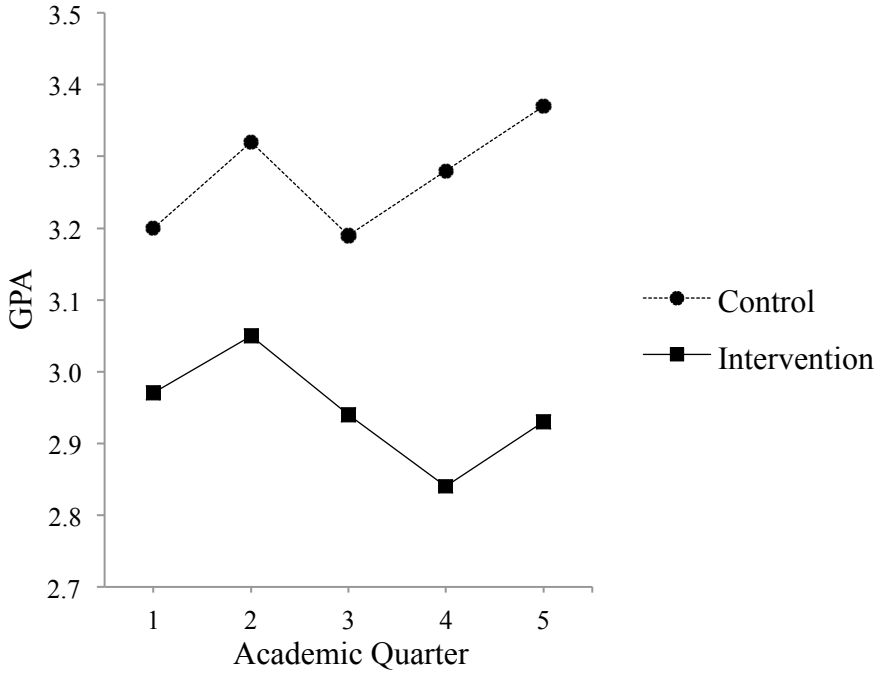

Figure 2. Effects of the downgrading intervention on GPAs over five academic quarters.

expectations to correspond with better student performance by helping them respond adaptively to potential or recent academic setbacks (Hall et al., 2006a; Heckhausen & Tomasik, 2002; Tomasik et al., 2009).

Discussion

Hypothesis 1: Optimism and Expectations

According to the first hypothesis, participants in the intervention condition were expected to demonstrate better adjusted (i.e., lower) levels of optimism and expectations for future success, therefore becoming more calibrated with their highly achievement-oriented academic reality and potential for academic disappointment. These results instead revealed that on the post-test measures of optimism and expectations (controlling for pre-test scores), students in the

intervention condition reported *higher* levels of optimism as well as expectations for academic success. These findings are thus very much contradictory to the study hypothesis as the intervention aimed to lower students' overconfidence by explicitly targeting their overly optimistic expectations, and suggesting adaptive ways of thinking about their academic future.

One possible explanation for these iatrogenic results comes from Robin and Beer (2001) who argue that when overconfident students who are highly ego-involved in a task or a domain face failure, they often used self-enhancement as a strategy to maintain their high self-worth and self-esteem. In other words, reminding these students that they might fail a program in which they are so invested may have triggered a defensive reaction to the content of the intervention, and consequently produced higher, instead of lower, expectancy levels in these students. As students' in STEM degree programs are likely to have their self-esteem be closely tied to their performance in the program (Perez, 2012), it is possible that the intervention was perceived not as a guide for thinking about future achievement, but as a direct threat to students' ego. Consequently, a defensive reaction may have been triggered that caused these students' already high optimism and expectation levels to become even higher.

Similar findings have been observed for high self-esteem students, particularly those whose self-esteem is also highly variable over time (i.e., unstable, fragile; e.g., Kernis, Cornell, Sun, Berry & Harlow, 1993; Kernis, Greenier, Herlocker, Whisenhunt & Abend, 1997), who tend to react defensively to failure feedback that is not consistent with their self-schemas (e.g., self-handicapping, Newman & Wadas, 1997; derogation, Kernis et al., 1993). Moreover, these findings have been replicated in AR research showing students with high self-esteem to respond particularly negatively to the intervention content in which persistence is encouraged (e.g., Hall et al., 2010b, 2011). In these studies, only participants with high self-esteem perceived the

intervention as a threat to their self-worth (which is highly based on their perception of themselves as high-ability individuals) and consequently reacted adversely to it (i.e., exhibited poorer academic performance and employment interview success). Therefore, there is reason to believe that the unexpected results observed in this study could also be mediated by self-esteem levels, such that STEM participants with high self-esteem may be responding particularly negatively to the intervention. Unfortunately, as self-esteem was not included as a study measure (see Limitations section), this possibility could not be explored in the present study.

Hypothesis 2: Well-Being and Goal Orientation

The second hypothesis proposed that the preservation of motivational resources that should result from having more realistic expectations would also contribute to higher levels of students' overall well-being (lower depression, illness symptoms, academic anxiety, and boredom; higher enjoyment) and more adaptive achievement goals (e.g., high levels of performance as well as mastery goals rather than an emphasis on performance goals). According to the motivational theory of life-span development (Heckhausen et al., 2010), and related research (Wrosch et al., 2003, 2007), the pursuit of unrealistic goals in young adulthood can deplete motivational resources and adversely affect one's motivation and well-being. In contrast to this hypothesis and prior research, our analyses revealed no significant effects of the intervention on measures of goal orientation and well-being. When taken together with the paradoxical results for Hypothesis 1, these findings suggest that the downgrading intervention may not be as effective for STEM students as for other student in other domains in which some failure events are more commonly experienced. Given that study participants did not appropriately incorporate the message of the intervention as reflected by opposite changes in expectancy-related cognitions, it is not surprising that they also did not reap the motivational and

well-being benefits found to be associated with this motivational strategy in other studies (Hall et al., 2006a, 2010a; Heckhausen & Tomasik, 2002; Tomasik et al., 2009; Wrosch et al., 2000).

Hypothesis 3: Academic Achievement

The goal of motivational interventions is to promote motivational variables that predict student engagement and persistence, and consequently improve students' academic performance. As personal disappointment is an inevitable occurrence for many students in STEM degree programs, due to their highly competitive nature, the goal of the present intervention was to provide students with a motivational strategy for maintaining persistence and performance in the face of failure. To assess the longitudinal effects of the intervention, participants' GPAs were collected for five semesters (two years) following the intervention. According to Hypothesis 3, participants in the intervention condition were expected to downgrade their expectations and therefore demonstrate higher GPAs relative to controls. The present analysis revealed that contrary to this hypothesis, students in the intervention condition consistently demonstrated significantly *lower* grades following the intervention than those in the control condition. Given that multiple background variables such as pre-intervention GPA, course load, age, and gender were controlled for, this finding is particularly discouraging in that it can more reliably be attributed to the intervention program as opposed to potential confounds.

One possible explanation for these surprising results involves the elevated optimism and expectations levels observed among intervention participants. Wrosch et al. (2003) argue that the pursuit of unattainable can be maladaptive and result in unnecessary disengagement when goals are not achieved. By adopting even more optimistic expectations, these students likely pursued goals that were even more difficult to attain despite being in such a competitive environment. If these goals were not attained, it is therefore conceivable that students may have begun to

disengage from their studies, resulting in lower GPAs over the subsequent semesters. Another potential account for these findings implicates self-enhancement as a defensive strategy in students with high self-esteem. Robins and Beer (2001) suggest that the combination of unrealistically high expectations and a fragile sense of self-worth (which facilitates the use of defensive strategies such as self-enhancement) can result in disengagement when the individual realizes that they might fail to live up to their expectations. As such, suggesting to the participants that they might not achieve their academic goals may trigger a defensive reaction, lack of effort, and failure to achieve their ambitious goals. This type of self-handicapping is well documented in highly performance-oriented students, whose self-worth is closely tied to performance outcomes (Graham & Williams, 2009). As the risk of academic failure poses a threat to their sense of self-worth, disengagement may be one way in intervention participants in this study sought to ensure that their ability was not perceived as the reason for their disappointing performance.

Taken together with the outcomes for the optimism and expectations measures, these results indicate that following the intervention, STEM students became less calibrated and more overconfident with the gap between their expectations and objective performance outcomes becoming larger (higher expectations combined with lower grades). Therefore, the intervention did not simply fail to produce the anticipated results, it essentially backfired and hurt study participants by contributing to both over-optimism and disengagement. As this type of motivational strategy has been found to be effective in past research conducted in higher education and related contexts for young adults (i.e., school to work transition), it is reasonable to assume that intervention content may not have been sufficiently tailored to unique characteristics of high-achieving, high self-esteem STEM students.

Limitations

The present study had several methodological and conceptual limitations. First, the study sample consisted of only 52 participants, which is a small sample size for a two-condition experimental study. More specifically, a power analysis for an ANCOVA with five covariates indicates that a sample of 128 would be required to achieve power of .80. This is therefore a limitation not only in terms of the generalizability of the results to the entire population of STEM students, but also in terms of the power to detect significant differences between groups (e.g., on well-being measures). Moreover, the methods of recruitment (i.e., recruitment email, optional participation) and compensation employed (i.e., multiple draws for electronics, gift certificates) may have resulted in a selection bias. For example, the study may have attracted primarily students who were motivated to benefit from student affairs programs, or obtain prizes, which could compromise the generalizability of the results due to such confound variables.

The second limitation involves the study instrumentation, as the majority of the study variables were assessed using self-report data to assess students' perceptions of optimism, expectations, well-being, emotions, and goal orientations. This type of data, when not triangulated with objective measures or other sources of participant information (e.g., first-hand observations, second-hand accounts from others), is susceptible to subjective bias and therefore can potentially be incomplete and/or inaccurate.

A third limitation of the present study is the failure to evaluate potentially critical mediating variables that may account for some of the study outcomes. For example, overconfident students have been found to use self-enhancement strategies in the face of disappointing performance outcomes to maintain their self-esteem, which can consequently lead to both overly optimistic expectations and disengagement (Robins & Beer, 2001). Although the

present study attempted to replicate past research showing individuals to benefit from downgrading their expectations, it neglected to include variables that could uniquely explain the contradictory results for the STEM student sample. For example, measures of students' self-enhancement strategies, or self-handicapping strategies (Newman & Wadas, 1997), may have allowed for a better understanding of the iatrogenic effects observed in this study. Whereas this study employed a similar experimental design and instrumentation in previous studies (e.g., AR research; Hall et al., 2007), these findings suggest that this study failed to adequately consider the unique manner in which STEM students respond to failure.

Implications and Future Research

Several directions for future research are suggested based on the present study findings. First, future research should aim to further explore self-esteem and self-worth as moderating variables, perhaps with a larger sample that includes participants with both high and low self-esteem (e.g., overconfident STEM students as well as students from less competitive degree programs). Such efforts could contribute to the research literature on motivational programs by exploring the relationship between self-esteem and related motivational strategies (e.g., self-enhancement), and their role in moderating the effects of motivational interventions. As high self-esteem students have been shown to respond adversely to some motivational interventions (e.g., AR; Hall et al., 2010b), it would be interesting to further explore this trend in order to better understand this population and provide researchers with the useful information on how to tailor motivational intervention for these at-risk students.

Another implication of the present results is that students disengaged from their studies and consequently demonstrated lower grades over five academic semesters following the downgrading intervention. Since downgrading strategies have been shown in the past to have

positive effects for individuals in various developmental contexts where loss of control is experienced, future research should expand the present study by also exploring how students reengage in other goals following disengagement. Such findings could inform efforts to help students not simply disengage from unrealistic goals, but also to appropriately reengage in other, more adaptive goals. Wrosch et al. (2003) argue that goal reengagement plays a critical role in buffering the negative effects of disengaging from an unattainable goal. Based on this rationale, it would perhaps be most beneficial for overconfident STEM students to not only learn that their expectations might be too high considering their demanding degree program, but also to discover other more attainable goals that can be pursued (i.e., a 3.6 vs. a 4.0 GPA). Efforts to inform students of such goals may reduce the probability of student disengagement due to fear of failure, and help to offset the adverse achievement outcomes observed in the present study.

Finally, future research should similarly aim to incorporate objective measures of students' achievement and well-being, as well as employ a longitudinal study design, so as to provide clear evidence as to the performance and developmental effects of motivational programs for at-risk students. Moreover, broader sampling protocols are recommended to better assess the effects of downgrading interventions on university students more generally, and to further explore the effects of theory-based motivational programs for students in the natural sciences who are typically overlooked. It is anticipated that by incorporating objective measures (e.g., information from the registrar's office, objective measures of health and well-being such as cortisol levels), triangulating objective with self-report measures, and adding additional study phases to evaluate the long-term effects of motivational interventions, researchers will be able to produce more reliable and generalizable findings that can inform best practices and interventions to help curb overconfidence while maintaining student engagement and motivation.

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Appendix A

Ethics Documentation

JUTTA HECKHAUSEN SOC ECOL-PSYCHOLOGY & SOCIAL BEHAVIOR

RE: HS# 2007-5465, "Improving Academic Development through Secondary Control Interventions" [e-CPA# 4744]

Your IRB approved document(s) are now available for download at the http://apps.research.uci.edu/irbdocs .

Please note the following:

* The document(s) approved with this IRB submission will include the IRB approval date in the document description. For instance, if the document description reads, "HS# 2008-1234 Protocol Narrative 04/01/08", this means that the document was approved by the IRB on 04/01/08.

* Always remember to use the most current version of the IRB approved, stamped consent/assent form when enrolling research participants.

* Only the most current versions are available at the IRB Doc Depot. Please be sure to retain hard copies of all IRB approved, stamped documents in the study file.

* If you are required to obtain HIPAA Authorization please download a copy of the Permission to Use Personal Health Information for Research form and include it with the informed consent document.

If you have any questions or concerns, please do not hesitate to contact me. The IRB thanks you in advance for your continued dedication to the protection of human research participants.

Regards, Human Research Protections staff Human Research Protections Office of Research Administration UC Irvine 300 University Tower Irvine, CA 92697-7600 (ZOT 7600) http://www.rgs.uci.edu/ora/staff/

cc: SCOTT C BLUM

From: Lynda McNeil
Sent: Friday, November 04, 2011 2:20 PM
To: Nathan Hall
Cc: Florise Lam Tsang On; Deanna Collin
Subject: RE: REB Approval for Existing Data

Hi Nathan,

As we just discussed on the phone, since all the data has been collected and there will be no further contact with participants, and you are only conducting data analysis as per the original consent terms, you are not required to get further ethics approval from McGill.
Florise- funds can be released.

Regards, Lynda

Lynda McNeil, Research Ethics Officer
Research Ethics Board Office
McGill University
James Administration Building, room 429
845 Sherbrooke Street West
Montreal, QC,Canada H3A 2T5
Tel: (514) 398-6831 Fax: (514) 398-4644
Email: lynda.mcneil@mcgill.ca
www.mcgill.ca/research/researchers/compliance/human/

Appendix B

Aptitude Test

Abstract Reasoning and Abilities Test (ARAT)

The Abstract Reasoning and Abilities Test (ARAT) is a GRE-type aptitude test developed for use in universities and schools across North America as a measure of student ability. On the reverse are a subset of 5 questions from the ARAT involving math problems. You are allowed 5 minutes to complete these items.

Please remember to choose the one response that best answers the question. There is no penalty for incorrect answers, and try to answer as many questions as possible. Once instructed, turn the page to begin. Please note your answers on the sheet provided and not on the test itself.

Directions: Each of the problems in this section is followed by 5 alternatives. Solve each problem and then choose the correct answer.

An example of a math question is:

A certain type of siding for a house costs $10.50 per square yard. What does it cost for the siding for a wall 4 yards by 60 feet long?

The answer is b) $840

The area of the wall = 4 yrds. x (60 ft./3) = 4 yds. x 20 yds. = 80 sq. yds. The cost = 80 x $10.50 = $840.

(a) $800
(b) $840
(c) $2520
(d) $3240
(e) $1940

1. A large field of 700 acres is divided into 2 parts. The difference of the areas of the 2 parts is one-fifth of the average of the 2 areas. What is the area of the smaller part?

   (a) 225 acres
   (b) 300 acres
   (c) 335 acres
   (d) 315 acres
   (e) cannot be determined from the information

2. Given that [y] means the greatest integer less than or equal to y, find the value of: [-1/4] + [5 1/2] + [7]

   (a) 12 1/4
   (d) 11

(b) 12 (e) 10

(c) 12 1/2

3. Anne has 3 blouses, 4 skirts, and 2 pairs of shoes. How many different outfits can she wear, if an outfit consists of any blouse worn with any skirt and either pair of shoes?

(a) 8 (d) 9

(b) 12 (e) 48

(c) 24

4. Car A runs at constant speed of 30 miles per hour (mph), and car B at a steady rate of 5 mph. Starting from the same spot, car B drives due west, while car A drives due north for 1 hour and then turns due east (maintaining speed) for 2 hours. How far apart are the cars 2 hours after they both started out originally?

(a) 72 miles (d) 50

(b) 60 miles (e) 36

(c) 55 miles

5. Bill can mow 200 sq. ft. of lawn in 12 minutes and Fred can mow 300 sq. ft. in 15 minutes.

What is the ratio of Bill's mowing to Fred's rate?

(a) 6/5 (d) 4/5

(b) 5/6 (e) 6/4

(c) 5/4

Debriefing Text

"The aptitude test is now complete. If you feel you did not perform well on this test, you are not alone. Most students typically rate their performance as poor upon completing the exam, with most students answering less than 50% of the answers correctly when the entire test is completed. In fact, this aptitude test was designed to be very difficult and given mainly to:

CONTROL GROUP:

"get you thinking in a more abstract way, so that you can better remember the information about medical issues that I will present next"

TREATMENT GROUPS:

"get you thinking about how it feels to do more poorly than you expected on an academic-type test, and allow you to better remember the information about students' performance in university which I will present next."

Appendix C

Intervention Condition: Reading and Writing Exercise

"Failure is not an option! Never give up!"

Sound familiar? Here are some realistic alternatives for how you can think about negative experiences in your life:

Rather than thinking . . .	Instead . . .
¸ Failure is not an option.	¸ Failure is a part of life - every student experiences disappointment. Successful students invest a lot of effort, but also have realistic expectations. Realistically evaluate your potential: - Do I have enough time to study properly? - Do I have enough energy/interest to do my best? - Is the material/schedule just too difficult for me?
¸ Anything less than the best is failure.	¸ Overly high goals can make you feel like a failure even when you succeed. By being more realistic, you can avoid feeling frustrated and stay motivated. Set realistic goals for yourself: - Am I overly optimistic about my study habits or grades? - Based on my time/interest/ability, what grades can I reasonably expect?
¸ Lowering your expectations is the same as giving up.	¸ Lowering your expectations can be the best way to realistically assess and improve your abilities after a disappointing performance. An example: After failing to make his high school varsity basketball team, Michael Jordan played on the junior varsity team to practice his skills.
¸ Nothing is more important than achieving your goals.	¸ Holding on to unattainable goals can have negative effects on your health. Research suggests that lowering unrealistic academic expectations can lead to fewer illness symptoms (headaches, fatigue, muscle tension, sleep problems, etc.).
¸ Successful people don't change their goals.	¸ Successful people often change their goals to better suit their abilities. Abraham Lincoln failed in business - twice - before getting into politics. If necessary, reevaluate your academic program: - Can I make the most of my abilities in this field? - Are there other programs that can help me reach my career goals? - For assistance with program issues, contact your student affairs office.

Unrealistic expectations can negatively affect your health and academic success.

Discussion Questions

1. Discuss and summarize the main points of the handout in your own words.
2. Provide as many examples as possible of academic goals which university students are often overly optimistic about, and discuss how lowering one's expectations could be beneficial in these situations.
3. Try to recall a recent instance where you performed poorly, or didn't perform as well as expected, on an important course exam or assignment.

   Discuss as openly and honestly as you can how the event made you feel.

   All your writing is completely confidential.
4. Discuss and describe several examples of how you could apply the main points of the handout to the way you currently approach your university courses.

Appendix D

Control Condition: Reading and Writing Exercise

Is it OK to Swim After Eating?

Below is a list of common medical myths,
and the truth, if any, behind them.

MYTH	FACT
¸ It's dangerous to swim after eating.	¸ This myth was disproved in the '60s, but is still pretty common. The very worst you can expect is a stitch - a short, sharp pain in the side, in which case you should stop swimming and get out of the water.
¸ You only use 10 percent of your brain.	¸ Which 10 percent? Untrue. This myth is based on studies of rare people who have undetected hydrocephalus, a condition involving the abnormal accumulation of cerebrospinal fluid in and around the brain.
¸ The human body is 98 percent water.	¸ It's actually about 70 percent.
¸ You can catch syphilis from toilet seats.	¸ The worst you could catch from a toilet seat is gastroenteritis, and even then you'd have to try pretty hard.
¸ You should drink six pints of water a day to stay healthy.	¸ Wrong! This is based on the requirements for intravenous fluids of someone who is getting nothing by mouth, and even then they also need various salts and sugar.
¸ The bathroom is the dirtiest, buggiest room in the house.	¸ That honor actually goes to the kitchen, especially the chopping board and the sink.
¸ Women have a higher pain threshold than men.	¸ Apparently only during the third trimester of pregnancy.
¸ Carrots help you see in the dark.	¸ No, this myth possibly stems from British World War II propaganda aimed at concealing the invention of radar. Beta found in carrots is converted to vitamin A, which is needed for healthy eyesight.

Source: Dr. P. Trotman; http://health.discovery.com/fansites/dr_know

Discussion Questions

1. Discuss and summarize the main points of the handout in your own words.
2. Provide as many examples as possible of any other health-related or medical myths you know about, and if possible, where you first heard about it (e.g., friends, family, TV, Internet, magazine, etc.).
3. Try to recall a recent instance where you realized that something you thought was true about a health-related or medical issue was only a myth. Discuss as openly and honestly as you can how that event made you feel. All your writing is completely confidential.
4. Discuss and describe several examples of how you could apply the main points of the handout to the way you approach your own health.

Appendix E

Consent Form

ONLINE ACHIEVEMENT STUDY

UNIVERSITY OF CALIFORNIA, IRVINE
CONSENT TO ACT AS A HUMAN RESEARCH SUBJECT

You are being asked to participate in a research study. Participation in this study is completely voluntary. Please read the information below and ask questions about anything that you do not understand before deciding if you want to participate. A researcher listed below will be available to answer your questions.

RESEARCH TEAM
Lead Researcher:
Dr. Jutta Heckhausen
Department of Psychology and Social Behavior
Co-Researcher:
Dr. Nathan C. Hall
Department of Psychology and Social Behavior
949-824-5574 (leave message)
halln@uci.edu

PURPOSE OF STUDY

The purpose of this research study is to explore how the motivational strategies used by university students contribute to their long-term academic performance and development.

SUBJECTS

Inclusion Requirements
Due to the achievement-focused nature of this study, only students who consent to release their grades/course information to the experimenter from the registrar's office are eligible to participate (GPA, core course grades (e.g., Bio 93/94, Chem 1P,A-C, Human. Core, Writing 39A/B), units attempted, course study, major field, level of study; 09/01/06 to 10/01/08). You provide this consent by clicking the button below, and entering your UCInetID and password on the UCI Secure Web Login page.

Your identifying information will be used only to link the institutional data with your questionnaire responses, and will be omitted immediately afterward to ensure complete confidentiality and anonymity.

Number of Participants and Time Commitment
This three-part study will include a maximum of 1000 subjects. Estimated time required for Part 1 = 15 mins, Part 2 = 30 mins, and Part 3 = 15 mins (1 hour in total).

PROCEDURES

PART 1 is a short questionnaire completed over the Internet. PART 2 requires you to attend an in-person information session. PART 3 involves completing the same web-based questionnaire from Part 1 at the end of the quarter (April, 2007).

Participants complete the online questionnaire, then sign up online for an in-person information session. There are multiple session times available, held from February 12, 2007 through February 16, 2007. Participants who do Parts 1 and 2 are then contacted by email a few months later to complete the second online questionnaire.

RISKS AND DISCOMFORTS

This study involves no more than minimal risk. There are no known harms or discomforts associated with this study beyond those encountered in normal daily life.

BENEFITS

Subject Benefits
The possible indirect benefits you may experience from the procedures described in this study include significant improvements in academic motivation and performance.

Benefits to Others or Society
The possible benefits of this study to others involve providing empirical support for the large-scale use of strategy-based methods for assessing and improving academic development in university students.

ALTERNATIVES TO PARTICIPATION

The only alternative to participation in this study is not to participate.

COMPENSATION, COSTS AND REIMBURSEMENT

Compensation for Participation
Students who complete the first two parts of the study are entered to win one of four 30 GB Video iPods (approx. value: $250 each) to be awarded in March, 2007.
Students who complete all three parts of the study are ALSO entered to win one of 50+ gift certificates for the UCI bookstore, ranging from $10 to $50. Gift certificates are awarded in May, 2007.

CONFIDENTIALITY

Subject Identifiable Data
All identifiable information that will be collected about you will be removed at the end of data

collection.

Data Storage
All research data will be stored electronically on a secure computer with encryption and password protection, with extra encryption provided for identifying information.

Data Access
The research team, authorized UCI personnel, the study sponsor (if applicable), and regulatory entities such as the Food and Drug Administration (FDA) and the Office of Human Research Protections (OHRP), may have access to your study records to protect your safety and welfare. Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed by these entities without your separate consent, except as specifically required by law.

Research records provided to authorized, non-UCI entities will not contain identifiable information about you. Publications and/or presentations that result from this study will not include identifiable information about you.

Data Retention
The researchers intend to keep the research data in electronic format for at least 10 years.

IF YOU HAVE QUESTIONS

If you have any comments, concerns, or questions regarding the conduct of this research please contact the lead researcher listed at the top of this form via email.

If you are unable to reach a member of the research team listed at the top of the form and have general questions, or you have concerns or complaints about the research study, research team, or questions about your rights as a research subject, please contact UCI's Office of Research Administration by phone, (949) 824-6068 or (949) 824-2125, by e-mail at IRB@rgs.uci.edu or in person at University Tower - 4199 Campus Drive, Suite 300, Irvine, CA 92697-7600.

VOLUNTARY PARTICIPATION STATEMENT

Participation in this study is voluntary. You may refuse to answer any question or discontinue your involvement at any time without penalty or loss of benefits to which you might otherwise be entitled. Your decision will not affect your future relationship with UCI or your quality of care at the UCI Medical Center.

START THE STUDY

Please feel free to print the consent information above for your records.
You should not log in to the study unless you have read the above information.