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Summary: This scholarly publication on value reappraisal is an example of my individually-driven line of original research on student motivation and self-regulation. This manuscript was published in a respectable journal with an impact factor of 1.633.

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Effects of a Value-Reappraisal Intervention on Statistics Students' Motivation and Performance

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The authors investigated the effects of an exploratory value-reappraisal intervention on students' motivation and performance in an undergraduate introductory statistics course. They sampled 82 students from 2 instructors' sections during both the fall and spring semesters. Students were randomly assigned within each section to either the Value-Reappraisal (VR) or Control condition (C). VR presented messages about the importance of statistics and guided students in exploring potential values of learning statistics. Results showed positive effects of VR on task value, endogenous instrumentality, and a choice-behavior measure of interest. The authors found VR to affect exam performance, but only for students who had a particular instructor. This research helps broaden literature on self-regulation and expectancy-value models of motivation by focusing on the regulation of value perceptions.

Keywords: achievement, attitude, expectancy value, interest, intervention research, math and science education, motivation, self-regulation

MANY STUDENTS HAVE TROUBLE learning math and science, and they also find it difficult to understand why learning these subjects is important for them on an individual level. Furthermore, there are growing economic and social needs to increase students' achievement and continued interest in math and science education (National Science Foundation, 2006; U.S. Department of Education, 2006). Research in the areas of achievement motivation and self-regulated learning has identified important predictors of students' academic achievement and continued

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interest as well as factors that could potentially be targeted in interventions to increase these outcomes.

Expectancy-value theory posits that students' achievement and continued interest in a particular subject area can, in part, be explained by their expectations about successfully performing academic tasks and the degree to which they value those tasks (Eccles et al., 1983; Wigfield & Eccles, 2002). Students are thought to choose and be motivated toward academic tasks and courses that they expect they can successfully complete and perceive as valuable (Atkinson, 1964; Eccles & Wigfield, 2002). Although both expectation beliefs and value perceptions have been found to be positively related to motivation and achievement (e.g., Simpkins, Davis-Kean, & Eccles, 2006; Wigfield & Eccles, 1992, 2000), expectation beliefs have been found to be stronger predictors of achievement, and value perceptions have been found to be stronger predictors of continued interest in a particular subject area (e.g., enrollment in and intentions to take math courses; Meece, Wigfield, & Eccles, 1990; Wigfield & Eccles, 1992, 2000). For example, in a study of 250 seventh- through ninth-grade students, Meece et al. found that expectation beliefs directly predicted subsequent math grades and value perceptions directly predicted intentions to enroll in future math courses. Furthermore, this pattern of results held for both boys and girls. On the basis of these findings, helping students to increase their expectation beliefs might lead to stronger gains in achievement, and helping students increase their value perceptions might lead to stronger gains on measures of continued interest and, perhaps, further study in a particular content area.

Theory and research on self-regulation has suggested that students can actively modify their academic values, beliefs, and goals through the use of self-regulatory strategies (Boekaerts, Renninger, Sigel, Damon, & Lerner, 2006; Corno & Kanfer, 1993; Pintrich, 2000, 2004; Pintrich & DeGroot, 1990; Wolters, 1998, 2003; Zimmerman, 1989, 2000). Central to models of self-regulation are processes involved in setting, pursuing, and evaluating learning and achievement goals. According to Zimmerman's (2000) model, self-regulation involves three cyclical phases: forethought (setting goals and planning how to reach those goals strategically), performance/volitional control (implementing plans and metacognitively monitoring implementation efforts), and self-reflection (evaluating goal progress and reacting to and reflecting on successes and failures). A large body of research on strategic and self-regulated learning has suggested that students can increase their expectation beliefs for success and achievement through the use of self-regulatory strategies (Bandura, 1997; Bandura & Cervone, 1983; Bandura & Schunk, 1981; Cleary & Zimmerman, 2001; DeCorte, Verschaffel, & Masui, 2004; Fuchs et al., 2003; Glaser & Brunstein, 2007; Kitsantas, Reiser, & Doster, 2004; Kramarski & Gutman, 2006; Lynch, 2006; Metallidou & Vlachou, 2007; Pintrich & DeGroot; Schunk, 1996; Schunk & Ertmer, 1999, 2000; Torrance, Fidalgo, & Garcia, 2007; Zimmerman, 2000; Zimmerman, Bandura, & Martinez-Pons, 1992).

However, there is a dearth of theory and research focused on helping students to place value on and develop a continued interest in a particular subject area. Both motivation and self-regulation researchers have highlighted a need for more work in this area (Brophy, 1999; Pintrich, 2000, 2004; Wolters, 1998, 2003). For instance, Brophy (1999) argued that "... the value (as opposed to the expectancy) aspects of human motivation, particularly motivation to engage in domain-specific learning tasks" need to be further developed and emphasized in theoretical and empirical work (p. 75). Brophy addressed concepts and principles such as building learning communities that help students to adopt learning goals, providing students with optimally challenging tasks, and choosing tasks that have a potential to be perceived as important, given the learners' past knowledge and experiences. However, Brophy (1999) did not focus on self-regulatory processes and strategies that students could use to regulate their value perceptions and interest. In Pintrich's (2000, 2004) theoretical model of four self-regulatory phases (forethought, planning, and activation; monitoring; control; and reaction and reflection) and four areas that can be regulated during each phase (cognition, motivation/affect, behavior, and context), he emphasized that one way students can actively increase their motivation is by activating and regulating their value perceptions. Wolters's (1998) research provided support for this idea because it showed that students reported using strategies to both increase their interest in a task (e.g., by making studying into a game) and increase the relevance of a task (e.g., by thinking how learning course content could be useful in one's career). However, more theoretical, empirical, and intervention research is needed to investigate strategies that can help students to increase the value they place on their coursework and generate a continued interest in different content areas, particularly in the areas of math and science.

The purpose of this study, on the basis of an integration and organization of disparate research conducted by educational and social psychologists that is relevant to the self-regulation of students' value perceptions, was to explore the effect of an exploratory value-reappraisal intervention on motivational variables and achievement in a college statistics course.

A GENERAL FRAMEWORK FOR VALUE REAPPRAISAL

Rooted in information processing theory, models of persuasion (e.g., Chaiken, 1987; Petty & Cacioppo, 1986) and conceptual change (e.g., Dole & Sinatra, 1998) share a basic framework that is useful for understanding the modification of students' value perceptions about academic tasks and courses. This framework suggests that the processing or elaboration of a message increases the potential for attitude, or conceptual, change (Murphy, 2001; Murphy, Holleran, Long, & Zeruth, 2005; Woods & Murphy, 2001). Processing a message favorably increases the potential for attitude change in the direction advocated in the message; processing a message unfavorably increases the potential for attitude change in the opposite direction from what was advocated in the message (Bohner & Schwarz, 2001; Greenwald, 1968; Pettty, Ostrom, & Brock, 1981). The effect of a persuasive message on a students' attitude is, therefore, believed to be mediated by the students' cognitive responses to the message. This indicates that presenting students with messages about why a task may be valuable and then guiding them in processing these messages favorably could help them to positively reappraise the value of the task. However, very few studies have been conducted on strategies to help guide students in processing persuasive messages. Research on persuasion and conceptual change has primarily focused on the persuasive aspects of the message (e.g., credibility of the author, strength of arguments, ease of understanding text, balanced arguments, emotion provoking, interesting text) and personal characteristics of the participants (e.g., preexisting beliefs and values, level of prior knowledge about the message topic, and motivation to process the message) and how these variables interact to predict students' cognitive responses to a message and hence their change in attitudes or beliefs (Bohner & Schwarz, 2001; Murphy, 2001).

Persuasion and conceptual change researchers also acknowledge that there are two routes that students can use to process a message (Woods & Murphy, 2001). The central route refers to "... effortful scrutiny of message arguments and other relevant information" (Bohner & Schwarz, 2001, p. 419) and involves linking "... any incoming arguments to issue-relevant information previously encoded within a recipients' memory" (Woods & Murphy, 2001, p. 644). Conversely, the peripheral route refers to less effortful and more superficial processing of a message, such as by using heuristic rules (e.g., "experts make valid arguments," "longer arguments are more persuasive than shorter arguments") to decide on the persuasiveness of a message (Bohner & Schwarz, 2001; Wood & Murphy, 2001). Whereas the peripheral route has been found to promote temporary attitude change, the central route has been associated with lasting attitude change (Stiff, 1994).

The extent to which students elaborate on a message through the central route has been found to depend on their motivation and ability to process the message (Petty & Cacioppo, 1986). Low levels of student motivation and ability to process a message can thus pose a problem when researchers and/or educators wish for students to actively process messages. One possible solution to this problem is for students to complete activities that guide them in actively processing the messages. However, there is a lack of research focused on interventions that both present students with messages and guide them in using strategies to explore issues related to those messages.

Persuasive Messages

Providing students with messages about the different reasons that an academic task might be valuable has been suggested as one approach that could help students to positively reappraise the value of a task (Brophy, 1999; Hofer, 2002). For example, Dholakia and Bagozzi (2003) found that students had stronger commitments and were more likely to access extra not-for-credit reading assignments when they received a message about the importance of the reading compared with those students who received no such message. Similarly, providing a rationale when assigning a task has been found to lead to relatively higher motivation and performance in work/occupational settings (Latham, Erez, & Locke, 1988). However, what content should the message convey to students to convince them that an academic task is important? Current conceptualizations of task value put forth by Eccles and Wigfield (see Eccles et al., 1983; Eccles & Wigfield, 2002) postulated that students might value a task for different reasons, and this framework could be used to help explain to students the potential value of a task. For example, students may value a task because it is generally important to them and in line with their self-concept (attainment value), useful for achieving their future goals (utility value), or enjoyable in and of itself (intrinsic value; Eccles, 2005; Eccles et al., 1983; Wigfield & Eccles, 1992, 2000). In addition, the cost of task engagement (e.g., time, effort, negative emotions) is another type of value perception that could be addressed (Eccles et al., 1983). Although providing students with messages about why a task may be important could be instrumental in helping students positively reappraise the value of a task, reappraising a task's value may also involve the active use of strategies, and interventions could guide students in using such strategies.

Value-Reappraisal Strategies

Wolters (1998) found that students reported using strategies to enhance their valuation for academic tasks in order to increase their motivation, especially in situations in which they initially appraised the material as irrelevant. Students reported strategies such as trying to make the task personally relevant, finding ways that the task could be useful in future situations, and trying to make the task more enjoyable. Helping students actively brainstorm different reasons and generate rationales for course engagement might help students to modify their course-related value perceptions and continued interest in a subject area.

Using imagination and mental simulation (Markus & Nurius, 1986; Pham & Taylor, 1999; Singer, 1975) to explore the value of learning (e.g., imagining experiencing positive incentives associated with task success) might also be an important strategy involved in generating value perceptions. Singer showed that most humans daydream and use imaginative processes to elaborate thoughts and ideas and that these processes are instrumental in linking cognition, emotion, and motivation. Furthermore, Markus and Nurius suggested that imaginative processes are involved in the elaboration of future possible selves, which are schemata that serve to motivate people toward the futures that they envision for themselves.

In addition, contrasting future benefits of learning with costs of task engagement (Oettingen, Pak, & Schnetter, 2001) has been found to help students increase their commitments to learning course material. Oettingen et al. conducted a series of studies across various domains (e.g., academic, interpersonal) and found that contrasting future benefits with realistic costs of a task resulted in higher task commitment and performance compared with when they were asked to imagine only future benefits or only realistic costs. On the basis of disparate theory and research, value-reappraisal strategies might include brainstorming, generating rationales, imagining, and contrasting pros and cons about the importance of academic tasks, courses, and subject areas. Such strategies could potentially be used by students to self-regulate their value perceptions.

METHOD

Overview of the Study

The major purpose of this study was to design a value-reappraisal intervention and investigate its effects on self-report measures of task value (perceived value of course tasks), endogenous instrumentality (perceived usefulness of developing knowledge and skills related to a course for the attainment of future goals), and self-efficacy (confidence in one's capabilities to succeed at the work in a course); a choice-behavior measure of interest in statistics (whether students accessed extra not-for-credit Web sites related to statistics); and postintervention exam performance.

The VR intervention was designed to help students positively reappraise the value they placed on developing statistical knowledge and skills. Students were presented with messages about the importance of becoming an intelligent consumer of statistics in everyday life (attainment value), academic and professional uses of statistics (utility value), and the intrinsic enjoyment of learning statistics (intrinsic value). Students were also guided in actively processing the content of these messages through the central route by brainstorming, generating rationales, imagining, and contrasting pros and cons related to the importance of learning statistics. A no-treatment control condition (C) was also included and students were randomly assigned to either VR or C.

Since VR was focused on increasing students' value perceptions, it was hypothesized that students in the VR group would evidence stronger gains on measures of task value and endogenous instrumentality over time (pretest, immediate posttest, 2-week delayed posttest) compared to students in the control group. Furthermore, it was hypothesized that the VR group would be more likely to access extra not-for-credit statistics websites (the choice-behavior measure of interest) than the control group. Because VR was focused on modifying students' value perceptions, not their expectation beliefs; and, because research on expectancy-value theory has suggested that value perceptions are stronger predictors of continued interest and expectation beliefs are stronger predictors of achievement (Meece et al., 1990; Wigfield & Eccles, 1992, 2000), it was questionable whether VR would affect students' ratings of self-efficacy and their postintervention exam performance. Therefore, we made no specific hypotheses about these two outcome variables.

The domain of statistics was chosen for these studies because students often express negative attitudes and beliefs toward statistics (Fullerton & Umphrey, 2001; Gal & Ginsburg, 1994; Gal, Ginsburgh, & Schau, 1997; Garfield, Hogg, Schau, & Whittinghill, 2002; Mills, 2004), and given the common usage of statistics in the media and across various occupations, there might be valid reasons for students to increase the value they place on learning statistics. In addition, the introductory statistics course in which this research was conducted included a research participation requirement. This made it convenient to recruit participants and conduct experimental intervention research.

Participants

A total of 82 college students from an introduction to statistics course offered through the educational psychology department of a large public university in the South Central United States were recruited through the department's human subject pool. Students received research participation credit for completing this study. Students were sampled from four sections of the course over two consecutive semesters: Fall Section 1 ($n = 21$) and Section 2 ($n = 19$); Spring Section 3 ($n = 23$) and Section 4 ($n = 19$). There were two instructors: Instructor A taught Sections 1 and 3, and Instructor B taught Sections 2 and 4. There were 68 women and 14 men, which is representative of those who enroll in introductory statistics courses through this department but not of the university at large, which enrolls 51% female students. The ethnic composition of the sample was as follows: African American ($n = 2$), Asian ($n = 16$), Caucasian ($n = 49$), Hispanic ($n = 12$) and 3 did not specify an ethnicity. Students tended to be in upper division: first year students ($n = 1$), sophomores ($n = 15$), juniors ($n = 33$), seniors ($n = 27$), and graduate students ($n = 6$). Students were enrolled in various colleges and programs across campus and intended to seek degrees in the following areas: advertising ($n = 9$), anthropology ($n = 1$), applied learning and development ($n = 1$), athletic training ($n = 1$), biology ($n = 2$), chemistry ($n = 1$), communication sciences and disorders ($n = 8$), communications ($n = 1$), educational psychology ($n = 1$), exercise physiology ($n = 2$), human development and family sciences ($n = 14$), human ecology ($n = 1$), kinesiology ($n = 7$), music ($n = 2$), nursing ($n = 16$), nutrition ($n = 6$), pharmacy ($n = 2$), physical therapy ($n = 2$), public relations ($n = 1$), textiles and apparel ($n = 3$), and urban studies ($n = 1$). Furthermore, most students had already declared a major ($n = 78$). For many students, completing the introductory statistics course fulfilled a degree requirement even though taking this particular course may not have been required. The average age was 21.43 years ($SD = 3.21$).

Design

Potentially confounding variables were partially controlled for within the experimental design by using stratified random assignment. Students were stratified on instructor, gender, and year in school and then randomly assigned to one of two groups: VR group ($n = 41$) or the control group ($n = 41$). The repeated measures design used in this study included a pretest (immediately before the intervention), an immediate posttest (immediately after the intervention), and a 2-week delayed posttest.

Procedures

Table 1 provides an overview of the study procedures. Students in this study came to two sessions. Session 1 (approximately 100 min) was held in a computer lab with enough computers for 20 people. Sessions were held on weekdays, typically between 5:00 p.m. to 7:30 p.m., for approximately 3 weeks. On average, 10 students came to each session. Students were greeted and asked to sit at one of the computer stations. After signing the consent form, students completed the pretest measures (task value, endogenous instrumentality, and self-efficacy). Then,

TABLE 1
Overview of Study Procedures

Stage of Project	*Timing*	*Activity*
Preintervention Course Exam	Approximately 3 weeks into the semester	• Students took preintervention course exam
Session 1	Approximately 6 weeks into the semester	• Students took pretest measures • Students completed intervention/control condition • Students took immediate posttest measures
Session 2	Approximately 8 weeks into the semester	• Students took 2-week delayed posttest measures • Students took demographic survey
Choice-Behavior Measure	Approximately 10 weeks into the semester	• Statistics websites were posted for students to access
Postintervention Course Exam	Approximately 12 weeks into the semester	• Students took postintervention course exam

students were told how to sign on to the computers and download the relevant intervention (randomly assigned). The researcher was available to students to help with logistical questions. After the students completed the intervention, they took the immediate posttest measures (same as the pretest measures), signed up for Session 2, and left.

Session 2 (approximately 30 min) took place approximately 2 weeks after the students' first session in a classroom large enough to seat 50 people. On average, 20 students came to any one session (held weekdays at 4:00 p.m. or 5:00 p.m.). Students completed the 2-week delayed posttest measures (same as the pretest measures), and completed the demographic survey. Last, students were thanked and debriefed via e-mail once the study was completed. Students completed the pretest, immediate posttest, 2-week delayed posttest, and demographic measures by reading the items in a questionnaire booklet and bubbling in their responses on a Scantron sheet. The intervention and control conditions were delivered in the form of Microsoft Word 2000 files, and students typed their responses to the activities directly into these files.

Dependent Variables

Self-report measures of task value, endogenous instrumentality, and self-efficacy were administered at all three time points. All self-report measures used a 7-point Likert-type scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*), and referenced students' statistics course.

Task value. We used the Task Value Scale from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991) to measure task value generally (overall importance a student places on course-related tasks). The Task Value Scale has two items for attainment (e.g., "It is important for me to learn the course material in this course"), utility (e.g., "I think I will be able to use what I learn in this course in other courses"), and intrinsic value (e.g., "I am very interested in the content area of this course") resulting in a total of six items. The items are averaged together to compute an overall task value score. This scale has been used in numerous studies and strong reliability evidence has been established ($\alpha = .9$; Duncan & McKeachie, 2005). We included this measure because it has been successfully used as a general measure of task value with college populations.

Endogenous instrumentality. We used three items to measure endogenous instrumentality (the perceived usefulness of developing knowledge and skills related to a task for the attainment of future goals; e.g., "What I learn in this course will be useful for my future occupation"). Items were taken from an unpublished revision of Husman, Derryberry, Crowson, and Lomax's (2004) four-item measure of endogenous instrumentality (J. Husman, personal communication, July 17, 2005). Endogenous instrumentality differs from task value because the Task Value Scale is a general measure that includes items related to attainment, utility, and intrinsic value. At a conceptual level, endogenous instrumentality is similar to utility value; however, one difference is that endogenous instrumentality is specifically focused on the utility of learning course material, as opposed to, for example, the usefulness of passing a class. Another difference is that each item from the endogenous instrumentality scale makes an explicit reference to the future, whereas, the items from the Task Value Scale do not reference the future explicitly. We included endogenous instrumentality as an outcome in this study because a major focus of the VR intervention was to help students discover the relevance of developing knowledge and skills in statistics. Empirical evidence suggested that the original 4-item measure of endogenous instrumentality had good reliability ($\alpha = .86$; Husman et al.). In addition, on the basis of results from structural equation modeling, Husman et al. found that their endogenous instrumentality measure, the MSLQ Task Value Scale (two of the six items were removed because of poor reliability), and the MSLQ measure of intrinsic motivation, were measuring unique constructs. Also, endogenous instrumentality and task value were found to be positively related, but the relation reported was fairly weak.

Self-efficacy. The Perceived Academic Competence Scale was developed by Kaplan and Midgley (1997) by selecting seven items from the Academic Self-Beliefs Scale of Midgley, Maehr, and Urdan's (1993) Patterns of Adaptive Learning Survey. This scale was used to measure self-efficacy for completing course-related tasks (e.g., "I can do almost all the work in this course if I don't give up"). Items loaded as expected in a factor analysis that also included learning and performance goal orientation items and allowed factors to correlate (Kaplan & Midgley). In addition, good reliability data ($\alpha = .83$ to .85) were reported (Kaplan & Midgley). For the purposes of the present study, the items were adapted to refer to students' statistics course instead of English or math classes.

Preintervention exam performance. We used the first course exam, which was given approximately 3 weeks before the administration of the intervention, as a baseline measure of students' course achievement and treated it as a covariate in analyses examining intervention effects on postintervention exam performance. Because instructors did not use the same exam, we standardized the preintervention exam scores within each section by dividing the standardized residual by an estimate of its standard deviation, which yielded a mean of 0 and a standard deviation of 1 for each section. Instructor A's exam covered the following topics: introduction to statistics, frequency distributions, central tendency, variability, z

scores, and probability. Instructor B's exam covered the same topics as Instructor A's exam but also covered introduction to hypothesis testing and introduction to the *t* statistics.

Postintervention exam performance. The third course exam, which was given approximately 1 month after the administration of the intervention, was used as a dependent variable. We also standardized postintervention exam scores using the same procedures as described in the previous paragraph. Instructor A's exam covered the following topics: related samples *t* test, independent samples *t* test, correlation, simple linear regression, and chi-square test of association. Instructor B's exam covered the same topics as did Instructor A's exam, with one exception: Instructor B's exam covered statistical techniques for ordinal data, whereas Instructor A's exam covered *t* tests.

Choice-behavior measure of interest in statistics. Approximately 3 weeks after the intervention, two Web sites (one that was related to statistics concepts and procedures and the other that was related to how statistics is used in different careers) were posted on the course Web site. Then, an e-mail was sent out to students by their instructor with the following message:

> Hi, Class,
> A graduate student of mine found two really good Internet sites related to statistics. One site has definitions and explanations for statistical terminology and the other has information about why statistics is important and how people use statistics in various occupations. If you have some free time, please check them out. They are interesting.

Students could then go to the course Web site and access either or both of the statistics Web sites that were posted. Accessing the Web sites was not a requirement, and students could not earn points by accessing them. When an assignment is not required and points cannot be earned, accessing it could potentially be used as an indicator of interest in that subject area. A feature on the course Web site was enabled that tracked which students clicked on the statistics Web sites. Unfortunately, the statistical tracking mechanism was not available for us to use during the fall semester, so this measure was only included during the spring semester of the study ($n = 42$). A dichotomous variable indicating whether students accessed the Web site was of interest, as opposed to the frequency of times a student accessed the Web site. This was because once a student accessed one of the statistics Web sites, he or she could then save that Web site to his or her own computer and access it later, barring our statistical tracking mechanism from tracking that student's access to that Web site.

Description of the Value-Reappraisal Intervention and Control Conditions

We administered the experimental conditions using computers in a campus computer lab. The materials were in the form of Microsoft Word 2000 files downloaded from a designated Web site. For each condition, students read a series of reading passages and completed associated activities. Students typed their responses to the activities directly into the file. The number of passages, activities, and approximate time it took to complete each condition are as follows: control (four passages, four activities, 75 min) and value reappraisal (six passages, eight activities, 75 min).

Value-Reappraisal Intervention (VR). VR was designed to help students reappraise their values related to their introductory statistics course. Students were presented with messages and strategies to explore the value of learning statistics. Particular emphasis was given to helping students consider the importance of developing statistical knowledge and skills.

Passage 1 (639 words) explained what attitudes are and why it is important for students to construct a positive attitude toward their coursework. Activity 1 asked students to describe one positive and one negative attitude students generally might have toward college courses.

Passage 2 (453 words) explained that one possible route to developing a more positive attitude toward a course is to understand why learning the content and mastering the skills related to that course may be personally important. Activity 2 asked students to create a list of knowledge and skills that could be developed from learning the content presented in their statistics course. In addition, students were asked to first create a list of incentives for developing that knowledge and skill; and second, to generate mental simulations of them realizing these incentives in the future. We used Oettingen et al.'s (2001, p. 740) instructions for generating mental simulations.

Passage 3 (482 words) discussed how developing statistical knowledge and skill could help students become more intelligent consumers of statistical information. Activity 3 asked students to describe past and future situations in which they used or would use statistically based information. They were also asked to generate a rationale for why learning the material in their statistics course could help them become more intelligent consumers of statistical information.

Passage 4 (70 words) briefly discussed how developing statistical knowledge and skills could help students become better prepared for future courses. Activity 4 asked students to brainstorm a list of upcoming courses in which having statistical knowledge and skills might be useful and to generate a rational for why learning the material in their statistics course could help them in a future course.

Passage 5 (136 words) briefly discussed how developing statistical knowledge and skills could be instrumental in becoming better prepared in a future career and provided examples of how statistics are used in various careers. In Activity 5, students were asked to create a list of potential careers for them and then to chose one and describe the ways in which they saw statistical knowledge and skills being used in that career. They were also asked to generate a rationale for why learning statistics could help prepare them for that career.

Passage 6 (244 words) briefly discussed how statistics could be challenging, interesting, and enjoyable. It also discussed how negative thoughts related to learning statistics can make it less enjoyable. Activity 6 asked students to identify two negative thoughts that they had related to their introductory statistics course and to replace each thought with a positive thought. We adapted this particular activity from Weinstein, Woodruff, and Awalt's (2002) "Becoming a Strategic Learner: Attitude Module."

The last part of VR was designed to help students examine the costs and benefits related to learning statistics. This part did not have any reading passages, only activities. Activity 7 asked students to generate an argument supporting why statistics was important for them and an argument supporting why statistics was not important for them. Then, students were asked to choose which argument was truer for them. Activity 8 asked students to contrast positive incentives for learning statistics with obstacles standing in their way. This activity was taken from Oettingen et al. (2001) and adapted to focus on students' statistics course.

Control condition. Students read four passages on multicultural education: Passage 1 (2,192 words), Passage 2 (1,116 words), Passage 3 (2,155 words), and Passage 4 (1,043 words). Multicultural education was chosen as the topic of the control condition because learning about it was not expected to affect the variables of interest but could potentially be beneficial to students in other ways. After students read each passage, we asked them (a) to explain what they liked most about the reading and why; (b) what they liked least about the reading and why; and (c) to summarize some of the main points from the reading.

RESULTS

Reliability analyses of the pretest self-report measures yielded strong Cronbach's alpha coefficients: task value (.90), endogenous instrumentality (.88), and self-efficacy (.90). Pearson product-moment correlation coefficients suggested that the three self-report measures were intercorrelated. Self-efficacy was positively correlated with task value ($r = .38$, $p < .01$) and endogenous instrumentality ($r = .26$, $p < .05$), and task value was positively correlated with endogenous instrumentality ($r = .75$, $p < .01$). The high correlation between task value and endogenous instrumentality raised concerns about the redundancy of conducting analyses on

TABLE 2
Descriptive Statistics for Self-Report Measures by Intervention Group

	Pretest		*Immediate Posttest*		*2-Week Delayed Posttest*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
Task Value						
Control	3.81	1.33	3.60	1.33	3.66	1.32
Value Reappraisal	3.51	1.39	4.26	1.37	4.00	1.35
Endogenous Instrumentality						
Control	3.85	1.69	3.91	1.65	3.93	1.65
Value Reappraisal	3.71	1.67	5.02	1.44	4.52	1.55
Self-efficacy						
Control	5.15	1.32	5.18	1.29	5.03	1.36
Value Reappraisal	5.22	1.13	5.36	1.03	5.19	1.01

Note. Control ($n = 41$) and VR ($n = 41$). A 7-point scale was used for each self-report measure.

both variables. However, because task value and endogenous instrumentality were found to be both empirically unique and theoretically distinct in previous work with much larger sample sizes, and because researchers whose work pertains to task value and endogenous instrumentality might prefer to see the results presented separately for each measure, both measures were retained and analyzed separately.

Table 2 presents the pretest, immediate posttest, and 2-week delayed posttest means and standard deviations for the Control and VR groups on all self-report measures. To check whether group differences existed at pretest, we conducted 2 (VR: present or absent) × 2 (instructor: A or B) × 2 (semester: fall or spring) analyses of variance (ANOVAs) for task value, endogenous instrumentality, and self-efficacy. No statistically significant intervention group, instructor, or semester main effects or interactions were detected on any of the pretest self-report variables. There were too few men in this study to examine the effect of gender in any of the analyses. In addition, the number of graduate students in this study was too small to examine differences with undergraduates. Because students' gender and year in school could potentially affect results, we used stratified random assignment to control for these variables.

A major purpose for this study was to examine the effect of VR on self-report measures of task value, endogenous instrumentality, and self-efficacy over time. Even though students were randomly assigned to either the Control or VR group within each section, it was possible that the VR intervention could have differentially affected students' ratings on the self-report measures on the basis of which instructor they had or which semester they were enrolled in the course. To investigate this, we ran a 2 (VR − present or absent) × 2 (instructor: A or B) × 2 (semester: fall or spring) × 3 (time: pretest, immediate posttest, 2-week delayed posttest) repeated measures ANOVA for each self-report variable. We conducted a power analysis using G*Power 3.0.10, and it suggested that there was sufficient power (.95) to detect between-within interaction effects with a modest effect size ($\eta_p^2 = .03$), given the following inputs: $\alpha = .05$; $N = 82$; groups = 8; repeated measures = 3; correlation among repeated measures = .75; and nonsphericity correction $\varepsilon = .94$. No main effects or interactions involving instructor or semester were detected nor where there any effect sizes larger than $\eta_p^2 = .03$, so we dropped these two variables in further analyses to increase power.

We analyzed the data subsequently reported for measures of task value, endogenous instrumentality, and self-efficacy using 2 (VR − present or absent) × 3 (time: pretest, immediate posttest, 2-week delayed posttest) repeated measures ANOVAs. We used F tests using the Greenhouse-Geisser degrees of freedom adjustment for violations of the sphericity assumption (no violations of sphericity were observed, but this test was used because it is more conservative) to test the significance of the main and interaction effects of VR and time. In addition, we used Bonferroni adjustments for post hoc pairwise comparisons to control for increases in Type I error as a result of multiple comparisons.

Task Value

Repeated measures ANOVA results for task value showed a strong VR × Time interaction, $F(1.98, 158.48) = 16.99$, $p < .01$, $\eta_p^2 = .18$ (see Figure 1). Post hoc

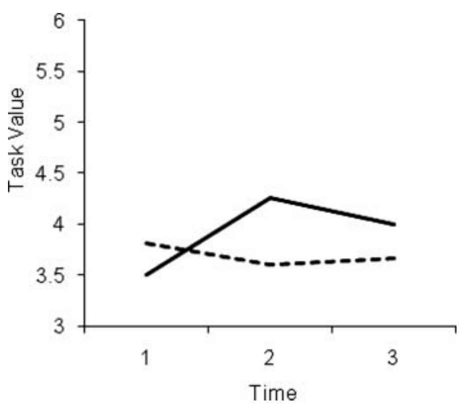

FIGURE 1 A statistically significant value-reappraisal x time interaction effect on task value is shown. Change over time is not statistically significant for the control group. The VR group increased significantly from Time 1 to 2 and Time 1 to 3, but change from Time 2 to 3 was not statistically significant. Time 1 = pretest. Time 2 = immediate posttest. Time 3 = two-week delayed posttest. Straight Line = VR group, Dotted Line = control group. Control ($n = 41$) and VR ($n = 41$).

tests using Bonferroni adjustments suggested that the control group did not make statistically significant gains or losses on task value over time. Conversely, the VR group made gains on task value from pretest to immediate posttest (difference in $M = 0.74$, $SE = 0.12$, CI = .44 to 1.04, $p < .01$, $d = .54$). These intervention effects were not found to attenuate significantly from immediate posttest to 2-week delayed posttest. Also, at the 2-week delayed posttest, students in the VR group still showed statistically significant gains on task value compared with their scores at pretest (difference in $M = 0.49$, $SE = 0.12$, CI = .20 to .78, $p < .01$, $d = .36$).

Endogenous Instrumentality

A similar pattern of results emerged for endogenous instrumentality as it did for task value. A strong VR was detected Time interaction $\times$, $F(1.98, 158.52) = 16.36$, $p < .01$, $\eta_p{}^2 = .17$ (see Figure 2). Post hoc tests using Bonferroni adjustments suggested that the control group did not make gains or losses on endogenous instrumentality over time. However, the value-reappraisal group made statistically significant gains on endogenous instrumentality from pretest to immediate posttest (difference in $M = 1.32$, $SE = 0.15$, CI = .94 to 1.70, $p < .01$, $d = .84$). These intervention effects were found to partially attenuate from immediate posttest to 2-week delayed posttest (difference in $M = –0.50$, $SE = 0.15$, CI = –.87 to –.14,

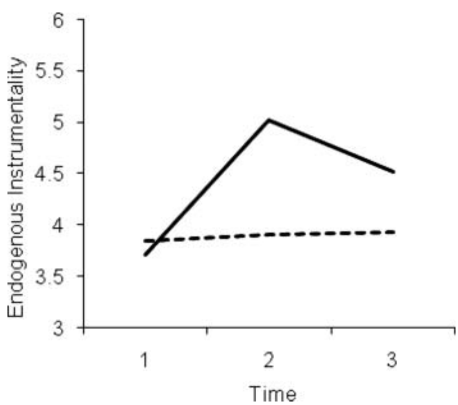

FIGURE 2 A statistically significant value-reappraisal x time interaction effect on endogenous instrumentality is shown. Change over time is not statistically significant for the control group. The VR group increased significantly from Time 1 to 2 and Time 1 to 3, and decreased significantly from Time 2 to 3. Time 1 = pretest. Time 2 = immediate posttest. Time 3 = two-week delayed posttest. Straight Line = VR group, Dotted Line = control group. Control ($n = 41$) and VR ($n = 41$).

$p < .01$, $d = -.33$). Despite this attenuation, the VR group made statistically significant gains on endogenous instrumentality from pretest to 2-week delayed posttest (difference in $M = 0.81$, $SE = 0.16$, CI = .42 to 1.21, $p < .01$, $d = .50$).

Self-Efficacy

Repeated measures ANOVA results revealed no statistically significant intervention effects on self-efficacy.

Choice-Behavioral Measure of Continued Interest

Whether or not students accessed two statistics Web sites that were posted on their course's Web site was tracked and used as a choice-behavior measure of interest in statistics. This measure was only administered to students in the Spring Semester and was thus limited to a total of 40 students (21 in the control group and 19 in the VR group). The data showed that all students who accessed one Web site also accessed the other website. Therefore, only one dichotomous outcome variable indicating whether or not students accessed both statistics Web sites was used. Of the 40 students, seven accessed both statistics Web sites that were posted (1 was in the control group and 6 were in the VR group; see Table 3). We used logistic regression to investigate intervention effects on this measure. First, we entered main and interactive effects of intervention group and instructor as predictors of choice behaviors. Because instructor and the interaction of instructor and intervention group were not statistically significant, they were removed from the model. The final model included intervention group as a predictor variable of the choice-behavior measure of interest in statistics, $\chi^2(1, N = 40) = 5.36$, $p < .05$, and explained approximately 13% of the variation in students' choice behaviors. As expected, a statistically significant VR main effect was detected ($\underline{B} = 2.22$, $\underline{SE} = 1.14$, p < .05, Odds Ratio = 9.23) (see Figure 1). This suggested

TABLE 3
Choice-BehaviorMeasure of Interest in Statistics by Group

	Accessed Websites		*Did Not Access Websites*	
	n	%	n	%
Control	1	4.8	20	95.2
Value Reappraisal	6	31.6	13	68.4

Note. Data on students' choice-behaviors were collected approximately 4 weeks after the administration of the VR intervention and control condition.

TABLE 4
Postintervention Standardized Exam Scores by Intervention Group and Instructor

	Instructor A			*Instructor B*		
	N	*Mean**	*SE*	*N*	*Mean**	*SE*
Control	22	.16	.2	19	$-.31_a$	.21
Value Reappraisal	22	$-.22$	.2	19	$.32_a$	.21

Note. Means sharing the same subscript are significantly different at $p < .05$.
*Means were adjusted for standardized pre-intervention exam scores.

that, on average, students in the VR group were 9.23 times more likely to access the statistics Web sites compared with students in the control group.

Postintervention Exam Performance

Another major purpose for this study was to investigate the effects of the VR intervention on students' postintervention exam performance. Furthermore, the possibility that the VR intervention differentially affected students' exam performance on the basis of which instructor they had or which semester they enrolled in the course needed to be examined. First, to check whether group differences existed on students' preintervention standardized exam scores, we conducted a 2 (VR − present or absent) × 2 (instructor: A or B) × 2 (semester: fall or spring) ANOVA. We detected no statistically significant group, instructor, or semester main effects or interactions on preintervention exam performance. Next, we analyzed students' postintervention standardized exam scores using a 2 (VR − present or absent) × 2 (instructor: A or B) × 2 (semester: fall or spring) analysis of covariance (ANCOVA), controlling for preintervention standardized exam scores. ANCOVA results suggested a statistically significant VR × Instructor interaction effect, $F(1, 73) = 5.93$, $p < .05$, $\eta_p^2 = .08$. Table 4 presents the adjusted means and standard errors for standardized postintervention exam scores by intervention group and instructor. For Instructor A's students, there was not a statistically significant effect of the VR intervention. However, for Instructor B's students, the VR group had significantly higher standardized postintervention exam scores compared with those of students in the control group (adjusted difference in $M = 0.62$, $SE = 0.30$, CI = .02 to 1.23, $p < .05$).

DISCUSSION

The hypotheses for task value and endogenous instrumentality were supported by the data. The VR group was found to make statistically significant gains on both task value and endogenous instrumentality from pretest to immediate posttest and from pretest to 2-week delayed posttest. The control group, on the other hand, remained stable on these measures over time. Furthermore, measures of effect size suggested that the gains observed for the VR group were substantial, particularly on endogenous instrumentality. These findings suggest that the VR intervention was effective at helping students to place greater importance on the tasks in their statistics course and to increase how useful they think developing statistical knowledge and skills is for the attainment of their future goals.

The hypothesis for the choice-behavior measure of interest in statistics was also supported by the data. Results showed that students in the VR group were significantly more likely to access the statistics Web sites than were the students in the control group; despite that, overall, a small number of students accessed the Web sites. These findings imply that the VR Intervention may have helped some students generate an interest in learning about statistics, particularly because accessing the statistics Web sites was not a course requirement. Furthermore, these results show that the VR intervention was powerful enough to influence students' choices 4 weeks after receiving the intervention.

These findings add causal support to theory and research suggesting that value perceptions and choice behaviors can be modified through self-regulation interventions (Pintrich, 2000, 2004; Wolters, 1998, 2003). These results are promising because they suggest that students' preexisting value perceptions about learning statistics can be improved by presenting them with messages and guiding them in using self-regulatory strategies to explore the value of learning statistics.

Previous theory and research has suggested that providing students with purposes and reasons for engaging in academic tasks can help them to place more value on those tasks (Brophy, 1999; Hofer, 2002; Latham et al., 1988). Eccles et al. (1983) outlined four components of the value construct (attainment, utility, intrinsic, and cost), and this framework was used to help structure the arguments presented in the VR intervention. Using Eccles et al. framework may have contributed to the success of the intervention and could be important to consider when crafting an argument about the importance of academic tasks.

This study also helps to provide support for theory and research that has suggested that students can actively use strategies to increase the value they place on academic tasks (Pintrich, 2000, 2004; Wolters, 1998, 2003). Wolters's (1998) work in this area showed that students report using strategies to increase the value they place on their academic tasks. The current study adds to this line of research by showing that an intervention focused on guiding students in using value-reappraisal strategies (brainstorming, generating rationales, imagining, and contrasting pros and cons) can lead to increases in students' value-perceptions and influence students' choice behaviors. Accordingly, using value-reappraisal strategies may be important for self-regulating one's motivation.

Models of persuasion and conceptual change have tended to focus on the persuasive aspects of messages and personal characteristics of the participants (Bohner & Schwarz, 2001; Murphy, 2001) but have given relatively little attention to strategies that could be used to guide participants in actively processing messages through the central route. This study was unique because students were both presented with persuasive messages and guided in using value-reappraisal strategies to actively process those messages. Even though we did not examine the unique effect of value-reappraisal strategies on the study outcome variables, researchers interested in modifying attitudes may want to consider using value-reappraisal strategies to facilitate central-route processing of messages.

Although the VR intervention was successful at influencing students' value perceptions and choice behaviors, we did not find it to affect students' self-efficacy beliefs for successfully completing course tasks. This finding provides interesting data related to a causal relation between expectancies and values by suggesting that increasing value perceptions might not lead to short-term increases in self-efficacy. Bandura's (1997) theory and research suggested that self-efficacy beliefs are directly influenced by students' past successes and failures, vicarious experiences, verbal persuasion, and physiological arousal. If increasing students' value perceptions could lead students to have a greater number of successes in the course, then changes in self-efficacy beliefs could potentially be observed sometime after those successes were made. However, in this study, we measured students' self-efficacy beliefs only up to 2 weeks after students completed the VR intervention.

An effect of the VR intervention on students' exam performance was only observed for students who had Instructor B. For students who had Instructor A, the difference between the VR group and control group was not statistically significant. It is difficult to pinpoint why this effect was only observed for Instructor B. Although the exams had different items, the topics covered on each exam were similar for each instructor, and all students took the exam approximately 1 month after the intervention. This finding suggests that the VR intervention has the potential to positively affect students' learning and achievement in a course but that the benefit of the intervention might depend on and interact with other instructor and course factors. For instance, intervention effects on exam performance may be more pronounced in academic contexts in which there is little support offered to help prepare students for exams (e.g., review sessions, exam objectives, study tips). Also, students whose instructors effectively motivate them may benefit less from a motivational intervention.

Limitations

One limitation of this study was that students were nested within four sections of the course. Although stratified random assignment to interventions within each section allowed for meaningful comparisons between intervention groups, a study with a more sufficient number of sections (at least 10) would allow for between class variance to be modeled hierarchically with participants at a lower level. Future studies could measure characteristics of the instructor and the course and examine them in interaction with the VR intervention. Another limitation of this study was that the sample was primarily women. It is, therefore, questionable whether these findings would generalize to male participants. Research on gender differences in math and science typically suggest that women have lower confidence and less interest in those subjects compared with men (see Wigfield & Eccles, 2002). Women may, therefore, be more likely to benefit from an intervention focused on increasing their value perceptions compared with men.

Future Research

While VR had positive impacts on students' values and choice behaviors, it is unclear what specific mechanisms within the intervention contributed to student gains. Students were asked to use a variety of value-reappraisal strategies (e.g., brainstorming attainment, utility, and intrinsic reasons for learning course content, generating rationales, imagining experiencing benefits resulting from learning course content, and contrasting benefits with costs of task engagement) and these strategies could have differentially affected students' values. A systematic investigation into the effects of different value-reappraisal strategies on students' values, choice behaviors, motivation, and achievement is an important area for future work. Furthermore, the messages students received about the reasons learning statistics might be important for them could have contributed to changes in students' values. The main and interactive effects of persuasive messages and value reappraisal strategies also need to be examined in future studies. In addition, it is important that future research examine the VR intervention over longer periods of time (e.g., months and years) and on other outcome measures (e.g., students' intentions to continue learning statistics and students' course enrollment decisions). It is also important to investigate whether students can be taught to successfully use value-reappraisal strategies on their own and without continual guidance from an intervention.

The high correlation between task value and endogenous instrumentality found in this study differed from previous research that found a fairly weak correlation between these measures (see Husman et al., 2004). However, the items used for each measure were not identical in both studies. In our research, we used a revised version of the endogenous instrumentality measure, and Husman et al. removed two items from the Task Value Scale because of poor reliability. More studies need to be conducted to further examine the uniqueness of these constructs. In future research on the VR intervention, we could try including either one general measure of task value or measuring specific components of the value construct.

Conclusion

Results from this study suggested that the VR intervention helped students to both increase the value they placed on learning statistics and develop a stronger understanding about how learning statistics could help them reach their future goals. The VR intervention was also found to positively affect students' choices to engage in learning activities related to statistics that were not required as part of the course. In addition, some tentative evidence was found that the VR intervention could increase students' performance on course exams but these benefits seemed to depend on unknown instructor and course factors which need to be further investigated in future research.

This research helps to address the growing economic and social needs to develop and test theory-based interventions aimed at increasing students' continued interest in math and science (National Science Foundation, 2006; U.S. Department of Education, 2006). The VR intervention could potentially be used in introductory statistics courses to help students increase the value they place on learning statistics. Because many undergraduate programs within the United States require successful completion of an introductory statistics course for graduation or entry into an upper division major, and because the number of students taking introductory undergraduate statistics courses has been reported to be increasing (Loftsgaarden & Watkins, 1998), this intervention may be relevant to a great deal of students. The VR intervention could also serve as a model for instructing students about the importance of learning course material in other math and science courses.

Theoretically, this research is important because it helps to expand and integrate research on self-regulation and motivation by examining an approach to modifying students' value perceptions that involves both presenting them with persuasive messages and guiding them in using value-reappraisal strategies. The framework used in this study could help guide other researchers interested in investigating the effects of persuasive messages and value-reappraisal strategies on students' value perceptions, continued interest, self-efficacy, and achievement in math, science, and statistics courses.

AUTHOR NOTES

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