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The Benefits of Combining Value for the Self and Others in Utility-Value Interventions

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Utility-value (UV) interventions, in which students complete writing assignments about the personal usefulness of course material, show great promise for promoting interest and performance in introductory college science courses, as well as persistence in science, technology, engineering, and mathematics fields. As researchers move toward scaling up this intervention, it's important to understand which features are key to its effectiveness. For example, prior studies have used different types of UV assignments (i.e., self-focused essays and other-focused letters) and different assignment structures (i.e., over time, researchers provided a variety of tasks or choices between tasks), without comparing them. It is not known whether these assignment features are incidental details or key aspects of the intervention that impact its effectiveness. In the current study, we systematically compared different UV assignments, as well as ways of combining them, in a randomized controlled trial in an introductory college biology course ($N = 590$). Specifically, we compared different versions of the intervention in terms of their relative effectiveness for promoting course performance and the motivational mechanisms through which they operated. The intervention was most effective when students had opportunities to write about utility for both the self and others. Grades were higher in conditions in which students were either assigned a variety of self-focused and other-focused assignments or given the choice between the two. Among students with low performance expectations, grades were higher when students were assigned a specific combination: a self-focused assignment followed by other-focused assignments. Results suggest that different versions of the intervention may work through different mechanisms.

Educational Impact and Implications Statement

The current study is the first to systematically compare different versions of the UV intervention, in which students complete writing assignments describing how what they are learning is relevant and useful. Our results suggest that college science educators and intervention scientists can help students perform better in difficult introductory classes if they give students opportunities to write about utility for both themselves and close others over the course of the semester by giving students a variety of UV writing assignments or allowing them to choose between the different types.

Keywords: utility value, expectancy-value theory, interventions, interest

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It can be challenging for instructors to engage students who have a range of interest and motivation levels. Some students genuinely enjoy the content and are motivated to learn and do well. Other students may care less about the topic, find the course to be less engaging, or lack appreciation for the importance of the content, wondering, “Why do they make me take this class?” or “When will I ever use this information?” This lack of interest and motivation is associated with lower levels of learning and performance (Hidi & Harackiewicz, 2000). A key question for educators, then, is how to create a classroom environment and course activities that will keep students motivated, engaged, and performing up to their potential. Recent experimental research suggests that a utility-value (UV) intervention in which students write about how course material is relevant to their lives or the lives of close others can increase interest, performance, and persistence in a field, particularly for the students who are most likely to underperform (e.g., students with a history of poor performance; Harackiewicz & Priniski, 2018; Lazowski & Hulleman, 2016). In this study, we explore which types and combinations of UV writing assignments are most effective for promoting student motivation and performance.

Eccles’ expectancy-value model posits that achievement behaviors such as persistence and performance are influenced by (a) one’s expectations of success in a given task and (b) one’s subjective valuing of that task (Eccles et al., 1983; Wigfield & Eccles, 2000). Subjective task values have four major components: intrinsic value (inherent enjoyment of the task), UV (the usefulness of the task achieving for one’s goals), attainment value (the importance of the task for one’s sense of identity), and cost value (the limitations on time, energy, and effort created by engaging in the task). Educational researchers have zeroed in on UV as an ideal target for interventions to improve student motivation and achievement. Correlational studies have found that when students perceive UV in their courses, they work harder, develop more interest, and perform better (Brophy, 1999; Harackiewicz, Durik, Barron, Linnebrink-Garcia, & Tauer, 2008; Hulleman, Durik, Schweigert, & Harackiewicz, 2008; Wigfield, 1994). Similarly, laboratory studies testing value manipulations have found positive effects on interest, persistence, academic self-regulation, and effort (e.g., Canning & Harackiewicz, 2015; Durik, Schechter, Noh, Rozek, & Harackiewicz, 2015; Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Yeager et al., 2014).

Field Tests of Utility-Value Interventions

A growing body of evidence from field experiments suggests that UV interventions are effective in promoting academic performance and interest. Early tests of these interventions resulted in improved grades and interest among high school science students who had low expectations of success in their science course (Hulleman & Harackiewicz, 2009) and among college students with a history of poor performance in introductory psychology (Hulleman et al., 2010). More recent tests of UV interventions conducted in college biology and psychology courses have found positive effects on interest and perceived UV (Rosenzweig et al., 2018) and on performance, for all students on average (Canning et al., 2018; Harackiewicz, Canning, Tibbetts, Priniski, & Hyde, 2016; Hulleman, Kosovich, Barron, & Daniel, 2017), for students with a history of poor performance (Harackiewicz et al., 2016),

and specifically for men with a history of poor performance (Hulleman et al., 2017). UV interventions have even helped to close achievement gaps for underrepresented racial/ethnic minority students who were also first-generation college students (Harackiewicz et al., 2016). Finally, initial tests of UV intervention effects on students’ academic pursuits suggest that a UV intervention implemented in an introductory course can have positive effects on students’ persistence in that field (Canning et al., 2018; Hecht et al., in press).

The extant literature points to the potential for UV interventions to have positive effects in science courses. However, before the intervention can be implemented at scale, it is important to establish best practices. Researchers and educators who want to implement the UV intervention need to know which aspects are necessary and sufficient for the UV writing assignments to promote positive student outcomes. For example, Canning and colleagues (2018) recently tested different doses of the UV intervention (one, two, or three UV assignments), and found that the intervention was most effective when students were given three UV assignments over the course of the semester. One area still in need of clarification is the potential impact of the different types and combinations of UV assignments used in the intervention. The writing assignments are the experimental manipulation that constitutes a UV intervention, but there has been substantial variation in the features of the UV writing assignments used in the literature, with little attention to whether this variability has any impact on the effectiveness of the intervention.

Prior work has used a combination of different assignments to help students find value in course content—primarily self-focused UV essays (i.e., students write essays about how the material is personally useful to them), other-focused UV letters (i.e., students write letters to friends/family members describing how the material is personally useful to the letter recipients), or a choice between the two. Specifically, Hulleman and Harackiewicz (2009) gave students a choice to write essays about the UV of the material for their own life or for a friend or relative, whereas Hulleman et al. (2010) used letters about UV for others, and Hulleman et al. (2017) used essays about UV for the self. Harackiewicz et al. (2016) and Rosenzweig et al. (2018) implemented a combination of essays about UV for the self, letters about UV for others, and choices between those two. Finally, Canning et al. (2018) gave all participants a choice between essays about UV for the self and letters about UV for others. Thus, there has been considerable variability in how the UV intervention has been implemented across studies, along two dimensions. The interventions have varied in terms of the assignment type (i.e., self-focused or other-focused UV assignments) and features of the assignment structure (e.g., whether students are exposed to a variety of assignments, whether students are given choices about which assignments to complete).

An important question is whether the variation in assignment types and structures across studies is meaningful. On the one hand, all assignments are designed to help students to find value in course content, and in that sense it may not matter what types of assignments are used. The fact that prior studies have shown positive effects on student motivation and performance suggests that many different types of assignments and assignment structures can be beneficial. However, it is also plausible that different types and structures of assignments could elicit different styles of writ-

ing, initiate different motivational processes, and affect students' performance to different degrees. Whereas most previous studies have treated assignment type and structure as incidental aspects of intervention implementation, we believe that these design "details" could have important theoretical implications, especially for understanding the mechanisms driving UV intervention effects. For example, motivation researchers have long recognized the benefits of variety and choice for supporting motivation in the classroom (e.g., Ames, 1992), but it is unclear whether incorporating variety or choice in the UV assignments might enhance the motivational benefits of the intervention. To make UV interventions as effective as possible, it is important to examine whether different types and structures of assignments might promote student success through different mechanisms and whether a particular type or structure of assignments might be more effective than others.

Assignment Type: Self-Focused Versus Other-Focused Utility Value

Eccles and colleagues' (1983) definition of UV as the usefulness of a task for one's own goals suggests that UV connections need to be self-focused. Students should benefit most from drawing connections to their own lives and personal goals. However, almost all previous studies have used a combination of writing assignments in which students relate the material to their own lives or to the lives of others (e.g., Canning et al., 2018; Harackiewicz et al., 2016), without attention to the critical differences between them. As a result, it is unclear whether having students make connections to their own lives, their friends' or families' lives, or any combination thereof, would be equally beneficial. Thus prior intervention work offers a broader conceptualization of UV, yet this raises important questions about how the intervention works to promote value. In particular, it is not clear whether or why writing about value for others would work through the same mechanisms as writing about value for the self.

When students write essays relating course material to their own personal goals or important aspects of their lives, it could help them to perceive more intrinsic value in their studies (Priniski, Hecht, & Harackiewicz, 2018). Consistent with the Eccles et al. (1983) model, this kind of self-focused utility should foster interest and perceived value. Indeed, to the extent that writing about self-focused UV initiates self-related cognitive processing, it should trigger situational interest (Hidi, Renninger, & Northoff, 2017), because cognitive processing of self-relevant information includes activation of reward circuitry (for a review, see Northoff, 2016). Encoding information in reference to the self also enhances learning because it leads to deeper, more elaborative processing (Klein, 2012; Symons & Johnson, 1997). Thus, self-focused UV assignments should increase motivation and performance by promoting perceived value for the self and initiating self-related cognitive processing that promotes interest and learning.

On the other hand, writing about utility for others could provide a "foot in the door," by allowing students who might struggle to see the relevance of their coursework to their own lives to make connections to others' lives instead. It may be easier for students to come up with a real-life connection when they can choose among everyone they know as a target for the writing assignment. Although this process may not target perceived UV for the self directly, it should promote perceived value on a more general

level. Over time, students who perceive the material to be generally useful may come to perceive more UV for the self as well. In addition, the format of this assignment—a letter to another person—provides a platform for explaining the material, which is a good way to test one's understanding of course concepts (e.g., Fiorella & Mayer, 2013; Roscoe & Chi, 2007). In sum, reflecting on UV for the self and for others might work through different processes (e.g., self-related cognitive processes and perceived value for self vs. cognitive processes related to explaining the material to others and more general perceived value, respectively), but both types of reflection should ultimately promote motivation and performance.

Different types of UV assignments could also lead to differences in the way that students write about course material. Recent work on UV interventions has found that compared to control assignments in which students summarize course material, UV writing is characterized by particular linguistic features, such as a more personal and colloquial style and the use of more words related to social and cognitive processes (Harackiewicz et al., 2016). These features predict the quality of the UV content in students' writing across different types of assignments (Beigman Klebanov, Burstein, Harackiewicz, Priniski, & Mulholland, 2017). However, it is unclear whether essays about utility for the self and letters about utility for others may result in differences in writing style or content that could impact the effectiveness of the intervention. Understanding the linguistic features of different types of assignments could elucidate the processes by which they influence student motivation and performance, alone or in combination.

Assignment Structure: Combining Self- and Other-Focused Utility Value

If both self-focused and other-focused UV assignments are beneficial, the intervention may be more effective when students complete a combination of the two. In previous studies, self-focused and other-focused UV assignments have been combined in two ways: by assigning students a variety of assignments over time (e.g., starting with one type, and then assigning the other type later in the semester) or by giving students a choice between the two assignments. These assignment structures should be beneficial for at least two reasons. First, variety and choice in academic tasks are known to promote motivation (e.g., Ames, 1992), so incorporating them in any assignments should be beneficial. Second, there is reason to believe that variety and choice in UV assignments might be particularly advantageous, and we discuss the potential benefits of each assignment structure below.

An assignment structure that includes variety guarantees that students are exposed to both types of assignments. This introduces novelty, which may help keep students engaged and interested in the assignments over time (e.g., Palmer, 2009). Furthermore, asking students to complete a variety of assignments pushes them to think about the material in new and different ways, which may promote deeper cognitive engagement and learning (e.g., Paris & Paris, 2001). This deeper cognitive engagement may then be reflected in the content of the assignments.

In addition to these general benefits of variety, if self-focused and other-focused UV assignments promote motivation and performance in different ways, exposing students to both could have additive or even synergistic effects. For example, after being

exposed to assignments targeting utility for the self and utility for others, students may be more likely to make both types of utility connections in a single assignment, which could initiate processes related to both perceived value for the self and more general perceived value. It might even be possible to order the assignments in a way that would maximize their effectiveness over time.

Another way to expose students to both self- and other-focused writing assignments is to give them a choice between the two. All UV assignments involve some degree of choice, because students choose the scientific topic to write about, as well as the examples to use in their essays. However, in several prior studies (Canning et al., 2018; Harackiewicz et al., 2016; Hulleman & Harackiewicz, 2009; Rosenzweig et al., 2018) students were also given a choice about the type of assignment to complete (self-focused UV essays or other-focused UV letters). The literature on choice in education suggests that providing meaningful choices can increase students' interest and engagement in academic tasks (see Patall, Cooper, & Robinson, 2008, for a review). Choices are thought to promote a sense of autonomy and personal control by helping students engage in activities in a way that aligns with their personal interests and values, which can help them be more intrinsically motivated and interested in their learning over time (Ryan & Deci, 2000). Making choices about how to engage with course assignments can also help students to self-regulate their level of interest (Sansone, Smith, Thoman, & MacNamara, 2012).

In the context of a UV intervention, choosing which assignments to complete may allow students to reap the benefits of both types of assignments, either because they choose to complete a variety of assignments over the course of the semester or simply because the structure of the task encourages students to think about both self-focused and other-focused utility as they decide which type of assignment to complete. This process may also result in higher-quality UV content; students may think about connections to themselves and others, and then choose which type of assignment to complete based on the best connection that comes to mind.

Initial evidence supports the hypothesis that giving students more choices of UV assignment type could make UV interventions more effective. Rosenzweig et al. (2018) showed that students reported higher levels of perceived UV and interest if they completed UV interventions with three choices between self- and other-focused writing assignments, compared to interventions that included only one such choice across three assignments. However, because all students in this study had at least one choice, there was not a no-choice condition. More work is needed to explore the effects of choosing types of writing assignments compared to never receiving such choices. In particular, it remains unclear whether assignment structures that allow students to choose between assignment types would be better or worse than assignment structures that require students to complete a variety of assignment types in UV interventions. Including choice in the assignment structure guarantees that students will have the opportunity to do both types of assignments, but students might decide to complete only one type (e.g., students may elect to write three self-focused UV essays rather than a combination of assignment types), such that they would miss out on the benefits of actually engaging in the other type of UV writing.

In sum, there is reason to hypothesize that both self-focused UV essays and other-focused UV letters would be beneficial for student motivation and performance, and that features of the assign-

ment structure (namely, variety and choice) could enhance the effectiveness of the intervention. Specifically, variety and choice may augment the effects of the UV intervention by introducing novelty and personal control, respectively. However, because the existing literature contains few direct comparisons between different versions of the UV intervention, it is unclear how these versions differ, in terms of the content and style of the writing they elicit, the mechanisms by which they promote student motivation and performance, and their relative effectiveness.

The Current Study

Whereas most of the prior UV intervention research has treated assignment type and structure as incidental details of intervention implementation, the current study tested whether these assignment features have different effects, and whether these effects are driven by different motivational mechanisms. Thus, the goal of the current study was to compare the most common versions of the UV intervention from previous research within a single study, by systematically manipulating both the types and structures of the writing assignments. We randomly assigned students to six conditions representing different combinations of UV assignments and different assignment structures: one control condition, two "variety" UV conditions in which students were assigned a combination of self- and other-focused writing in two different orders (with self-focused UV first or other-focused UV first), two "same" UV conditions in which students were assigned either all self-focused or all other-focused UV writing, and one condition in which students were always given a choice between self- and other-focused writing. This design allowed us to test the effects of the structural assignment features of variety and choice, as well as the effects of different combinations of UV writing assignments, to answer the following research questions: (a) Do the effects of the intervention vary as a function of assignment structure (variety vs. no variety, choice vs. no choice)? (b) Do the effects of the intervention vary as a function of assignment types (self-focused only vs. other-focused only, self-first variety vs. other-first variety)? (c) Are these versions of the intervention effective, compared to control?

We analyzed the data in four phases. In the first and second phases, we examined treatment effects on course performance and motivational variables (task engagement with the assignments, interest in biology, and personal importance of biology), respectively. These analyses included tests of moderation by three of the variables that have been shown to moderate the effects of UV interventions in previous research: performance expectations, which is a measure of anticipated performance specific to the current course (Hulleman & Harackiewicz, 2009), prior performance, which is a general measure of academic performance across all previous college courses (Canning et al., 2018; Harackiewicz et al., 2016; Hulleman et al., 2010, 2017), and gender (Hulleman et al., 2017).¹ In the third phase, we examined whether different versions of the intervention promoted course performance through different mechanisms. Specifically, we tested

¹ Harackiewicz et al. (2016) also found that the UV intervention effects were moderated by race/ethnicity and social class (as indicated by first-generation college student status). Our sample lacked sufficient diversity to test for moderation by these variables.

whether effects on motivational variables mediated effects on performance. Finally, we conducted exploratory analyses of the content of students' writing assignments to determine whether the different combinations of UV assignments resulted in differences in writing style or content (e.g., differences in the quality of the UV connections).

Method

A UV intervention was administered in a randomized field experiment in two sections of an introductory biology course at a public flagship university in the Midwest United States. The course is the second in a two-semester introductory biology sequence taken by prospective majors in the biological and health sciences, typically during the sophomore year. The course consists of lectures, discussion sections, and labs, for a total of 5 credits. The content is divided into three 5-week units and is team-taught, with different faculty covering each unit.

Experimental Design

A UV/control writing assignment was given to students before each of three unit exams.² There were six conditions: a control condition, in which students wrote a summary of course material, three times across the semester, and five UV conditions designed to test the effects of different combinations of UV assignments and different assignment structures. There were two "variety" conditions.³ In the self-first variety condition, students wrote one self-focused UV essay relating course material to their own lives, followed by two other-focused UV letters relating course material to the lives of close others. In the other-first variety condition, students wrote one other-focused UV letter, followed by two self-focused UV essays. There were also two "same" conditions in which students completed the same type of writing assignment three times over the semester. In the self-focused-only condition, students wrote three self-focused UV essays. In the other-focused-only condition, students wrote three other-focused UV letters. Finally, in the choice condition, students were given the option to write either a self-focused essay or an other-focused letter for each of the three assignments.

We examined which assignments students chose to complete in the choice condition. Students chose to write comparable numbers of self-focused essays and other-focused letters on each of the assignments (56% essays on Assignment 1, 61% essays on Assignment 2, 63% essays on Assignment 3). Taken together, of the students in the choice condition who completed all three assignments,⁴ 34% chose to complete a variety of assignments (13% completed a variety with a self-focused essay first, 21% completed a variety of assignments with an other-focused letter first), and 66% chose to complete the same type of assignment three times (41% completed only self-focused essays, 25% completed only other-focused letters). Additional analyses of students' choices can be found in the online supplemental materials.

Procedure

The UV and control assignments were fully integrated into the curriculum of the course; all students completed these writing assignments, regardless of participation in the research study, but

the assignments were only included in the research if the student provided their consent for release of coursework and academic records (96% of students did so). This procedure allowed the instructional staff to remain blind to students' participation in the research and ensured that students experienced the writing assignments authentically as homework. The writing assignments of participating students were fully de-identified for research purposes.

For each writing assignment, all students were instructed to pick a topic that had been covered in the current unit, formulate a question, and answer it using information from the class. In the control condition, students were instructed to answer their question by writing a summary of the course material. In the five UV conditions, students were instructed to answer their question either by writing a personal essay describing how the material was relevant to their own life, or by writing a letter to a close friend or family member describing how the material was relevant to the letter recipient's life (see the online supplemental materials for writing prompts).

The UV and control assignments were administered in the second week of each 5-week unit of the course, each consisting of a one- to two-page paper assignment, completed as homework. The writing assignments were e-mailed to students through a course management system, submitted electronically to a drop box, and graded by biology graduate students. The essays were graded for accuracy of the scientific content and for following directions, and were returned to students before the unit exam (which occurred on the final day of the 5-week unit). Together, the three writing assignments accounted for 0.6% of students' final grades.

Participants

Of the 615 undergraduate students enrolled in the course, 590 (96%) agreed to participate in this research and gave consent for

² This study was part of a larger, multisection project that included multiple studies, some of which are reported in articles by Harackiewicz et al. (2016), Canning et al. (2018), and Rosenzweig et al. (2018). Although those studies were conducted in a different introductory biology course, the methods used across studies were nearly identical. The larger project included a test of a values-affirmation intervention, crossed with the UV intervention (see Harackiewicz et al., 2016, for details). As in prior studies (Canning et al., 2018; Harackiewicz et al., 2016; Rosenzweig et al., 2018), we did not see any effects of the values-affirmation intervention or interactions with the UV intervention in the present study. Furthermore, accounting for values-affirmation condition in the analyses reported in this article does not change the pattern of results. Therefore, we collapsed across values-affirmation condition for all analyses. Analyses accounting for the values-affirmation intervention are available in the online supplemental materials.

³ Because there were three assignments in the semester, we could not have even numbers of self-focused essays and other-focused letters across conditions. Therefore, we opted to introduce variety by giving students a different type of assignment for the first and second assignments, and to have the third assignment match the second assignment.

⁴ Across conditions, 85% of students completed all three assignments. Number of assignments completed did not differ by condition, $\chi^2(15) = 14.00, p = .526$.

access to their coursework and academic records.⁵ The sample comprised 371 women (63%) and 219 men (37%), with an average age of 19.61 ($SD = 1.16$). In this sample, 3% of students were African American or Black, 14% Asian or Asian American, 4% Hispanic or LatinX, 0.3% Native Hawaiian or Pacific Islander, 0.8% Native American, and 78% White.

Measures

Baseline measures. Prior grade point average (GPA, measured on a 4.0 scale) and biology motivation (7-point Likert-type items) were measured via questionnaires administered in the first week of the course. The motivation items were derived from Eccles and colleagues' (1983) expectancy-value model, and were taken from scales used in previous studies (e.g., Harackiewicz et al., 2016). Performance expectations for the course were measured with two items ("I expect to get a good grade in this course" and "I am confident that I will obtain a final grade of *B* or better in this course," Cronbach's $\alpha = .76$). Subjective task values were measured with two scales, interest and personal importance. Interest in biology (which reflects intrinsic value) was measured with four items ("Biology fascinates me," "I think the field of biology is very interesting," "To be honest, I just don't find biology interesting" (reverse-coded), and "I'm excited about biology," Cronbach's $\alpha = .91$). Personal importance of biology (which reflects a combination of UV and attainment value) was measured with three items ("I think what we are learning in Introductory Biology is important," "The study of biology is personally important to me," and "I think what we are studying in this course is useful to know," Cronbach's $\alpha = .81$).

Outcome variables. Interest in biology and personal importance of biology were measured in the 14th week of the course, with the same items used at baseline (Cronbach's $\alpha = .91$ and $.85$, respectively). Consistent with previous research (e.g., Grinberg, Careaga, Mehl, & O'Connor, 2014; Harackiewicz et al., 2016; Lo & Hyland, 2009; Tausczik & Pennebaker, 2010) we used word count as a measure of task engagement in the assignments. All students were given the same length requirement (one to two pages). Thus variation in assignment length represents meaningful differences in the way that students completed the assignment, with students who were more engaged being more likely to go beyond the bare minimum. Task engagement across the three assignments was measured by computing the average number of words per assignment, and was z scored for analysis.⁶

Course performance was assessed through final course grades, which were supplied by the course coordinators. Final grades were based on performance in lecture, laboratory, and discussion sections, including multiple-choice and short-answer exams and quizzes (60%), an independent research project (17.5%), laboratory activities (17.5%), and discussion activities (5%). Two sections of the course are included in this sample. Course coordinators worked together to ensure standardization of content, exams, and grading procedures across sections. For example, teaching assistants for the two sections received the same training, met regularly, and used the same grading rubrics and procedures for all assignments. Grades were calculated on a 4.0 scale where *A* = 90–100% (4.0 grade points), *AB* = 88–89.99% (3.5 grade points), *B* = 80–87.99% (3.0 grade points), *BC* = 78–79.99% (2.5 grade points), *C* = 70–77.99% (2.0 grade points), *D* = 60–69.99% (1.0

grade points), and *F* < 60% (0 grade points). None of the grading was curved.

Content analysis variables. Linguistic Inquiry and Word Count software (LIWC; Pennebaker, Boyd, Jordan, & Blackburn, 2015) and hand-coding were used to quantify the linguistic features of the assignments. LIWC scores represent the proportion of words in a given text that come from preset "dictionaries," lists of words that represent a particular category or theme. We used a subset of the LIWC personal pronouns dictionary to capture the degree of personal focus in the writing (Hecht et al., in press). Specifically, because the current study included essays about utility for the self and letters about utility for others, we examined the use of first-person singular pronouns (e.g., *I*, *me*, *my*) and second-person pronouns (e.g., *you*, *your*). We used two LIWC dictionaries that were indicative of UV writing in previous research (Harackiewicz et al., 2016) to characterize the content of the assignments: the social processes dictionary (e.g., *friend*, *aunt*, *talk*) and the cognitive processes dictionary (e.g., *think*, *cause*, *know*). LIWC scores were averaged across the three writing assignments.⁶ All LIWC variables were z scored for analysis.

We used an established measure of articulated UV to quantify the degree to which students wrote about the UV of course material in the assignments (Canning et al., 2018; Harackiewicz et al., 2016). Research assistants coded all assignments for level of UV articulated on a 0–4 scale, where a 0 = *no UV*, 1 = *general utility applied to humans generically*, 2 = *utility that is general enough to apply to anyone but is applied to the individual*, 3 = *utility that is specific to the individual*, and 4 = *a strong, specific connection to the individual that includes a deeper appreciate or future application of the material*. This coding rubric produced high interrater reliability ($\kappa = 0.88$): Two independent coders provided the same score on 91% of essays. Disagreements were resolved by discussion. We summed scores across the three assignments to create an overall measure of articulated UV, ranging from 0 to 12. Articulated UV was z scored for analysis.

Results

Descriptive statistics and correlations are available in Table 1. The direction and magnitude of the correlations were similar to those found in previous studies in college biology courses (e.g., Canning et al., 2018; Harackiewicz et al., 2016). Consistent with previous research examining the structure of subjective task values, interest and personal importance were highly correlated but empirically separable (e.g., Gaspard, Dicke, Flunger, Brisson, et al., 2015). Means by condition are shown in Figure 1 and Table S1 in the online supplemental materials.

⁵ Of the 590 participants in the study, 488 were enrolled in a different intervention study the semester prior to the current study. We found no carry-over effects of the previous intervention in the current study, nor did enrollment in the prior study or condition in the prior study interact with UV condition. Furthermore, the pattern of results reported here remains consistent when prior enrollment and prior condition were controlled in the models. Therefore, we collapse across prior enrollment and prior condition in all analyses reported here (see the online supplemental materials for additional information).

⁶ Students who completed no assignments ($n = 9$, 1–3 per condition) were given a score of 0 for task engagement, as well as all of the content analysis variables. The pattern of results we report does not change if those scores are treated as missing.

Table 1
Descriptive Statistics and Correlations

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. Baseline interest in biology												
2. Baseline personal importance of biology	.76***											
3. Prior GPA	.06	.09*										
4. Baseline performance expectations	.32***	.35***	.23***									
5. Course grade	.10*	.13***	.64***	.24***								
6. Task engagement	-.02	.03	.23***	.10*	.28***							
7. Final interest in biology	.75***	.62***	.12***	.24***	.24***	.07						
8. Final personal importance of biology	.58***	.65***	.10*	.22***	.23***	.07	.78***					
9. Personal focus	-.07	-.10*	.05	-.06	.04	.09*	-.04	-.06				
10. Social processes language	-.12***	-.15***	.04	-.07	.00	.12***	-.08	-.08	.62***			
11. Cognitive processes language	-.02	-.02	.07	-.02	.08	.27***	-.02	-.04	.41***	.39***		
12. Articulated utility value	.00	.00	.14***	-.05	.20***	.24***	.06	.06	.64***	.39***	.35***	
<i>M</i>	5.71	5.62	3.31	5.87	2.97	493.32	5.63	5.58	2.37	5.18	10.76	6.71
<i>SD</i>	1.06	.96	.42	.95	.73	123.19	1.08	1.08	1.65	2.23	2.33	3.72
Minimum	1	1	1.70	2.50	0	0	1	1	0	0	0	0
Maximum	7	7	4.00	7	4	1093	7	7	8.29	12.06	17	12
<i>N</i>	580	580	568	580	590	590	584	584	590	590	590	590

Note. GPA = grade point average.
* $p < .05$. *** $p < .001$.

Intervention Fidelity

We examined two indices of participant responsiveness to evaluate intervention fidelity: response frequency (i.e., completion rates for the writing assignments) and response quality (i.e., level of articulated UV; Hulleman & Cordray, 2009). We found that 580 students (98%) completed at least one writing assignment, and 504 (85%) completed all three. The number of assignments completed did not differ by condition, $\chi^2(15) = 14.00, p = .526$. In terms of articulated UV, we found that students in the UV conditions articulated more UV ($M = 7.85, SD = 2.94$) than students in the control condition ($M = 1.17, SD = 1.41$). Furthermore, whereas only 29% of control writing assignments contained UV (i.e., scored >0 on the articulated UV scale), and only 6% of control writing assignments contained personal UV (i.e., >1 on the articulated UV scale), 92% of UV writing assignments contained UV,

and 79% contained personal UV. Therefore, we concluded that the UV intervention was implemented with a high degree of fidelity.

Analytic Strategy

Analyses occurred in four phases. In the first and second phases, we examined effects of different combinations of UV writing assignments on course performance and motivational variables (task engagement in the writing assignments, interest in biology, and personal importance of biology), respectively. Regression analyses were conducted within a path-modeling framework using the lavaan package in R (Rosseel, 2012), which allowed us to use full-information maximum likelihood estimation to account for missing data (<4% on any variable). Five orthogonal contrasts were created to test the following research questions (see Table 2 for contrast weights): (a) Was writing a variety of self-focused and

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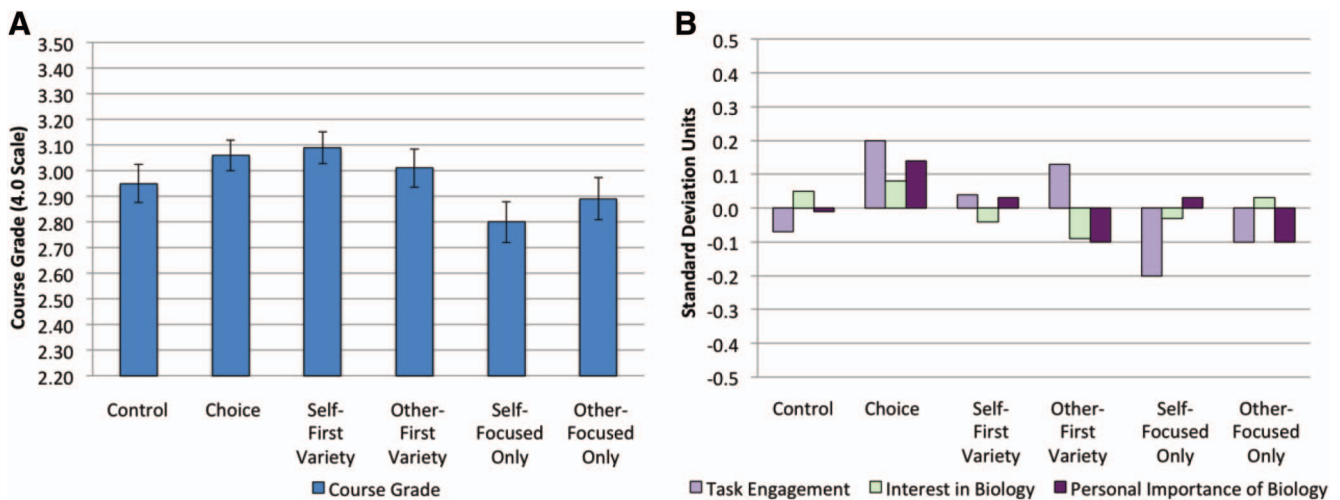


Figure 1. (A) Course grade and (B) motivational outcomes by condition. Error bars represent ± 1 standard error of the mean. See the online article for the color version of this figure.

Table 2
Condition Contrasts

Contrast	Condition				Choice	Control
	Self-focused UV (S–S–S)	Other-focused UV (O–O–O)	Self-first variety (S–O–O)	Other-first variety (O–S–S)		
Variety contrast	–1	–1	1	1	0	0
Self-first vs. other-first contrast	0	0	1	–1	0	0
Self-focused vs. other-focused only contrast	1	–1	0	0	0	0
Choice contrast	–1	–1	–1	–1	4	0
Intervention contrast	1	1	1	1	1	–5
<i>N</i>	97	97	98	101	96	101

Note. UV = utility value; S = self-focused UV essay; O = other-focused UV letter.

other-focused UV assignments better for students' performance, task engagement, interest in biology, and personal importance of biology than writing the same type of assignment three times (variety contrast)? (b) Within the variety conditions, was one sequence of variety better than the other (self-first vs. other-first contrast)? (c) Within the "same" conditions, did the effects of the intervention vary by type of assignment (self-focused vs. other-focused-only contrast)? (d) Did the effects of the intervention vary by whether students were given choice, relative to the conditions in which assignment types were fixed (choice contrast)? (e) Did the UV interventions (combined across types) improve students' outcomes relative to control (intervention contrast)? These contrasts allowed us to test our primary research questions about the effects of assignment type and structure within the UV conditions. A secondary research question is whether the effect of each unique UV condition replicates the effects observed in previous studies. Therefore, we also report a comparison of the effect size for each UV condition (vs. control) to effect sizes from previous studies (see the Replication Analyses section).

We tested the five orthogonal contrasts in a model with three variables that have moderated UV intervention effects in previous research (i.e., baseline performance expectations, prior GPA, and gender) and their interactions with each of the contrasts. In addition, because the sample included two sections of introductory biology, we included a lecture contrast to account for the nesting of students within two lecture sections (Lecture A = 1, Lecture B = –1).⁷ Thus the basic model had 24 terms: five intervention condition contrasts, baseline performance expectations (z scored) and its five two-way interactions with the condition contrasts, prior GPA (z scored) and its five two-way interactions with the condition contrasts, gender (man = 1, woman = –1) and its five two-way interactions with the condition contrasts, and lecture. Analyses on all outcomes used this basic model, with two exceptions. The regression on interest controlled for students' baseline levels of interest, and the regression on personal importance controlled for students' baseline levels of personal importance. Significant interactions were explored with simple effects analyses for subgroups (at ± 1 standard deviation for continuous moderators).

In the third phase of analyses we tested whether effects on the motivational variables (task engagement, interest in biology, personal importance of biology) mediated effects on performance. To test mediation, we computed indirect effects within path models that included all paths described above on performance and the mediators, as well as the paths from the mediators to performance.

Indirect effects, indices of moderated mediation, and conditional indirect effects were computed using formulas specified by Hayes (2013). Finally, in the fourth phase of analyses, we conducted exploratory content analyses to examine treatment effects on the content of students' writing assignments, using the basic model. When appropriate, false discovery rate procedures (Benjamini & Hochberg, 1995) were used to account for testing multiple moderators and/or outcomes within a family of tests. Therefore, p values reported in the text and tables are false discovery rate-adjusted, when applicable. Additional details are available in the online supplemental material.

Effects on Course Performance

Results on course performance are displayed in Table 3. There was a significant main effect of the variety contrast, which compared the two conditions in which students wrote a variety of self- and other-focused UV assignments to the two conditions in which students wrote only one type of assignment, on course grades, $\beta = 0.07$, $p = .024$ (see Figure 1A). Students who wrote a variety of UV assignments earned higher grades in the course ($M = 3.05$, $SD = 0.69$) than students who completed the same type of assignment three times ($M = 2.85$, $SD = 0.80$). In addition, there was a significant interaction between performance expectations and the self-first contrast, which compared the two sequences of variety (self-first vs. other-first), $\beta = -0.08$, $p = .045$ (see Figure 2). Students with low performance expectations (-1 SD) did better in the course when variety in UV writing assignments was introduced with a self-focused essay, followed by two other-focused letters, $\beta = 0.11$, $p = .017$, whereas students with high performance expectations ($+1$ SD) performed equally well in both variety conditions, $\beta = -0.05$, $p = .231$. There was also a main effect of the choice contrast on course performance, $\beta = 0.06$, $p = .040$, such that students who were given a choice between UV assignment types earned higher grades in the course ($M = 3.06$, $SD = 0.59$) than students in the four conditions in which UV assignment types were fixed ($M = 2.95$, $SD = 0.75$).

⁷ The intraclass correlation indicated that lecture accounted for only 3% of the variance in course grade, 7% of the variance in task engagement, and <1% of the variance in interest in biology and personal importance of biology. However, to be sure that the nesting of students in sections did not bias our parameter estimates, we also tested models including interactions between lecture and the condition contrasts. Including these interactions had no impact on the pattern of results reported in this study.

Table 3
Regression Results Predicting Course Grades

Predictor	B	SE	z	β	p ^a
Course grade (DV)					
Variety contrast	.06	.03	2.26	.07	.024
Self-first vs. other-first contrast	.04	.04	.96	.03	.337
Self-focused vs. other-focused only contrast	-.02	.04	-.54	-.02	.593
Choice contrast	.03	.01	2.06	.06	.040
UV intervention contrast	.00	.01	.41	.01	.683
Performance expectations	.06	.02	2.52	.08	.016
Prior GPA	.44	.02	19.21	.62	<.001
Gender	.01	.02	.55	.02	.583
PE × Variety Contrast	.05	.03	1.65	.06	.150
GPA × Variety Contrast	-.06	.03	-2.18	-.07	.090
Gender × Variety Contrast	.02	.03	.54	.02	.589
PE × Self-First Contrast	-.11	.04	-2.43	-.08	.045
GPA × Self-First Contrast	.01	.04	.13	.00	.893
Gender × Self-First Contrast	.05	.04	1.23	.04	.327
PE × Self vs. Other Contrast	.03	.04	.85	.03	.596
GPA × Self vs. Other Contrast	-.02	.04	-.63	-.02	.527
Gender × Self vs. Other Contrast	-.09	.04	-2.10	-.07	.108
PE × Choice Contrast	-.00	.01	-.33	-.01	1.000
GPA × Choice Contrast	-.00	.01	-.03	-.00	.979
Gender × Choice Contrast	.01	.01	.93	.03	1.000
PE × UV Contrast	.01	.01	.69	.02	.490
GPA × UV Contrast	-.01	.01	-.97	-.03	.501
Gender × UV Contrast	-.02	.01	-1.60	-.05	.327
Lecture	-.11	.02	-4.94	-.15	<.001

Note. DV = dependent variable; UV = utility value intervention; PE = performance expectations; GPA = grade point average. Performance expectations and prior GPA are z scored; gender is coded man = 1, woman = -1. See Table 2 for contrast codes.

^ap values are false discovery rate-adjusted for multiple comparisons; additional details are available in the online supplemental materials.

The effect of the contrast comparing the two “same” conditions (self-focused vs. other-focused only) was not significant; students performed equally well when they wrote all self-focused UV essays or all other-focused UV letters. Finally, there were no

overall effects of the intervention contrast (comparing all UV conditions, on average, to the control condition) or interactions with the intervention contrast. Whereas we found benefits of the variety and choice conditions, it could be the case that the less effective conditions reduced the average intervention effect. We explore differences between specific UV conditions and control below (see Replication Analyses).

In summary, analyses on course performance revealed that the UV assignments had more positive effects on performance when students wrote a variety of assignments (compared to the same assignment three times) and when students were given a choice regarding the types of assignments to complete (compared to no choice). Furthermore, we found that one specific combination of UV assignments—self-first variety—was more effective for students with low performance expectations.

Effects on Motivational Variables

We then tested whether the type and structure of the UV writing assignments affected motivational variables (task engagement, interest in biology, personal importance of biology). There were main effects of the choice contrast on task engagement, $\beta = 0.10$, $p = .030$, and on students’ level of interest in biology at the end of the semester, $\beta = 0.06$, $p = .048$. Students who were given a choice between assignment types were more engaged in the writing assignments ($M_{\text{words}} = 518.26$, $SD = 122.90$) and reported higher levels of interest ($M = 5.72$, $SD = 1.09$) than students whose assignment types were fixed ($M_{\text{words}} = 489.43$, $SD = 123.63$ and $M = 5.60$, $SD = 1.12$, respectively). No other condi-

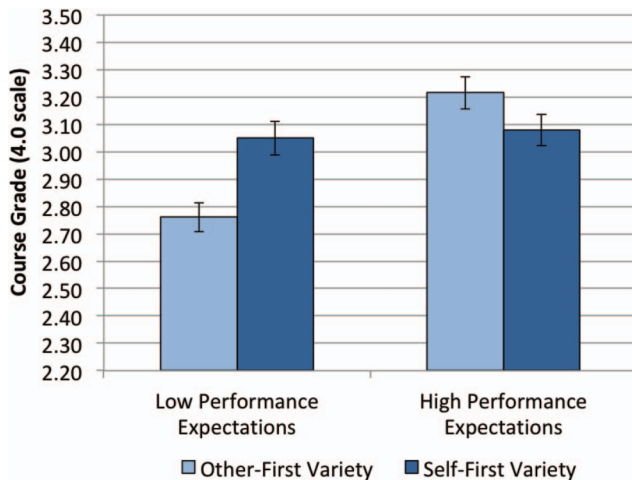


Figure 2. Interactive effects of performance expectations and the self-first contrast (self-first condition vs. other-first condition) on course grade. Predicted values are computed from the multiple regression equation (low performance expectations = -1 SD, high performance expectations = +1 SD). Error bars represent ±1 standard error of the point estimates. See the online article for the color version of this figure.

tion effects on task engagement or interest were significant (see Table 4).

For personal importance of biology, there was a significant interaction between gender and the self-first contrast, $\beta = 0.09$, $p = .045$, indicating that men found biology to be more personally important in the self-first variety condition than the other-first variety condition, $\beta = 0.14$, $p = .006$, whereas personal importance did not differ among women, $\beta = -0.05$, $p = .245$. No other condition effects on personal importance were significant (see Table 4).

Mediation Analyses

Results for motivational variables might help us to understand some of the performance effects. Specifically, students were more engaged in the writing assignments and reported higher levels of interest in the choice condition, which might explain the benefits of choice for performance. Therefore, we conducted a mediation analysis using path modeling to determine whether the effects of choice on performance were mediated by task engagement and/or interest in biology (see Figure 3 for a conceptual model).

We found a significant indirect effect of the choice contrast on performance through task engagement ($p = .029$), but the indirect effect of the choice contrast through interest in biology was not significant ($p = .051$). Whereas including choices in the structure of the assignments improved both students' task engagement and their interest in biology, it was task engagement that proved to be the more important mechanism for the effect of choice on performance in the course. Full output from this model is presented in Table 5.

Exploratory Content Analyses

To explore how different assignment types and structures affected the way in which students wrote about biology, we examined the style and content of students' writing in the assignments. We tested the same basic model on three LIWC variables (personal focus, social processes content, cognitive processes content), as well as the hand-coded measure of articulated UV. Full regression results are displayed in Table 6.

Consistent with prior work characterizing the style and content of UV assignments (Beigman Klebanov et al., 2017; Harackiewicz et al., 2016), UV writing assignments had a more personal focus (i.e., used more "I" and "you" pronouns), $\beta = 0.56$, $p < .001$, included more content related to social processes, $\beta = 0.37$, $p < .001$, and cognitive processes, $\beta = 0.28$, $p < .001$, and contained higher levels of articulated value, $\beta = 0.66$, $p < .001$, than control assignments. Interestingly, having choice in the assignment structure did not significantly influence the style or content of students' writing, $\beta s < 0.06$. However, the analyses did reveal effects of assignment type among the fixed UV assignment conditions (see Figure 4A). Specifically, we found that students' writing differed as a function of how many other-focused letters they wrote. The self-focused-only condition was lower than the other-focused-only condition on personal focus ($\beta = -0.25$, $p < .001$), social processes content ($\beta = -0.40$, $p < .001$), and cognitive processes content ($\beta = -0.10$, $p = .031$). In other words, students used more personal pronouns and wrote more about social and cognitive processes when writing letters about UV for others.

We found similar effects within the two variety conditions: students' writing again differed as a function of how many other-focused letters they wrote. The self-first variety condition (in which students wrote one self-focused essay followed by two other-focused letters) was higher than the other-first variety condition (in which students wrote one other-focused letter followed by two self-focused essays) on personal focus ($\beta = 0.13$, $p < .001$) and social processes content ($\beta = 0.15$, $p < .001$). In other words, students used more personal pronouns and wrote more about social processes when they were assigned variety with two other-focused letters than when they were assigned variety with one other-focused letter, which is consistent with the assignment type effect described above (see Figure 4A).

In contrast, articulated UV did not differ between the two "same" conditions in which students wrote only essays about UV for the self or letters about UV for others ($p = .10$). However, students in the self-first variety condition articulated higher levels of UV ($M = 8.45$, $SD = 2.68$) than those in the other-first condition ($M = 7.60$, $SD = 2.72$), $\beta = 0.08$, $p = .012$ (see Figure 4B). Thus, the quality of students' UV connections varied not as a function of type of assignment but rather as a function of the structure of the assignments, with students making the highest-quality UV connections in the self-first variety condition.

In sum, the content analyses revealed several effects of other-focused UV assignments. Although all UV assignments are characterized by a more personal style and more content related to social and cognitive processes compared to control assignments, these effects were even larger when students wrote more other-focused UV assignments, likely due to the fact that these assignments are written in letter format. The letter format encourages students to write with a more colloquial style and to personalize the content to the recipient. However, there were also effects of combining self-focused UV writing with other-focused UV writing. Students articulated more UV in their assignments when they wrote a self-focused UV essay first, followed by other-focused UV letters.

Given the higher levels of articulated UV in the self-first variety condition, we tested whether the Self-First Contrast \times Performance Expectations interaction on performance might be mediated by articulated UV. The indirect effect of the Self-First Contrast \times Performance Expectations interaction on course performance through articulated UV was marginal ($p = .054$). However, conditional indirect effects analyses revealed a significant effect of the self-first variety contrast on course performance through articulated UV for students with low ($-1 SD$) performance expectations ($p = .017$), and a nonsignificant effect of the essay-first variety contrast on course performance through articulated UV for students with high ($+1 SD$) performance expectations ($p = .973$). In other words, among students who doubted their ability to do well in the course, the self-first variety condition led them to articulate more UV in their writing assignments, and this promoted higher levels of performance in the course. These results should be interpreted with caution, given that the indirect effect of the interaction was not significant and that the analysis was conducted post hoc. However, the results do suggest that UV writing processes may contribute to the benefits of the self-first variety condition for students with low performance expectations.

Table 4
Regression Results Predicting Task Engagement, Interest in Biology, and Personal Importance of Biology

Predictor	B	SE	z	β	p ^a
Task engagement (DV)					
Variety contrast	.10	.05	2.02	.08	.129
Self-first vs. other-first contrast	-.04	.07	-.61	-.02	.812
Self-focused vs. other-focused only contrast	-.05	.07	-.72	-.03	1.000
Choice contrast	.06	.02	2.59	.10	.030
UV intervention contrast	.01	.02	.65	.03	.515
Performance expectations	.07	.04	1.62	.07	.245
Prior GPA	.19	.04	4.64	.19	<.001
Gender	-.05	.04	-1.26	-.05	.414
PE × Variety Contrast	.01	.05	.26	.01	.894
GPA × Variety Contrast	-.07	.05	-1.36	-.06	1.000
Gender × Variety Contrast	.04	.05	.75	.03	1.000
PE × Self-First Contrast	-.05	.08	-.66	-.03	.658
GPA × Self-First Contrast	.08	.08	1.03	.04	.686
Gender × Self-First Contrast	.05	.07	.73	.03	.698
PE × Self vs. Other Contrast	.07	.07	.97	.04	1.000
GPA × Self vs. Other Contrast	.00	.07	.07	.00	1.000
Gender × Self vs. Other Contrast	-.07	.07	-.90	-.04	1.000
PE × Choice Contrast	-.05	.02	-2.27	-.09	.207
GPA × Choice Contrast	.01	.02	.24	.01	.908
Gender × Choice Contrast	.05	.02	2.21	.09	.122
PE × UV Contrast	.01	.02	.40	.02	1.000
GPA × UV Contrast	-.00	.02	-.11	-.00	.913
Gender × UV Contrast	-.02	.02	-.82	-.03	1.000
Lecture	.20	.04	5.02	.20	<.001
Interest in biology (DV)					
Variety contrast	-.04	.04	-1.03	-.03	.453
Self-first vs. other-first contrast	-.02	.05	-.32	-.01	.750
Self-focused vs. other-focused only contrast	-.03	.06	-.54	-.02	.589
Choice contrast	.04	.02	2.15	.06	.048
UV intervention contrast	.02	.01	1.26	.04	.312
Performance expectations	-.02	.03	-.6	-.02	.699
Prior GPA	.09	.03	2.87	.09	.011
Gender	.03	.03	.95	.03	.534
PE × Variety Contrast	-.00	.04	-.05	-.00	.957
GPA × Variety Contrast	.01	.04	.27	.01	1.000
Gender × Variety Contrast	.03	.04	.77	.02	1.000
PE × Self-First Contrast	-.07	.06	-1.28	-.04	.597
GPA × Self-First Contrast	.06	.06	1.00	.03	.574
Gender × Self-First Contrast	.02	.06	.39	.01	.694
PE × Self vs. Other Contrast	-.00	.05	-.05	-.00	.962
GPA × Self vs. Other Contrast	-.03	.05	-.53	-.02	.894
Gender × Self vs. Other Contrast	-.08	.06	-1.37	-.04	1.000
PE × Choice Contrast	-.01	.02	-.73	-.02	.839
GPA × Choice Contrast	.00	.02	.02	.00	.984
Gender × Choice Contrast	.02	.02	.91	.03	.821
PE × UV Contrast	-.01	.02	-.69	-.02	1.000
GPA × UV Contrast	.00	.01	-.22	-.01	.932
Gender × UV Contrast	.00	.01	.3	.01	.986
Lecture	-.02	.03	-.74	-.02	.643
Baseline interest	.77	.03	25.69	.75	<.001
Personal importance of biology (DV)					
Variety contrast	-.02	.04	-.53	-.02	.593
Self-first vs. other-first contrast	.09	.06	1.5	.05	.405
Self-focused vs. other-focused only contrast	.04	.06	.64	.02	.785
Choice contrast	.03	.02	1.71	.06	.087
UV intervention contrast	.02	.02	1.51	.05	.396
Performance expectations	-.01	.04	-.21	-.01	.838
Prior GPA	.05	.04	1.24	.04	.378
Gender	-.02	.04	-.51	-.02	.709
PE × Variety Contrast	-.01	.05	-.3	-.01	1.000
GPA × Variety Contrast	.02	.05	.49	.02	1.000
Gender × Variety Contrast	-.02	.05	-.45	-.02	1.000

(table continues)

Table 4 (continued)

Predictor	<i>B</i>	<i>SE</i>	<i>z</i>	β	<i>p</i> ^a
PE × Self-First Contrast	-.15	.07	-2.32	-.08	.095
GPA × Self-First Contrast	-.03	.07	-.4	-.01	.773
Gender × Self-First Contrast	.18	.06	2.81	.10	.045
PE × Self vs. Other Contrast	-.04	.06	-.67	-.02	1.000
GPA × Self vs. Other Contrast	.04	.06	.66	.02	.916
Gender × Self vs. Other Contrast	.01	.07	.12	.00	1.000
PE × Choice Contrast	.01	.02	.29	.01	.993
GPA × Choice Contrast	.01	.02	.55	.02	.879
Gender × Choice Contrast	.03	.02	1.69	.06	.273
PE × UV Contrast	-.02	.02	-.94	-.03	1.000
GPA × UV Contrast	-.01	.02	-.35	-.01	1.000
Gender × UV Contrast	-.01	.02	-.44	-.01	1.000
Lecture	-.01	.03	-.32	-.01	.803
Baseline personal importance of biology	.75	.04	19.4	.66	<.001

Note. DV = dependent variable; UV = utility value intervention; PE = performance expectations; GPA = grade point average. Performance expectations and prior GPA are *z* scored; gender is coded man = 1, woman = -1. See Table 2 for contrast codes.

^a *p* values are false discovery rate-adjusted for multiple comparisons; additional details are available in the online supplemental materials.

Replication Analyses

The focus of the primary analyses was to examine differences among the different types of UV assignments on performance, as well as motivational variables. Only one contrast (the intervention contrast) tested differences between the control condition and the UV conditions. We did not find any significant intervention effects when we compared all five UV conditions (on average) to the control condition. However, to understand the effectiveness of the UV conditions relative to the results from previous studies, it is useful to look not just at an overall contrast but at each condition individually compared to control, with respect to course performance. Therefore, we supplemented our primary analysis with a dummy-coded model to compare treatment effect sizes from the current study to those from the two other articles that reported effects on course performance in a similar introductory biology course (Canning et al., 2018; Harackiewicz et al., 2016). Those two articles used performance expectations and prior GPA as moderators. Therefore, we tested a model with

five dummy codes (each UV condition vs. control), performance expectations and its five interactions with the dummy codes, prior GPA and its five interactions with the dummy codes, and the lecture contrast (see Table S2 in the online supplemental materials for full regression results).

Canning et al. (2018) found a main effect of the UV intervention, using all choice assignments. Harackiewicz et al. (2016) found a main effect of the UV intervention, as well as a negative UV × Prior GPA interaction, using a combination of assignments (some students were assigned variety; some students received a choice). We did not find any statistically significant intervention effects in the dummy-coded model for the current study, likely due to the smaller sample size. However, we compared the effect sizes from Harackiewicz et al. (2016) and Canning et al. (2018) to the current study, to get a sense of the degree to which our results replicated the pattern of effects from previous studies (see Table 7).

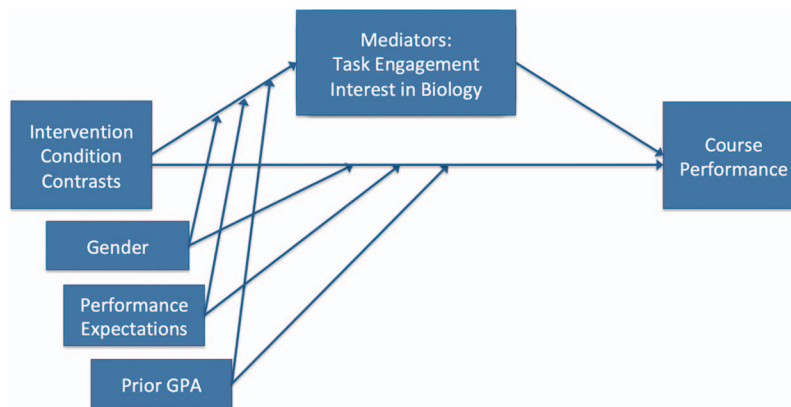


Figure 3. Conceptual model of the mediation analyses. In addition to the paths shown above, all models included main effects of lecture, the moderators (gender, performance expectations, and prior grade point average [GPA]), and baseline interest in biology, on both the mediator and course performance. See the online article for the color version of this figure.

Table 5
Direct and Indirect Effects From the Path Model Including Task Engagement and Interest in Biology as Mediators of Intervention Effects on Course Performance

Predictor	B	SE	z	β	p ^a
Task engagement (DV)					
Variety contrast	.10	.05	2.05	.08	.062
Self-first vs. other-first contrast	-.05	.07	-.69	-.03	.737
Self-focused vs. other-focused only contrast	-.05	.07	-.71	-.03	1.000
Choice contrast	.06	.02	2.56	.10	.033
UV intervention contrast	.01	.02	.68	.03	.746
Performance expectations	.07	.04	1.64	.07	.157
Prior GPA	.21	.04	5.07	.21	<.001
Gender	-.05	.04	-1.25	-.05	.297
PE × Variety Contrast	.01	.05	.19	.01	1.000
GPA × Variety Contrast	-.07	.05	-1.38	-.06	.501
Gender × Variety Contrast	.04	.05	.83	.04	.911
PE × Self-First Contrast	-.05	.08	-.59	-.03	.712
GPA × Self-First Contrast	.08	.08	1.04	.04	.671
Gender × Self-First Contrast	.06	.07	.76	.03	.668
PE × Self vs. Other Contrast	.07	.07	1.00	.04	.954
GPA × Self vs. Other Contrast	.00	.07	.06	.00	.954
Gender × Self vs. Other Contrast	-.07	.07	-.89	-.04	.837
PE × Choice Contrast	-.05	.02	-2.26	-.09	.216
GPA × Choice Contrast	.01	.02	.26	.01	1.000
Gender × Choice Contrast	.05	.02	2.21	.09	.122
PE × UV Contrast	.01	.02	.38	.02	1.000
GPA × UV Contrast	.00	.02	-.14	-.01	.892
Gender × UV Contrast	-.02	.02	-.84	-.03	1.000
Lecture	.20	.04	5.04	.20	<.001
Interest in biology (DV)					
Variety contrast	-.03	.04	-.95	-.03	.343
Self-first vs. other-first contrast	-.02	.05	-.37	-.01	.711
Self-focused vs. other-focused only contrast	-.03	.05	-.56	-.02	.863
Choice contrast	.03	.02	2.16	.06	.047
UV intervention contrast	.02	.01	1.23	.04	.651
Performance expectations	-.02	.03	-.62	-.02	.538
Prior GPA	.08	.03	2.91	.09	.009
Gender	.03	.03	.99	.03	.411
PE × Variety Contrast	-.00	.04	-.01	-.00	.992
GPA × Variety Contrast	.00	.04	.12	.00	1.000
Gender × Variety Contrast	.03	.04	.80	.02	.763
PE × Self-First Contrast	-.07	.05	-1.24	-.04	.968
GPA × Self-First Contrast	.06	.06	1.00	.03	.571
Gender × Self-First Contrast	.02	.05	.44	.01	.746
Gender × Self vs. Other Contrast	.01	.05	.11	.00	1.000
PE × Self vs. Other Contrast	-.03	.05	-.61	-.02	.818
GPA × Self vs. Other Contrast	-.08	.05	-1.50	-.05	.599
PE × Choice Contrast	-.01	.02	-.72	-.02	1.000
GPA × Choice Contrast	-.00	.02	-.04	-.00	.972
Gender × Choice Contrast	.02	.02	.95	.03	1.000
PE × UV Contrast	-.01	.02	-.72	-.02	1.000
GPA × UV Contrast	-.00	.01	-.15	-.00	.995
Gender × UV Contrast	.00	.01	.29	.01	.994
Lecture	-.02	.03	-.72	-.02	.510
Baseline interest	.75	.03	25.62	.75	<.001
Course performance (DV)					
Variety contrast	.08	.04	2.19	.07	.087
Self-first vs. other-first contrast	.06	.05	1.16	.04	.738
Self-focused vs. other-focused only contrast	-.02	.05	-.28	-.01	.777
Choice contrast	.02	.02	1.24	.04	.216
UV intervention contrast	.00	.01	.19	.01	.846
Performance expectations	.06	.03	1.76	.06	.137
Prior GPA	.56	.03	18.08	.57	<.001
Gender	.02	.03	.77	.02	.518
PE × Variety Contrast	.07	.04	1.69	.05	.414
GPA × Variety Contrast	-.09	.04	-2.21	-.07	.243

(table continues)

Table 5 (continued)

Predictor	<i>B</i>	<i>SE</i>	<i>z</i>	β	<i>p</i> ^a
Gender × Variety Contrast	.01	.04	.22	.01	1.000
PE × Self-First Contrast	-.13	.06	-2.18	-.07	.261
GPA × Self-First Contrast	-.01	.06	-.24	-.01	.810
Gender × Self-First Contrast	.06	.05	1.19	.04	.708
PE × Self vs. Other Contrast	.04	.05	.74	.02	.823
GPA × Self vs. Other Contrast	-.03	.05	-.60	-.02	.703
Gender × Self vs. Other Contrast	-.10	.06	-1.83	-.06	.612
PE × Choice Contrast	.00	.02	.27	.01	1.000
GPA × Choice Contrast	.00	.02	-.25	-.01	.902
Gender × Choice Contrast	.01	.02	.32	.01	1.000
PE × UV Contrast	.01	.02	.69	.02	.884
GPA × UV Contrast	-.01	.01	-.89	-.03	1.000
Gender × UV Contrast	-.02	.01	-1.40	-.04	1.000
Lecture	-.17	.03	-5.75	-.17	<.001
Baseline interest in biology	-.10	.05	-2.19	-.10	.058
Task engagement	.13	.03	4.17	.13	<.001
Interest in biology	.21	.05	4.66	.21	<.001
		<i>B</i>	<i>SE</i>	<i>z</i>	<i>p</i> ^a
Indirect effects					
Choice → Task Engagement → Grade	.01	.003	2.18		.029
Choice → Interest in Biology → Grade	.01	.004	1.95		.051

Note. DV = dependent variable; UV = utility value intervention; PE = performance expectations; GPA = grade point average. Performance expectations and prior GPA are *z* scored; gender is coded man = 1, woman = -1. See Table 2 for contrast codes.

^a*p* values are false discovery rate-adjusted for multiple comparisons; additional details are available in the online supplemental materials.

The choice condition and the two variety conditions (self-first variety and other-first variety) are the closest approximations of the UV interventions used in prior studies. For the choice condition, effect sizes were similar to those of previous studies. For the variety conditions, the main effects were smaller than those of previous studies, but the interactions with prior GPA were larger than in previous studies, indicating that the variety conditions were particularly beneficial for students with low prior performance. Simple slopes analyses revealed a pattern of positive effects of the self-first variety condition, $\beta = 0.13$, and other-first variety condition, $\beta = 0.10$, for students with low prior GPAs, but not for students with high prior GPAs, $\beta = -0.01$ and $\beta = -0.03$, respectively. In contrast, the self-focused- and other-focused-only conditions had negligible effects sizes for both the main effects and interactions with prior GPA.

In sum, the general pattern of results with the variety and choice conditions (which most closely mirror the design of the previous studies in college introductory biology courses) was consistent with prior results showing main effects of the UV intervention (Canning et al., 2018; Harackiewicz et al., 2016) and an Intervention × Prior GPA interaction (Harackiewicz et al., 2016) in a different introductory biology course. Effect sizes for the variety and choice conditions were similar or even somewhat larger in this study, whereas the effect sizes for the self-focused- and other-focused-only conditions were negligible. These results mirror the results of the primary model, which also indicated that the choice and variety conditions had more positive effects than the conditions in which students wrote the same type of assignment three times.

Discussion

To determine the best practices for implementing the UV intervention, it is important to understand how the different elements of the UV writing assignments work to promote positive student outcomes. The goal of this study was to test whether the type and structure of UV assignments affect the content of the writing they elicit, the mechanisms by which they promote student motivation and performance, or the relative effectiveness of the UV intervention. Although a single study cannot test all possible versions of the UV intervention or draw definitive conclusions about which is the most effective across contexts, the current study provides an important first step.

We directly compared five of the most common versions of the UV intervention that were used in prior research and found that students benefitted most from the UV intervention when the assignment structure exposed them to both types of UV assignments, rather than instructing them to complete the same type of assignment three times. Students earned higher course grades when assigned a fixed combination of self-focused and other-focused UV assignments (i.e., in the variety conditions) or when given a choice of which type of assignment to complete. In addition, one particular sequence of variety (self-first variety) was more effective for students with low performance expectations. Only by testing different versions of the UV intervention were we able to identify the most powerful features of the intervention. Choice and variety have long been known to have powerful effects on motivation and performance, but our design allowed us to test these factors in the specific context of

Table 6
Regression Results Predicting Content Variables

Predictor	B	SE	z	β	p ^a
Personal focus (DV)					
Variety contrast	.03	.04	.67	.02	1.000
Self-first vs. other-first contrast	.23	.06	4.00	.13	<.001
Self-focused vs. other-focused only contrast	-.44	.06	-7.47	-.25	<.001
Choice contrast	-.01	.02	-.63	-.02	.530
UV intervention contrast	.25	.02	16.68	.56	<.001
Performance expectations	.00	.04	.12	.00	.967
Prior GPA	.04	.03	1.11	.04	.476
Gender	-.04	.03	-1.11	-.04	.534
PE × Variety Contrast	-.01	.04	-.26	-.01	1.000
GPA × Variety Contrast	.00	.04	.05	.00	.960
Gender × Variety Contrast	-.01	.04	-.25	-.01	1.000
PE × Self-First Contrast	-.06	.06	-.95	-.03	.590
GPA × Self-First Contrast	.09	.06	1.47	.05	.338
Gender × Self-First Contrast	.09	.06	1.55	.05	.363
PE × Self vs. Other Contrast	.03	.06	.51	.02	1.000
GPA × Self vs. Other Contrast	.01	.06	.25	.01	.960
Gender × Self vs. Other Contrast	-.01	.06	-.13	-.01	.897
PE × Choice Contrast	-.00	.02	-.11	-.00	.913
GPA × Choice Contrast	-.01	.02	-.53	-.02	.791
Gender × Choice Contrast	-.03	.02	-1.40	-.05	.644
PE × UV Contrast	.00	.02	.23	.01	.983
GPA × UV Contrast	.02	.01	1.37	.05	.410
Gender × UV Contrast	-.01	.02	-.32	-.01	1.000
Lecture	-.03	.03	-1.02	-.03	.493
Social processes language (DV)					
Variety contrast	-.02	.04	-.35	-.01	.973
Self-first vs. other-first contrast	.25	.06	4.27	.15	<.001
Self-focused vs. other-focused only contrast	-.69	.06	-11.19	-.40	<.001
Choice contrast	-.01	.02	-.64	-.02	.700
UV intervention contrast	.16	.02	10.38	.37	<.001
Performance expectations	.00	.04	.11	.00	.909
Prior GPA	.01	.04	.28	.01	.893
Gender	-.09	.04	-2.41	-.08	.064
PE × Variety Contrast	-.03	.04	-.71	-.03	1.000
GPA × Variety Contrast	.01	.04	.21	.01	1.000
Gender × Variety Contrast	-.00	.05	-.06	-.00	1.000
PE × Self-First Contrast	-.02	.07	-.24	-.01	1.000
GPA × Self-First Contrast	-.00	.07	-.07	-.00	.948
Gender × Self-First Contrast	-.02	.06	-.24	-.01	1.000
PE × Self vs. Other Contrast	.05	.06	.78	.03	1.000
GPA × Self vs. Other Contrast	-.02	.06	-.31	-.01	1.000
Gender × Self vs. Other Contrast	.05	.06	.82	.03	1.000
PE × Choice Contrast	-.04	.02	-1.93	-.07	.318
GPA × Choice Contrast	-.04	.02	-2.09	-.07	.444
Gender × Choice Contrast	.00	.02	.14	.01	.971
PE × UV Contrast	-.03	.02	-1.51	-.06	.396
GPA × UV Contrast	.01	.02	.9	.03	.738
Gender × UV Contrast	.01	.02	.55	.02	.875
Lecture	.13	.03	3.95	.13	<.001
Cognitive processes language (DV)					
Variety contrast	-.00	.05	-.08	-.00	.937
Self-first vs. other-first contrast	-.11	.07	-1.51	-.06	.132
Self-focused vs. other-focused only contrast	-.17	.07	-2.27	-.10	.031
Choice contrast	.02	.02	.90	.04	.736
UV intervention contrast	.12	.02	6.69	.28	<.001
Performance expectations	-.04	.04	-.79	-.04	.623
Prior GPA	.09	.04	2.00	.09	.123
Gender	.08	.04	1.97	.08	.110
PE × Variety Contrast	-.05	.05	-.95	-.04	1.000
GPA × Variety Contrast	-.01	.05	-.11	-.01	1.000
Gender × Variety Contrast	.00	.05	.08	.00	1.000
PE × Self-First Contrast	.02	.08	.24	.01	.973
GPA × Self-First Contrast	.11	.08	1.43	.06	.308

(table continues)

Table 6 (continued)

Predictor	<i>B</i>	<i>SE</i>	<i>z</i>	β	<i>p</i> ^a
Gender × Self-First Contrast	-.01	.07	-.18	-.01	.935
PE × Self vs. Other Contrast	.04	.07	.58	.03	1.000
GPA × Self vs. Other Contrast	-.02	.07	-.29	-.01	1.000
Gender × Self vs. Other Contrast	-.04	.08	-.49	-.02	1.000
PE × Choice Contrast	-.02	.02	-.78	-.03	.870
GPA × Choice Contrast	.03	.02	1.20	.05	.693
Gender × Choice Contrast	-.01	.02	-.43	-.02	.798
PE × UV Contrast	-.00	.02	-.05	-.00	.962
GPA × UV Contrast	.03	.02	1.82	.08	.276
Gender × UV Contrast	-.00	.02	-.09	-.00	1.000
Lecture	.02	.04	.43	.02	.893
Articulated utility value (DV)					
Variety contrast	.08	.04	2.22	.07	.108
Self-first vs. other-first contrast	.13	.05	2.61	.08	.012
Self-focused vs. other-focused only contrast	-.09	.05	-1.65	-.05	.100
Choice contrast	.03	.02	1.82	.05	.276
UV intervention contrast	.29	.01	21.93	.66	<.001
Performance expectations	.01	.03	.36	.01	.887
Prior GPA	.13	.03	4.24	.13	<.001
Gender	-.13	.03	-4.09	-.12	<.001
PE × Variety Contrast	-.01	.04	-.38	-.01	1.000
GPA × Variety Contrast	-.02	.04	-.60	-.02	1.000
Gender × Variety Contrast	.09	.04	2.27	.07	.276
PE × Self-First Contrast	-.14	.06	-2.39	-.08	.204
GPA × Self-First Contrast	.09	.06	1.55	.05	.484
Gender × Self-First Contrast	.10	.05	1.87	.06	.372
PE × Self vs. Other Contrast	.08	.05	1.52	.05	1.000
GPA × Self vs. Other Contrast	.01	.05	.23	.01	.890
Gender × Self vs. Other Contrast	-.03	.05	-.56	-.02	1.000
PE × Choice Contrast	-.01	.02	-.87	-.03	.926
GPA × Choice Contrast	.01	.02	.56	.02	.860
Gender × Choice Contrast	.01	.02	.61	.02	.931
PE × UV Contrast	.01	.02	.63	.02	.910
GPA × UV Contrast	.04	.01	2.70	.08	.084
Gender × UV Contrast	-.03	.01	-1.89	-.06	.354
Lecture	-.06	.03	-2.06	-.06	.125

Note. DV = dependent variable; UV = utility value intervention; PE = performance expectations; GPA = grade point average. Performance expectations and prior GPA are *z* scored; gender is coded man = 1, woman = -1. See Table 2 for contrast codes.

^a*p* values are false discovery rate-adjusted for multiple comparisons; additional details are available in the online supplemental materials.

UV interventions, and our analyses revealed that some types of variety are more effective than others.

Implications for Intervention Effectiveness

Prior studies have shown positive effects of UV interventions on students' course performance using many different types of assignments and assignment structures, suggesting that all can be beneficial. However, the current study offers some clarifying evidence regarding the relative effectiveness of these interventions within a single college biology course. Replication analyses indicated that interventions including only self-focused or only other-focused UV assignments had negligible effects on students' performance. In contrast, interventions with assignment structures that included both self-focused and other-focused UV assignments (either by assigning a fixed combination or by giving students choices between the two types of assignments) showed similar or even somewhat larger effect sizes compared to previous studies conducted in similar courses (Canning et al., 2018; Harackiewicz et al., 2016). These previous studies used UV assignment structures that included choice and/or fixed combinations of

self-focused and other-focused UV assignments, and the results of the current study suggest that those structures may be necessary in order for the intervention to be effective, at least in this particular context (i.e., introductory biology courses for prospective majors in the biological and health sciences). More work is needed to determine whether other assignment structures might be equally (or more) effective in other contexts.

The Benefits of Variety

Giving students a fixed combination of self-focused and other-focused UV assignments affords them the opportunity to complete both assignments, and thereby reap the benefits of each. Indeed, students performed better in the variety conditions than the conditions in which they completed the same type of assignment three times. Although we did not find effects of variety on the motivational variables we tested in this study (task engagement, interest in biology, personal importance of biology), it is likely that completing a variety of assignments has motivational benefits compared to completing the same assignment multiple times. For

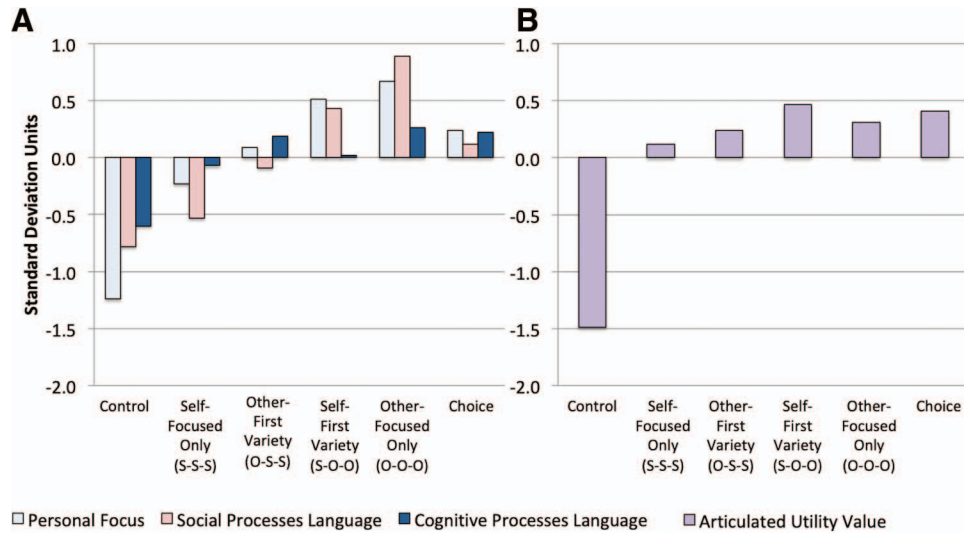


Figure 4. (A) Personal focus, social processes language, and cognitive processes language and (B) articulated utility value as a function of condition, among the fixed-order conditions. Values are presented in standard deviation units, standardized around the grand mean. S = self-focused UV essay; O = other-focused UV letter. See the online article for the color version of this figure.

example, having a variety of assignments introduces novelty over the course of the semester, which may promote situational interest or reduce negative academic emotions such as boredom or frustration (e.g., Palmer, 2009). Future research could include more measures to investigate the mechanisms of the variety effect.

In addition to the overall benefits of variety, we found that a particular sequence of variety—self-first variety—was more effective for students with low performance expectations. Finding that variety functions differently depending on the order of assignments and a student’s initial performance expectations is surprising because both of the variety conditions involved writing about utility for both the self and others. In light of Eccles and colleagues’ (1983) focus on the self in the expectancy-value model, it could be important that students start by thinking about UV for themselves. Indeed, content analyses revealed that the self-first variety condition helped students to articulate the highest levels of UV, and we found some suggestive evidence that articulated UV may partially explain the benefits of the self-first variety condition

for students with low performance expectations. The self-first combination of UV assignments may offer the best of all worlds. The first assignment allows students to search for the all-important self-focused UV to set them on the right path for thinking about the relevance of the course material to their own lives throughout the semester. Later assignments focused on UV for others provide opportunities to find utility for more individuals, possibly with a broader scope than writing about the self might entail. For students with low performance expectations, the process of finding value in this way could compensate for their initial doubts about their abilities in the class.

The Benefits of Choice

Another way to expose students to both types of UV assignments is to structure the assignments in a way that gives students choices about which assignments to complete. The current study builds upon earlier work by Rosenzweig and colleagues (2018),

Table 7
Effect Sizes (β s) From Harackiewicz et al. (2016), Canning et al. (2018), and the Current Study

Source	Intervention main effect β	Intervention \times Prior GPA interaction β
Harackiewicz, Canning, Tibbetts, Priniski, and Hyde (2016)		
Combination of variety and choice	.08	-.05
Canning et al. (2018)		
All choice	.09	-.02
Current study		
Choice condition	.07	-.06
Self-first variety condition	.06	-.09
Other-first variety condition	.03	-.08
Self-focused only condition	-.01	-.03
Other-focused only condition	-.02	-.01

Note. GPA = grade point average.

who found that adding more choices to the UV intervention (three choices vs. one) increased its effectiveness. The current study was a stricter test of choice (three choices vs. no choice), and there were direct effects on performance, whereas Rosenzweig and colleagues (2018) found only indirect effects on performance. The positive effects of choice were evident on motivational outcomes as well. Students who had a choice regarding their assignment types were more engaged in the assignments and reported higher levels of interest in biology at the end of the semester. Moreover, their levels of task engagement mediated the effect of choice on course performance. These effects are consistent with the mediation by engagement found by Harackiewicz et al. (2016) and with prior work on choice in academic tasks (Patall et al., 2008; Reber, Canning, & Harackiewicz, 2018).

The fact that the choice condition was associated with greater engagement in the material and more interest in the domain likely reflects processes involved in interest development (Hidi & Renninger, 2006). Having been given a choice of assignment types, students may have a greater sense of autonomy and personal control and thus take more ownership of the assignment (Ryan & Deci, 2000), causing them to engage more deeply with the assignment. This deeper task engagement is reflective of situational interest and may play a role in helping students to find deeper, more personalized UV connections, which would increase the effectiveness of the UV intervention and further contribute to students' interest development (Hidi & Renninger, 2006). This course is taken by students who plan to major in the biological or medical sciences, so all students presumably came in to the course with some level of interest in biology. However, providing students with meaningful choices may have helped to sustain their interest throughout the semester. Indeed, content analyses did not reveal any differences in the way that students wrote about biology in the choice condition compared to the fixed-order UV conditions. This suggests that the increased task engagement and interest observed in this condition were related to the structure of the assignment (i.e., the fact that students were given choices), more so than what students chose to write about.

Self-Focused and Other-Focused Utility Value

The current study provides some insights into the effects of self-focused and other-focused UV assignments. Most of the previous UV intervention studies have used combinations of UV assignments, either by providing students choices or by assigning a fixed combination (Canning et al., 2018; Harackiewicz et al., 2016; Hulleman & Harackiewicz, 2009; Rosenzweig et al., 2018), and we found this approach to be more effective than assigning students the same type of assignment three times. This insight is important, because the positive results found in previous studies might lead one to conclude that these assignments are interchangeable, and that combination and order do not matter. However, we found the opposite to be true: effects proved to depend on both the structure of the assignment as well as the type of assignment completed.

Content analyses provided some evidence regarding the differences between these assignments and how they work together. We found that other-focused UV assignments, which are written in the format of letters, were more effective than self-focused UV essays for encouraging students to write with a personal style and use language reflective of social and cognitive processes. However, it was when these

two assignments were combined in a sequence with a self-focused UV assignment first that students articulated the highest levels of UV. Something about the experience of finding value for the self first, followed by value for others, seemed to help students to make higher-quality UV connections in their assignments. These results provide initial evidence that the self-focused and other-focused UV assignments that have been used almost interchangeably in the past do not, in fact, work in the same way but rather work in tandem.

Together, the results of the current study underscore the idea that the UV intervention works through multiple mechanisms, depending on the structure of the assignments and the characteristics of the students (e.g., their performance expectations). Understanding this kind of treatment heterogeneity is crucial as researchers and educators begin to scale-up this intervention to new contexts and new populations (e.g., Schwartz, Cheng, Salehi, & Wieman, 2016; Weiss, Bloom, & Brock, 2014). It is clear that we need a better understanding of which types and structures of assignments work for which students, and why.

Limitations and Constraints on Generality

One important limitation of the current study (and previous studies) is that the self- and other-focused UV assignments were written in different formats (i.e., essays and letters). In other words, the target of the UV assignments (i.e., self vs. other) is confounded with the format of the assignment (i.e., essay vs. letter). Our use of these assignments was intentional; we compared versions of the intervention that had been used in previous studies. However, now that it has been demonstrated that assignment type and structure can impact the effectiveness of the intervention, it will be important for future studies to disentangle the effects of assignment format and target. For example, it would be informative to determine whether any of the benefits of combining self- and other-focused UV assignments might be due to having a combination of assignment formats. In addition, because there were three writing assignments, the variety conditions included one self-focused essay and two other-focused letters, or vice versa. Additional research could examine different patterns of variety (e.g., two self-focused essays followed by one other-focused letter), to test the generalizability of the variety effects observed here. Another possibility would be to test whether variety in the target of the assignments (e.g., self, friend or family) is more effective than variety in format (e.g., essay vs. letter), to further explore how variety works in structuring assignments over time.

It is important to note that the effect sizes in this study are not large. The effects of choice and variety range from $d = .11$ to $d = .27$, which is in the lower range of effects sizes for value interventions (Lazowski & Hulleman, 2016). This is unsurprising given that we were manipulating different versions of the same intervention. The current study serves first and foremost as a proof of concept, that within a single college introductory biology course, tweaking the features of the UV writing assignments can have an impact on the content and style of students' writing, on the mechanisms through which the intervention appears to support student motivation and performance, and ultimately on the relative effectiveness of the different versions of the UV intervention. Assignment type and structure should be treated not as incidental implementation details but as important aspects of intervention design with implications for how we understand intervention effectiveness.

With regard to the specific results of the current study, the benefits of choice and variety in the UV assignment structure for all students, on average, as well as the benefits of writing about utility for the self early in the semester for students with low performance expectations, reflect effects consistent with prior research and theory. Thus, based on theory, we expect the patterns of relative effectiveness (e.g., variety being more effective than no variety) would generalize, at least to other introductory science courses (Simons, Shoda, & Lindsay, 2017). Previous research has shown comparable intervention effects in introductory psychology courses (Hulleman et al., 2010; Hulleman et al., 2017) and high school science courses (Hulleman & Harackiewicz, 2009). Therefore, we have no reason to think that the benefits of variety, choice, and self-focused UV writing observed in this study, or the benefits of UV interventions generally, are limited to biology courses, but additional research would be needed to confirm that expectation empirically. We urge caution in generalizing to student populations of different ages, however, because these studies have all been conducted with college students, with one exception (Hulleman & Harackiewicz, 2009). The assignments implemented in the current study require college-level writing skills. Different approaches to promoting perceptions of UV may be necessary with younger students (e.g., Gaspard, Dicke, Flunger, Schreier, et al., 2015).

Finally, as in past studies, the UV intervention in the current study was fully integrated into the curriculum as course assignments. We believe this integration is necessary for the intervention to be effective. However, as with any intervention, the UV intervention should be tailored to the context (see Harackiewicz & Priniski, 2018). This may include adjustments to the assignment timing and including instructional supports with the assignment prompt to suit the writing level of the students (e.g., providing examples of UV connections, guidance regarding structure and formatting, etc.). Pilot testing is recommended before implementation in a new context.

Conclusion

The results of UV interventions to date have been promising. However, in order for scale-up efforts to be successful, we need to understand the mechanisms through which various elements of the UV assignments promote student motivation and performance, and we need to determine which elements are necessary and sufficient for the intervention to be effective. The current study contributes to that understanding by providing the first systematic comparison of the effects of self-focused and other-focused UV assignments and the assignment structures that combine them. Whereas most of the previous research treated assignment types and structures as incidental details, our results indicate that they are key features of intervention design, with implications for the content and style of students' writing, the mechanisms through which the intervention supports student motivation and performance, and the effectiveness of the UV intervention in promoting performance in college science classes. The results of the current study suggest that incorporating variety and choice into the structure of the UV assignments can improve the effectiveness of the intervention.

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