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Do I want to do this now? Task delay as a function of valence weighting bias

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ABSTRACT

Across three studies, we use behavioral measures of task delay to demonstrate that valence weighting bias predicts the extent to which individuals delay initiating a task, particularly when they lack the motivation and/or opportunity (e.g., mental resources) to deliberate on their initial appraisals of situations. Study 1 revealed that people with a more negative weighting bias delayed submitting tax returns to a greater extent. In Study 2, students with a more negative weighting bias delayed more as they earned course credit as part of a research experience program, with this relation being all the stronger among those low in trait self-control. Finally, Study 3 provided causal evidence for this relation: within a sample of students recruited for their procrastination, shifting the valence weighting tendencies of the strong procrastinators toward a more neutral, objectively correct point led to less delay in the context of participation in a research experience program.

1. Introduction

A propensity for procrastination tends to be harmful. For example, Tice and Baumeister (1997) found that at the end of the semester, student procrastinators tended to get worse grades, and report more stress, symptoms of illness, and visits to healthcare professionals. Moreover, a number of other studies and meta-analyses have documented a negative relation between procrastination and task performance, well-being, health behaviors, and financial success (see Rozental & Carlbring, 2014 and Steel, 2007, for reviews).

The focus of the current research concerns observable behavior. Hence, the work that we will report focuses on individuals' decisions to delay the initiation and/or completion of a task that they are required to complete. The current paper proposes a novel perspective on this phenomenon. Specifically, we hypothesize that task delay is at least partly explained by individual differences in valence weighting bias—an individual's characteristic manner of weighting positive and negative signals when evaluating a novel stimulus. Before fully detailing our rationale for this proposed relation, we review the literatures on procrastination and valence weighting bias.

2. Procrastination and task delay

Procrastination is commonly defined as “the intentional yet irrational postponement of a course of action despite knowing that this delay has negative effects” and, hence, leading to the experience of “subjective discomfort” (Ferrari & Tibbett, 2017, p. 4046). Thus, we consider procrastination to consist of various components, including people's awareness that they are incurring negative consequences as a result of delaying, the associated discomfort produced by such awareness, as well as the observable behavior regarding the actual amount of time by which a task is delayed (Malatincová, 2015). Our focus is on this latter behavioral component, which we refer to as *task delay*. Theorists have emphasized that task delay can occur without any necessary awareness of negative consequences and/or without any necessary accompanying experience of discomfort. Hence, delay, in and of itself, may not represent an instance of procrastination (Krause & Freund, 2014). Given that the current research concerns itself with behavioral outcomes, we are admittedly examining the predictors of task delay, not the subjective state of procrastination. Nevertheless, the work is informed by the literature on procrastination, and the conceptual framework informs our understanding of procrastination.

One major question surrounding procrastination concerns its causes. Although sometimes thought about as an issue of poor time management or planning, researchers generally agree that procrastination most often reflects a failure of self-regulation (Sirois & Pychyl, 2013). Using this lens, the literature has amassed an impressive list of potential causes of procrastination, both situational (e.g., temporal proximity to focal task)

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and dispositional in nature (e.g., conscientiousness; see Steel, 2007, for a review). One variable that has received strong empirical support is the aversiveness of the focal task. For instance, an experience sampling study revealed that when people were procrastinating, they rated the activity in which they were engaged as more pleasant, less confusing, less difficult, and less stressful than the one they were delaying (Pychyl et al., 2000). Indeed, Steel (2007)'s meta-analysis found that the more unpleasant the focal task, the more likely people were to procrastinate. In general, the emotion regulation perspective suggests that people often procrastinate because they prioritize resolving negative feelings triggered by the focal task over making progress toward their goal (Sirois & Pychyl, 2013; Tice et al., 2001; Tice & Bratslavsky, 2000).

With this in mind, we turn to a brief review of theory and research behind valence weighting bias before connecting weighting bias to task delay, and then laying out our rationale for our hypothesis.

3. Valence weighting bias

When people encounter novel stimuli, they can inform their behavior by generalizing from their pre-existing attitudes. For example, if an American tourist traveling through Australia spots a dingo (an animal that the tourist has never seen before but bears resemblance to both domestic dogs and wolves), they may inform their behavior (i.e., whether to run or get closer) by weighing the extent to which the novel stimulus resembles targets toward which they have positive attitudes—in this case, domestic dogs—versus negative attitudes—in this case, wolves. It has been argued that such generalization is an exercise in *valence weighting*—the consideration of the extent to which a novel stimulus resembles previously known positives versus negatives. Based on this idea, a relatively-lengthy program of research has used an attitude formation and generalization task called BeanFest (Fazio et al., 2004) to derive a performance-based measure of an individual's valence weighting tendencies (see Fazio et al., 2015, for a review). In BeanFest, people first develop attitudes toward previously-unfamiliar bean stimuli by interacting with them in the context of a game in which the purpose is to accumulate points by approaching those beans that have positive value and avoiding those beans that have negative value. In a subsequent test phase, people see the now familiar *game beans,* as well as *novel beans* that vary in their resemblance to the game beans, and must categorize each as either positive or negative. Based on the pattern of categorization of the novel beans, researchers can assess how these attitudes formed during the initial phase generalize to visually-similar, yet novel (i.e., never before seen) beans. Those who give greater weight to the positive (negative) signals are said to have a positive (negative) valence weighting bias.

Valence weighting bias has been linked to judgment and behavior across numerous domains, including rejection sensitivity, interpretations of ambiguous scenarios, and risk-taking such that people with a more negative weighting bias tend to be more rejection sensitive, interpret ambiguous scenarios in a more threatening manner, and demonstrate a greater aversion to risk (Pietri et al., 2013a). Importantly, valence weighting bias also prospectively predicts outcomes that unfold outside of the lab. For instance, Rocklage et al. (2017) found that first-year college students with a more negative weighting bias tended to form fewer new friendships over a two-month period early in their first semester. Moreover, this relation held true over and above the impact of students' self-reported levels of extraversion.

However, research suggests that, in a manner parallel to the predictions of the Motivation and Opportunity as DEterminants (MODE) model (Fazio, 1990), valence weighting bias most strongly influences judgment and behavior when the *motivation* and/or *opportunity* (e.g., time, mental resources) to deliberate on one's initial appraisals is relatively low (Rocklage & Fazio, 2014). In one particularly relevant line of research, Zunick et al. (2017) focused on examining the relation between valence weighting bias and impulse control as moderated by trait self-control. They reasoned that individuals who tend to overweight positive signals would be more likely to act on their impulses (which are by their nature positive signals). One study assessed valence weighting bias via BeanFest and impulse control via performance on incongruent trials of the Stroop task. Importantly, the Brief Self-Control Scale (BSCS; Tangney et al., 2004)—a self-report measure of trait self-control specifically designed to assess the extent to which people are successful at overriding their initial reactions (e.g., emotions or impulses) to bring about desired outcomes—served as a proxy for people's motivation and/or mental resources to override impulses. As predicted, among those relatively low in trait self-control, a more positive valence weighting bias was significantly associated with more errors on incongruent trials of the Stroop task. However, no such relation emerged for those relatively high in trait self-control. This pattern of results suggests that valence weighting bias is most tightly linked with behavior for individuals who lack the motivation and/or resources to deliberate more extensively before judging or acting.

Importantly, research suggests that individuals appear to have difficulty reporting their valence weighting tendencies. For instance, when directly asked about the extent to which they weigh positive versus negative information, individuals' self-reports did not correlate with their weighting tendencies as measured in BeanFest (Pietri et al., 2013a). Moreover, the performance-based estimates of valence weighting bias obtained via BeanFest are not related to self-report measures of individual difference constructs like approach/avoidance temperament, the behavioral activation and behavioral inhibition systems, and the Big Five personality traits—among others (see Fazio et al., 2015, for a review of such null relations). Of particular relevance for the current project, valence weighting bias has been shown to bear no relation to neuroticism—the general tendency to experience negative states—which has been linked to procrastination through meta-analysis (Steel, 2007). It also is worth noting that the relation of the performance-based index to behavioral outcomes has been observed even when controlling for self-reported valence weighting tendencies (e.g., Rocklage et al., 2017; Rocklage & Fazio, 2014). As has been noted by many researchers, valence is often confounded with distinctiveness and diagnosticity (e.g., Skowronski & Carlston, 1989), which makes discerning and reporting their valence weighting tendencies particularly challenging for individuals. Thus, valence weighting bias as assessed by BeanFest appears to provide a unique performance-based index of the manner in which people deal with positive and negative signals during attitude generalization.

4. Current research

The current research seeks to provide evidence for a novel perspective on task delay. We combine knowledge from the valence weighting and procrastination literatures to arrive at our central hypothesis: task delay is partly a function of individual's valence weighting bias. Specifically, we posit that when faced with having to complete a task by a certain deadline, individuals simulate starting or continuing to engage in it. Baumeister and Masicampo (2010) have suggested that such mental simulations—the imagination of future events—are a primary function of conscious thought, and can facilitate action by leading people to form attitudes toward behaviors. In the context of impulse control, desire has been conceptualized as being a result of mental simulations in which people imagine enacting a desirable behavior like eating cake (Hofmann & Vohs, 2016). In the current context, we posit that when considering a pending deadline, people are driven to ask, "do I want to do this now?" The resulting mental simulations are likely characterized by considerable evaluative ambiguity as there are both positive (e.g., the satisfaction of making progress) and negative features (e.g., tediousness). The central idea guiding this work is that the answer to the question "do I want to do this now?" is an issue of valence weighting. That is, we propose that valence weighting bias influences the degree to which the aversiveness of a task impacts one's desire to engage in it, and consequently, the likelihood of delaying initiation or completion of the task. Evidence supporting this idea would add to our knowledge of why some people tend to unnecessarily delay tasks.

Although valence weighting bias serves as a general influence on initial appraisals of situations, those relatively low in motivation and/or mental resources to deliberate (e.g., those characterized by relatively low trait self-control) are more likely to be influenced by these initial appraisals (Rocklage & Fazio, 2014; Zunick et al., 2017). Hence, individuals lower in trait self-control may be more influenced by their valence weighting tendencies when considering whether to initiate a task. Furthermore, we propose that valence weighting bias is a causal determinant of task delay behavior. As such, we predict that shifting the valence weighting tendencies of strong chronic procrastinators (i.e., those with a negative weighting bias and low motivation/mental resources for self-control) toward a more neutral, objectively-appropriate point will result in less task delay.

We report three studies that test our hypothesis. Importantly, these studies use behavioral measures of task delay. In Study 1, we pre-select participants who tend to either submit their taxes early (late January or first two weeks of February) or late (first or second week of April) relative to the traditional tax submission deadline in the United States, and predict their standing on this variable from their valence weighting bias. Study 2 builds on this finding by examining whether a more negative weighting bias predicts psychology students' task delay behavior in a research experience program, and for whom it does so most strongly. Lastly, Study 3 aims to provide causal evidence regarding the effect of valence weighting bias on task delay. Specifically, it targets individuals who report struggling with procrastination, and aims to reduce their delay behavior in a research experience program by shifting their negative valence weighting tendencies toward a more neutral, equally-balanced level.

5. Study 1

To test our hypothesis, we employed a targeted approach in which we first sought out people who reported filing their taxes either relatively early (at the start of tax season in early January or the first two weeks of February) or relatively late in the process (shortly before the deadline in the first or second week of April) over a five-year span. The filing of tax returns provides an interesting window into people's delay behavior as, prior to the COVID-19 pandemic, the American tax system had a clear and consistent timeline in which eligible tax-payers received the necessary documents by late January and knew the deadline to complete the submission fell in mid-April. We believe that this situation leads people to ask themselves, “do I want to do this now?”, with the resulting appraisal shaping people's subsequent behavior. Importantly, experts have noted that there is virtually no incentive to delay filing one's tax return once the necessary information is gathered (Reinicke, 2021). This is especially true for individuals who expect to receive a tax refund. Thus, the time at which people tend to file their taxes represents a relatively pure measure of task delay.

Those individuals who reported filing their taxes in either in late January or early February (“early filers”) or the first or second week of April (“late filers”) were invited for a follow-up session in which we assessed their valence weighting bias via BeanFest and their motivation and/or resources to deliberate via the BSCS (Tangney et al., 2004). This latter instrument has been used to assess dispositional levels of motivation and/or availability of mental resources to deliberate on one's initial appraisals in previous research involving valence weighting bias and goal pursuit (Zunick et al., 2017). We predicted that late filers would tend to have a more negative valence weighting bias than early filers. On the basis of prior literature demonstrating a moderating role of motivation and/or opportunity in the relation between weighting bias and behavior, we also conducted a secondary, exploratory analysis in which we tested whether valence weighting bias interacted with trait self-control such that the relation between valence weighting bias and tax submission time was stronger among those reporting lower trait self-control. Uncertainty about the nature of the distribution of trait self-control scores within a sample of online participants who met our inclusion criteria was responsible for regarding the analysis as exploratory.

The university's institutional review board approved all study procedures (IRB: 2013B0528). Study 1 was preregistered. The preregistration documentation for this study—which includes the study design, planned sample size, inclusion/exclusion criteria, and planned primary analyses—is available online: https://aspredicted.org/CJZ_8J9.[2] All relevant measures, manipulations, and exclusions are reported. Study materials, data, syntax, and codebook files can be retrieved online: https://osf.io/jgue2/?view_only=f289c641c66d46bba272d2e0fd343e0a.

5.1. Method

5.1.1. Participants and prescreening

Participants were recruited via the MTurk platform. Recruitment was restricted to workers who were based in the USA. With the aim of enhancing the likelihood of obtaining a sample of conscientious participants, recruitment was further restricted to those who had completed at least one-hundred tasks (referred to as Human Intelligence Tasks or HITs) on the platform, and achieved at least a 95 % acceptance rate on the submission of those tasks (i.e., a HIT approval rate of 95 % or better). Participants provided informed consent prior to completing the study. We aimed to conduct our central analysis predicting tax submission time from valence weighting bias using a sample of 200 participants. This target sample size was determined by a desire to have approximately 100 participants per tax submission time cell.

Four thousand and seventy-eight MTurk workers participated in a one-minute pre-screening session in exchange for $0.50. During pre-screening, participants reported the time of the year at which they typically submitted their tax return over a five-year period (spanning from 2014 to 2019) using a seven-point scale starting with the response option “late January or first two weeks of February,” and escalating in two-week increments to the response options “first week of April” and “second week of April.” Importantly, only those participants who reported being personally responsible for filing tax returns, filed their tax returns on time, and *expected to receive a tax refund* were considered for inclusion in the study (see Supplemental Material for more details regarding the pre-screening procedure). In conjunction with the dangers associated with delaying one's taxes (Reinicke, 2021), the restriction of our sample to only those who expected to receive a refund allows us to infer that participants in this study reasonably expected to be worse off as a result of delaying their taxes, making the results of this study all the more relevant to procrastination. Although the pre-screening criteria do not speak to the experience of subjective discomfort, the expectation of a refund does indicate the awareness of a negative consequence to delaying.

We invited 447 participants who met the preregistered criteria (a random sample of 201 early filers and all 246 eligible late filers) to participate in the follow-up session. In total, 242 MTurk workers participated in a 30-minute online session in exchange for $4.00. However, ten participants were excluded for not having engaged sufficiently with the central task. We planned to maintain consistency with prior studies involving BeanFest by excluding participants whose learning of either the positive or negative beans fell 2.5 median absolute deviation units below the median of the corresponding distribution (Granados Samayoa & Fazio, 2021). However, when this approach yielded a negative value as a cutoff for poor learning, we elected to adopt a stricter criterion of excluding participants whose learning fell 2.0 median absolute deviation units below the median. Using this new criterion, nine participants were excluded for poor learning of either

[2] In the interest of full disclosure, Study 1 was conducted last, but we chose to present it first for expository purposes.

positive or negative game beans. One additional participant was excluded for failing an attention check. The final sample consisted of 232 participants (early filers = 98, late filers = 134; 118 males, 111 females, one non-binary, two preferred not to respond). According to a sensitivity analysis conducted using G*Power specifying a two-tailed test, an $\alpha = 0.05$, and a sample of 232, the study was adequately powered to detect a small effect ($OR = 0.68$) at 80 % power (Faul et al., 2007).

5.1.2. Tax submission time item

For the purposes of the central preregistered statistical analysis, we dichotomized people's reported tax submission time responses such that those filing in late January of the first two weeks of February were assigned a value of 0 and those submitting in either the first or second week of April were assigned a value of 1.

5.1.3. BeanFest

BeanFest consists of two phases. In an initial learning phase, participants are told that they will play a game that involves beans and points. The stimuli for this learning phase are 36 beans that are selected from different regions of a 10 × 10 matrix that varies along the dimensions of shape (ranging from circular to oblong) and number of speckles (ranging from one to ten). Half of these *game beans* are assigned positive value (+10 points), while the other half are assigned negative value (−10 points; see Fig. 1).

The goal of the game is to select positive beans and avoid the negative beans to maximize one's point total. On each trial of the learning phase, participants must decide whether they want to select or not select a bean. If they select a positive bean, their point total increases by ten points. If they select a negative bean, their point total decreases by ten points. If they decide to not select a bean, they are shown the value of the bean, but their point total does not change. This phase consists of three blocks of thirty-six trials, and each bean is presented once per block. Over the course of the learning phase, participants form positive and negative attitudes toward the game beans.

Next, participants enter a test phase in which they see all 100 beans from the matrix (the 36 game beans and 64 *novel* beans), and categorize each as having either been helpful or harmful during the game. When presented with a novel bean, participants must generalize from the attitudes they formed during the learning phase. However, because generalization partly depends on how well the game beans are learned, valence weighting bias is calculated as the difference between the participant's actual pattern of responding to the novel beans and their expected pattern of responding given their level of learning of the game beans, which is derived from a normative regression equation (see Fazio et al., 2015). In this way, valence weighting bias represents the extent to which people weigh positive or negative signals more strongly when evaluating novel stimuli.

5.1.4. Brief self-control scale

The BSCS (Tangney et al., 2004) was used to assess trait self-control. Individuals who score high on the scale are reporting that they typically have the motivation and resources for successful self-control. The scale consists of 13 items that ask participants to indicate the extent to which statements like "I am good at resisting temptation" and "I often act without thinking through all the alternatives" (reverse scored) reflect how they typically are using a five-point scale (1 = "Not at all like me" and 5 = "Very much like me"). The scale showed good reliability ($\alpha = 0.91$).

5.2. Results

To test our central hypothesis, we used IBM SPSS Statistics (Version 27) to model the relation between valence weighting bias and tax submission time using binary logistic regression. As predicted, a more negative valence weighting bias was significantly associated with delay in submitting taxes, $B = -1.49$, 95 % CI [−3.05, −0.13], $SE = 0.74$, $Wald = 4.02$, $p = 0.045$, $OR = 0.23$.

As a secondary preregistered analysis, we examined whether trait self-control interacted with valence weighting bias to predict tax submission delay. Notably, valence weighting bias and trait self-control were not significantly related, $r(230) = -0.03$, 95 % CI [−0.15, 0.11], $p = 0.71$. To test our exploratory hypothesis, we regressed dichotomized tax submission time (0 = early filers, 1 = late filers) on valence weighting bias, trait self-control, and their interaction term. The results revealed no significant interaction between valence weighting bias and trait self-control, $B = 0.77$, 95 % CI [−1.14, 2.69], $SE = 0.98$, $Wald = 0.63$, $p = 0.428$, $OR = 2.17$.

5.3. Discussion

The results of Study 1 suggest that valence weighting bias plays a role

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
X1	+	+	+			−	−	−		
X2	+	+			−	−	−			
X3						−				
X4									+	+
X5		−						+	+	+
X6	−	−	−						+	
X7	−	−								
X8					+					
X9				+	+	+			−	−
X10			+	+	+			−	−	−

Fig. 1. Selection of beans from the full matrix for use in the game phase of BeanFest. Beans differ in shape along the X-axis (from circular [X1] to oblong [X10]) and in the number of speckles along the Y-axis (from one speckle [Y1] to ten speckles [Y10]). The beans presented during the learning phase of this version of BeanFest are noted with their corresponding positive (+) or negative (−) value. Reprinted from Fazio et al. (2015).

in shaping task delay behavior. Specifically, we find that people with a more negative valence weighting bias are more likely to delay submitting their tax returns. Our secondary hypothesis regarding the possibility of an interaction between weighting bias and trait self-control was not supported. The study may simply have lacked sufficient power to detect an interaction, especially in light of the noise that often is associated with research conducted in a more field-like setting. We also suspect that some idiosyncrasies regarding participant recruitment may have played a role. To maintain high data quality, only MTurk workers with a demonstrated record of achievement (95 % + HIT approval rate) were allowed to participate in the study. An unintended consequence of this decision was an abundance of scores at the top end of the trait self-control distribution, resulting in a statistically significant higher average level of trait self-control in this study ($M = 3.67$ 95 % CI [3.57, 3.78], $SD = 0.79$, 23.3 % of scores below the scale midpoint) relative to Study 2 ($M = 3.10$ 95 % CI [2.98, 3.22], $SD = 0.65$, 50.3 % of scores below the scale midpoint), $t(377) = 7.38$, $p < 0.001$, $d = 0.78$. The level of trait self-control reported in Study 2 much more closely resembles what has been observed in prior validation research (Tangney et al., 2004). We reason that this near-ceiling effect may have hindered our ability to detect differences in the relation between valence weighting bias and tax procrastination.

6. Study 2

Having found evidence for a relation between valence weighting bias and task delay in Study 1, we turn to an investigation that was better situated to detect the predicted interaction between people's attitude generalization tendencies and their motivation and/or opportunity to deliberate on their initial appraisals. To measure task delay, we decided to focus on tracking behavior as introductory psychology students enrolled in a research experience program worked to accumulate course credit in exchange for participating in research. Knowing that they have to earn their credits before the semester ends, students are likely simulating the process of participating in research studies (signing up for the study, traveling to the lab, taking part in the study, etc.) throughout the semester, and in effect asking, “do I want to do this now?” Beyond capturing real-world delay behavior, this measure is valuable because it takes into account multiple behavioral observations across the entire semester, thereby putting us in a better position to detect the predicted interaction with trait self-control. As in Study 1, weighting bias was assessed using BeanFest and motivation and/or opportunity to deliberate was assessed via the BSCS (Tangney et al., 2004). Importantly, however, both were measured in lab setting with a much more homogenous sample than was true of Study 1.

The university's institutional review board approved all study procedures (IRB: 2013B0528). All relevant measures, manipulations, and exclusions are reported. Study materials, data, syntax, and codebook files can be retrieved online: https://osf.io/jgue2/?view_only=f289c641c66d46bba272d2e0fd343e0a.

6.1. Method

6.1.1. Participants

One hundred and sixty-four undergraduates enrolled in a research experience program participated in this study in exchange for course credit. Participants provided informed consent prior to completing the study. We arrived at this sample size by trying to recruit as many participants as possible during one academic semester. Two participants whose learning of the positive or negative game beans fell >2.5 median absolute deviation units below the median of the corresponding distribution (Leys et al., 2013) were deemed not to have been engaged in the task and, hence, were excluded from the main analysis. An additional 15 participants were excluded from the main analysis for failing to reach the required number of research credits. Such individuals may have run out of time or abandoned the goal of earning credit, but we believe it was likely that they dropped the course altogether. Our data provided no clarity in this regard, as participants granted us access to their research participation records, not their academic records. The final sample consisted of 147 participants (76 females, 70 males, one individual preferred not to answer). According to a sensitivity analysis specifying a two-tailed test, an $\alpha = 0.05$, and a sample of 147 participants, the study was adequately powered to detect a small effect ($f^2 = 0.05$) at 80 % power (Faul et al., 2007).

6.1.2. BeanFest

BeanFest was implemented as in Study 1.

6.1.3. Brief self-control scale

As in Study 1, we assessed trait self-control using the BSCS (Tangney et al., 2004). The scale showed good reliability ($\alpha = 0.84$).

6.1.4. Participation in research experience program

Task delay was measured through a quantification of the pattern of participation in a research experience program in which introductory psychology students take part in studies in exchange for course credit. To get full credit, students have the majority of the academic semester (109 days to be exact) to complete a pre-determined number of hours of research. To operationalize task delay, we calculated the average day of participation, with higher numbers indicating greater delay.

6.2. Results

Descriptively, the average day of participation across students was somewhat past the midpoint of the 109-day semester ($M = 57.43$, $SD = 23.68$). Also, as noted earlier, the trait self-control mean was substantially lower than in Study 1 (3.10 versus 3.67, $t(377) = 7.38$, $p < 0.001$), with considerably more participants scoring below the midpoint of the scale (50.3 % versus 23.3 %). In this study, and unlike Study 1, valence weighting bias and trait self-control were significantly correlated, $r(145) = -0.31$, 95 % CI [−0.45, −0.15], $p < 0.001$.

To test our hypothesis, we conducted a regression analysis predicting average day of participation from valence weighting bias, trait self-control, and their interaction. First, there was a significant main effect of trait self-control, $B = -12.21$ 95 % CI [−18.07, −6.36], $t(143) = -4.12$, $p < 0.001$, such that those lower in trait self-control exhibited greater task delay. Importantly, the interaction between valence weighting bias and trait self-control was statistically significant, $B = 35.53$, 95 % CI [7.34, 63.72], $t(143) = 2.49$, $p = 0.014$. Once again, we used the PROCESS macro for SPSS (Hayes, 2022) to probe the interaction at one SD above and below the mean of trait self-control. Among those relatively low in trait self-control, a more negative valence weighting bias significantly predicted a later average day of participation, $B = -35.85$, 95 % CI [−64.76, −6.95], $t(143) = -2.45$, $p = 0.015$, but no such relation emerged among those relatively high in trait self-control, $B = 10.37$, 95 % CI [−17.03, 37.77], $t(143) = 0.75$, $p = 0.456$ (see Fig. 2).[3]

We also examined an alternative index of task delay—the day of the semester on which the students earned their final research credit. This analysis yielded the same statistical findings, details of which are reported in the Supplemental Material.

6.3. Discussion

Using a real-world behavioral measure of task delay, Study 2 finds that, particularly among those relatively low in motivation and/or mental resources to override their initial appraisals, valence weighting

[3] Details regarding how the impulsivity and restraints subscales of the BSCS each moderate this relation, in both Studies 1 and 2, are presented in the Supplemental Material.

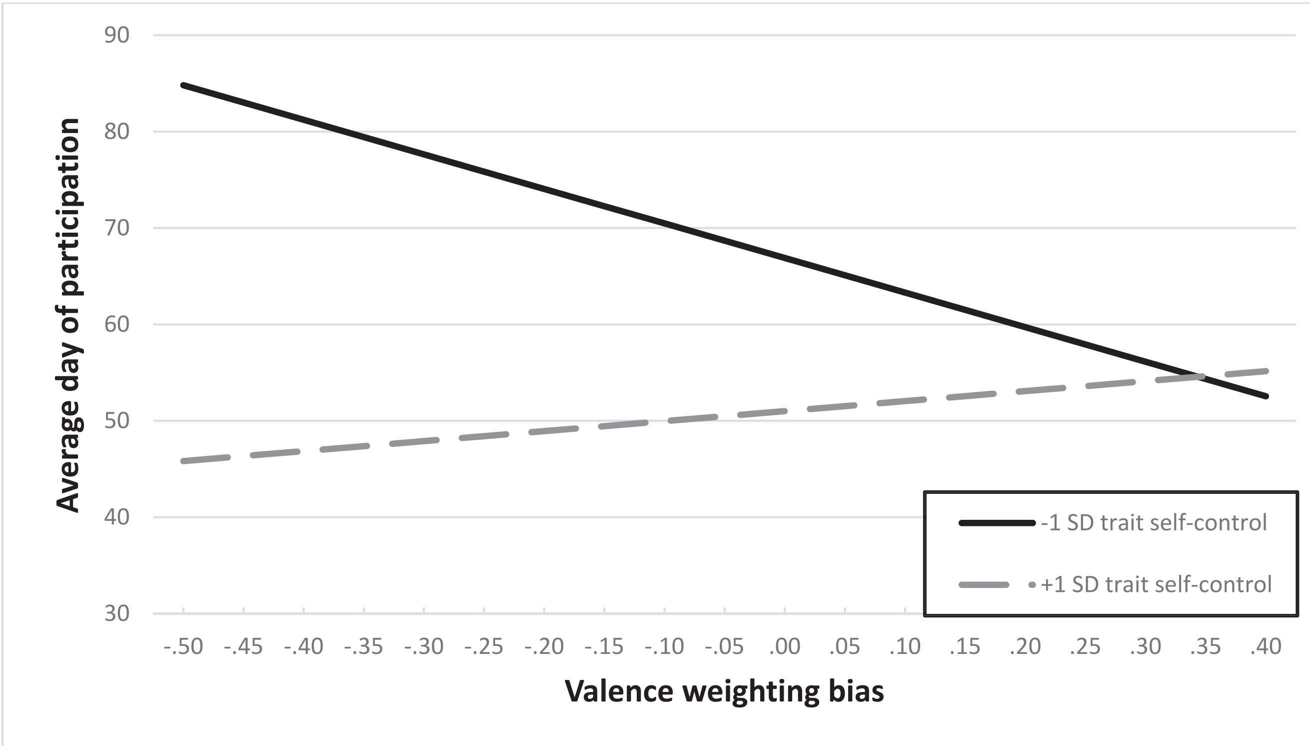

Fig. 2. Average day of participation in the research experience program by valence weighting bias, trait self-control, the interaction between valence weighting bias and trait self-control. Higher numbers on the vertical axis indicate later average day of participation.

bias predicts the extent to which students delay completion of their research experience program. In fact, it was those who both had a negative weighting bias and admitted that they generally lacked the motivation/resources for effective self-control that showed substantial evidence of task delay, as evidenced by a later average day of participation. In contrast, those who reported having relatively low motivation/mental resources but had a more positive weighting bias (and thus, more positive appraisals of engaging in the focal task) and those who reported having sufficient motivation/resources for effective self-control (independent of their weighting bias) tended to have an average day of participation that hovered around the midpoint of the semester, a pattern indicative of consistent effort toward completing the goal.

7. Study 3

Although the data presented thus far support the idea that valence weighting bias plays a role in driving task delay, causal inferences require experimental evidence. To examine causality, past research has adapted the BeanFest paradigm in such a manner as to allow for the manipulation of people's valence weighting tendencies (Pietri et al., 2013b). As before, participants start this version of BeanFest by developing attitudes toward game beans during the learning phase. After the learning phase, they are randomly assigned to either a control or *recalibration* condition. In the control condition, participants categorize both game and novel beans as having either been helpful or harmful during the game without receiving any feedback. However, those in the recalibration condition receive objectively-correct feedback regarding their categorization of every bean presented. For example, if a participant categorizes a novel bean that more closely resembles a positive game bean as being negative, they receive a message informing them that they categorized it incorrectly ("Error! This was *not* a negative bean"). As a result of recalibration, participants come to weigh positive and negative signals in a more balanced, objectively-correct manner.

The most immediate effect of recalibration is observed during BeanFest itself: by the end of the test phase, those in the recalibration condition are significantly more accurate in classifying novel beans. Not surprisingly, participants come to weigh positive and negative valence in a more objectively-correct manner as a result of the verbal reinforcement. Importantly, the influence of recalibration extends beyond the BeanFest environment: a series of studies by Pietri et al. (2013b) found that among those initially cautious (who tend to have a more negative weighting bias), recalibration led to increases in risk-taking and exploration. In contrast, among those with initial risky tendencies (who tend to have a more positive weighting bias), recalibration led to more cautious behavior. Similarly, recalibration of individuals who were initially relatively high in rejection sensitivity has been shown to reduce rejection sensitivity and lead to the subsequent formation of more friendships—attesting to the power of recalibration holds for shaping behavior beyond the lab (Rocklage et al., 2017).

To examine the issue of causality in the current domain, we tested whether recalibrating self-reported procrastinators lessens their task delay behavior in the context of a research experience program. Pursuing the same targeted intervention approach employed in past research (e.g., Rocklage et al., 2017), we sought individuals who report struggling with procrastination because this group should—according to the results of Study 2—tend to have a more negative valence weighting bias and lower motivation/mental resources to deliberate. Once in the lab, participants provided access to their record of participation in the research experience program, self-reported their tendency to procrastinate, and were then randomly assigned to either the control or recalibration version of BeanFest.

We predicted that those in the recalibration condition (vs. control) would subsequently delay less, as evidenced by greater participation in research in the two weeks following the in-lab session and less time taken to reach the maximum number of credits. Importantly, in line with previous research (Pietri & Fazio, 2017), this effect should be strongest among those with the greatest initial procrastination tendencies. The university's institutional review board approved all study procedures (IRB: 2013B0528). All relevant measures, manipulations, and exclusions are reported. Study materials, data, syntax, and codebook files can be retrieved online: https://osf.io/jgue2/?view_only=f289c641c66d46bba272d2e0fd343e0a.

7.1. Method

7.1.1. Participants

Sample size was determined by our attempts to recruit as many participants as possible from a limited pool of students who had been administered our prescreening questions and whose research participation records met the eligibility criteria across three academic semesters.

First, we needed to recruit individuals with a relatively negative weighting bias and low motivation/mental resources for effective self-control (in other words, people like the participants represented in the top left of Fig. 2). Preliminary data revealed that scores on the General Procrastination Scale (GPS; Lay, 1986)—a self-report measure of procrastination—are positively correlated with average day of participation in the research experience program, $r(103) = 0.40$, 95 % CI [0.21, 0.58], $p < 0.001$. Given that Study 2 suggests that those with a later average day of participation tend to have a more negative weighting bias and lower motivation/mental resources, we decided to recruit based on self-reported procrastination.

Due to time restrictions during the mass prescreening session, we were limited to using the two items from the GPS with the highest correlations with average day of participation ("In preparing for some deadline, I often waste time by doing other things" and "I usually start an assignment shortly after it is assigned" [R]). Students rated the extent to which these two statements were characteristic of them on a five-point scale (*1 = Extremely uncharacteristic, 5 = Extremely characteristic*). Our initial intention was to collect a sample of relatively extreme procrastinators by inviting those students who fell in the top tertile of the procrastination distribution. However, after encountering significant difficulty in recruiting enough participants, our invitation criteria were expanded to include those who fell above the median.

After three semesters of recruitment, 94 participants met all the criteria we had established for the experiment and constituted the effective sample (see Supplemental Material for details). We stopped data collection at this point because this sample size, after three semesters of data collection, was comparable to other in-lab experiments involving the recalibration of valence weighting tendencies. Previous sample sizes for such experiments range from $N = 77$ to $N = 109$ (Pietri et al., 2013b; Pietri & Fazio, 2017; Rocklage et al., 2017), with a mean of 89.4. All participants provided informed consent prior to completing the study.

As was true in previous studies, we also had to consider whether participants had successfully engaged with BeanFest to demonstrate adequate learning of the game beans. Nine participants (control = 2, recalibration = 7) whose learning of the positive and negative game beans fell >2.5 median absolute deviation units below the median of the distribution were excluded from the main analyses.[4] Thus, the final sample consisted of 84 participants (41 females, 42 males, one individual preferred not to answer). According to a sensitivity analysis specifying a two-tailed test, an $\alpha = 0.05$, and a sample of 84 participants, the study was adequately powered to detect a small effect ($f^2 = 0.10$) at 80 % power (Faul et al., 2007).

7.1.2. Self-reported procrastination tendencies

Because our institutional review board limits the use of prescreening data to the recruitment of participants (i.e., they are not meant to be used in the main analyses), we assessed self-reported procrastination again once participants entered our lab. To do so, we employed the same two items from the GPS (Lay, 1986) that were used to prescreen students for the experiment.

7.1.3. BeanFest – Recalibration

The recalibration version of BeanFest shares similarities with the measurement version. It consists of a learning and a test phase. However, instead of interacting with 36 beans scattered throughout the larger matrix during the learning phase, in the recalibration version participants interact with 10 beans from each of the four corners of the matrix (see Fig. 3).

This simplified version of the matrix serves two purposes. First, it promotes near perfect learning of the game beans which is crucial when the aim is to shift attitude generalization tendencies. Second, this arrangement allows for each novel bean to be objectively classified as more closely resembling either a positive or negative game bean because the matrix can be divided into quadrants.

After completing three blocks of the game phase and a training exercise that provides feedback on their categorization of beans, participants enter the test phase. During the test phase, 60 beans from the matrix (20 game beans, 40 novel beans) are categorized as having either been helpful or harmful during the learning phase. Importantly, participants in the control condition categorize the beans without receiving any feedback. However, those in the recalibration condition receive objectively-correct feedback on their responses (e.g., "Error! This was *not* a positive bean") after each and every trial. Thanks to this feedback, participants learn to weight positive and negative signals in a more balanced manner which shifts their valence weighting tendencies toward a more neutral point (for full details regarding the recalibration procedure, see Pietri et al., 2013b and Pietri & Fazio, 2017).

7.1.4. Participation in research experience program

To detect changes in task delay behavior, we once again focused on participation in a research experience program in which introductory psychology students take part in studies in exchange for course credit. Importantly, we were interested in both the more immediate and longer-term impact of the manipulation on task delay. To assess the immediate impact of recalibration, we used the number of credits earned during the two weeks after the experiment as our outcome of interest. We chose this two-week timeframe because it is consistent with previous research on the real-world effects of recalibration (Rocklage et al., 2017), and we reasoned that it was a sufficiently large window to allow for variability in research participation. The more credits participants completed during this window, the less task delay they exhibited.

The longer-term influence of recalibration was assessed by determining the amount of time it took students to reach the required number of credits after participating in the experiment. Because this experiment was conducted over three semesters and different semesters involved a slightly different number of days available to complete the required number of credits, we calculated time to reach the maximum post-experiment as a percentage of total available days in the semester (i.e., number of days to reach maximum/number of days in semester). Those taking less time to reach the maximum showed evidence of less task delay. Of course, the time at which students reach the maximum number of credits depends on the day at which they participate in our experiment and the cumulative number of credits earned to that point. Thus, we included these covariates in the main analysis.

7.2. Results

7.2.1. Manipulation check – Effects within the BeanFest environment

Overall, participants included in the main analyses demonstrated near-perfect learning of the game beans ($M = 0.95$, $SD = 0.06$). We investigated whether participants in the recalibration condition became more accurate in their categorization of novel beans over time by taking a signal detection approach in which we calculated d' using the number of hits and false alarms (Stanislaw & Todorov, 1999) for both the first

[4] The results remain substantively unchanged if this exclusion criterion is not applied.

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
X1	+	+	+	+			−	−	−	−
X2	+	+	+					−	−	−
X3	+	+							−	−
X4	+									−
X5										
X6										
X7	−									+
X8	−	−							+	+
X9	−	−	−					+	+	+
X10	−	−	−	−			+	+	+	+

Fig. 3. Selection of beans for use in the game phase of the recalibration version of BeanFest. As before, beans differ in shape along the X-axis, from circular (1) to oblong (10) and in the number of speckles along the Y-axis, from 1 to 10. The beans presented during the learning phase are noted with their corresponding positive (+) or negative (−) value.

and last 20 trials of the test phase. As expected, there was a significant interaction between *d'* scores over time and condition, $F(1, 82) = 33.50$, $p < 0.001$, $\eta_p^2 = 0.29$. During the first 20 trials, the *d'* scores of those in the recalibration condition ($M = 0.89$, $SD = 0.84$) did not significantly differ from those in the control condition ($M = 0.59$, $SD = 0.70$), $t(82) = 1.77$, $p = 0.080$, $d = 0.38$. However, the *d'* scores of those in the recalibration condition ($M = 1.82$, $SD = 1.29$) were significantly higher than those of participants in the control condition ($M = 0.52$, $SD = 0.47$), $t(82) = -5.60$, $p < 0.001$, $d = 1.35$—suggesting that participants in the recalibration condition did indeed come to weigh positive and negative signals in a more balanced manner when evaluating novel stimuli.

7.2.2. Effects on participation in the research experience program

First, we examined whether the recalibration had an impact on participation during the two-week window following the experiment. On average, participants completed 2.05 credits during this window, although there was considerable variability around this value ($SD = 1.98$). To test our prediction, we ran a regression model predicting the number of credits accumulated during the two-week window from condition (control = −0.5, recalibration = 0.5), self-reported procrastination, and their interaction. Although there was no main effect of condition, $B = 0.53$, 95 % CI [−0.34, 1.41], $t(80) = 1.21$, $p = 0.230$, there was a significant interaction between condition and self-reported procrastination, $B = 1.70$, 95 % CI [0.38, 3.11], $t(80) = 2.54$, $p = 0.013$. As before, we used the PROCESS macro for SPSS (Hayes, 2022) to probe the interaction at one *SD* above and below the mean of procrastination. Among those initially reporting relatively high procrastination, recalibration led to the completion of more credits during this two-week window, $B = 1.83$, 95 % CI [0.40, 3.26], $t(80) = 2.55$, $p = 0.013$, but no such effect was evident among those reporting relatively low levels of procrastination, $B = -0.77$, 95 % CI [0.22, −2.02], $t(80) = -1.22$, $p = 0.225$. Looking at the data from another perspective, greater self-reported procrastination significantly predicted fewer number of credits completed during the two-week period, $B = -1.51$, 95 % CI

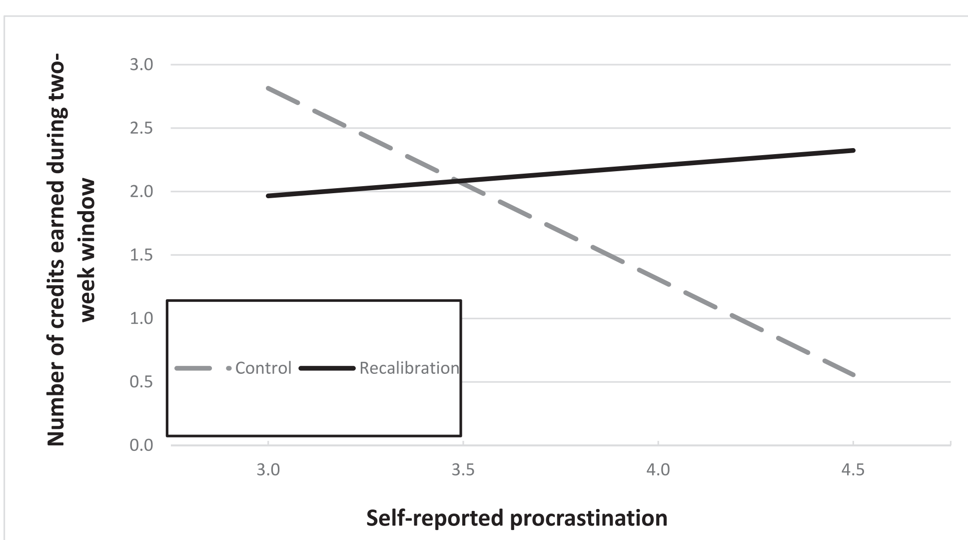

Fig. 4. Number of credits earned during two-week window after experiment by condition, self-reported procrastination, the interaction between condition and self-reported procrastination. Higher numbers on the vertical axis indicate a greater number of credits completed during the two-week window.

[−2.71, −0.30], $t(80) = -2.50$, $p = 0.015$—lending credence to our measure of task delay as indicative of procrastination. However, just as predicted, this relation was blunted by the recalibration procedure, $B = 0.24$, 95 % CI [−0.41, 0.89], $t(80) = 0.73$, $p = 0.468$ (see Fig. 4).

Next, we examined whether those in the recalibration condition reached the maximum number of credits sooner than those in the control condition. On average, it took participants 37.75 days to reach the maximum number of credits after taking part in our experiment, but there was, once again, considerable variability around the mean ($SD = 22.55$). As we expected, our covariates—the time of the semester at which students participated in our experiment and the number of cumulative credits earned to that point—were significantly associated with time taken to reach the credit maximum. Students tended to take less time to reach the maximum number of credits when they had participated in our experiment later in the semester, $r(82) = -0.42$, 95 % CI [−0.62, −0.20], $p < 0.001$, and when they had earned more cumulative credits as of that time, $r(82) = -0.29$, 95 % CI [−0.48, −0.09], $p = 0.007$. To test our hypothesis, we ran a regression model predicting time to reach the credit maximum from the covariates, condition (control = −0.5, recalibration = 0.5), self-reported procrastination, and the interaction between condition and self-reported procrastination. Once again, although there was no main effect of condition, $B = -0.04$, 95 % CI [−0.13, 0.06], $t(78) = -0.81$, $p = 0.422$, the interaction between condition and self-reported procrastination was statistically significant, $B = -0.16$, 95 % CI [−0.30, −0.02], $t(78) = -2.20$, $p = 0.037$. Among those initially reporting relatively high procrastination (1 *SD* above the mean), recalibration led to a reduction in the amount of time taken to reach the credit maximum, $B = -0.16$, 95 % CI [−0.31, −0.004], $t(78) = -2.04$, $p = 0.047$, but no such effect was evident among those reporting relatively low levels of procrastination (1 *SD* below the mean), $B = 0.08$, 95 % CI [−0.05, 0.21], $t(78) = 1.21$, $p = 0.230$. Focusing on the simple effect of self-reported procrastination within each condition revealed that greater self-reported procrastination predicted more time to reach the credit maximum, $B = 0.13$, 95 % CI [0.001, 0.25], $t(78) = 2.01$, $p = 0.048$, once again demonstrating the coherence between chronic procrastination and our measure of task delay. However, this relation was attenuated by the recalibration procedure, $B = -0.03$, 95 % CI [−0.10, 0.04], $t(78) = -0.88$, $p = 0.382$ (see Fig. 5).

7.3. Discussion

Study 3 provides evidence that weighting bias plays a causal role in shaping task delay. After screening for individuals with both a more negative weighting bias and relatively low motivation/mental resources for effective self-control using self-reports of procrastination, we found that among participants who reported the greatest chronic procrastination, those who underwent recalibration (vs. control) tended to engage in less task delay in both in the more immediate aftermath and over a longer period of time after the experiment. Although our prescreening approach was intended to exclusively recruit the most severe procrastinators, the slow pace at which participants initially enrolled in our experiment pushed us to begin recruiting those who fell above the median. Thus, the observed interaction between condition and self-reported procrastination was to be expected: recalibration should be most effective in reducing procrastination behavior among those participants who are higher in this regard at the start of the experiment. In other words, our manipulation of valence weighting tendencies was successful at reducing the procrastination behavior of those most likely to fit our desired profile of having a more negative weighting bias and relatively low motivation/mental resources for effective self-control. Among those with valence weighting tendencies that likely fall near the midpoint of the spectrum, recalibration should have no discernable effect, as was indeed the case.

Taking a different perspective on our findings is also instructive. We found that in the control condition, self-reports of procrastination significantly predicted task delay. That is, people's beliefs about their general chronic tendency to procrastinate tracked with their actual delay behavior. For one, this finding suggests that delay behavior in the context of the research experience program corresponds with people's reports of their chronic procrastination tendencies. Importantly, however, once participants learned to weigh positive and negative signals in a more balanced manner as a result of recalibration, the relation between self-reported procrastination and delay behavior was attenuated. Broadly, it was those control participants who reported the greatest procrastination that showed behavioral evidence of task delay. We found evidence of less delay among those who reported lower procrastination (irrespective of condition) and those who reported relatively higher levels of procrastination but underwent recalibration.

As noted earlier, the ability of a single administration of the

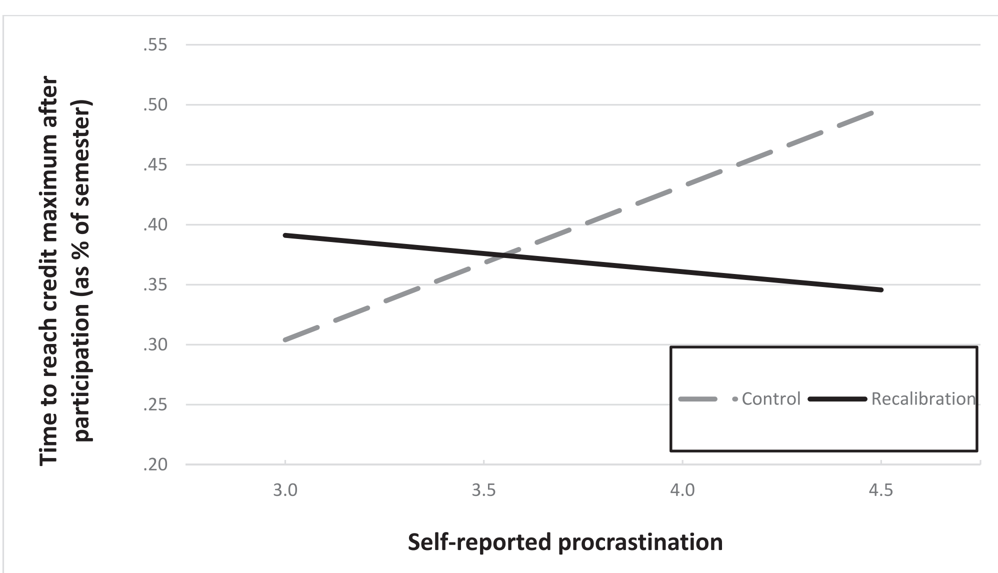

Fig. 5. Time to reach maximum number of credits after the experiment by time at which the student participated in the experiment, the cumulative number of credits earned to that point, condition, self-reported procrastination, and the interaction between condition and self-reported procrastination. Higher numbers on the vertical axis indicate more time taken to reach maximum number of credits after the experiment.

recalibration procedure to exert an effect on subsequent behavior, beyond the BeanFest context, has now been observed in many experiments. We believe that this can be attributed to several aspects of the procedure. First, recalibration is successful because it does something the real-world seldom does: it provides intense, consistent feedback over multiple trials about how one is weighing positive and negative signals when judging novel stimuli. Current theorizing posits that recalibration operates through operant conditioning mechanisms in which people come to learn to balance positives and negatives in a more equal manner through reinforcement as opposed to more controlled mechanisms like increased deliberation (Fazio et al., 2020). Second, because recalibration targets the fundamental psychological process of valence weighting, alterations to the manner in which people weigh positives and negatives during BeanFest transfers to the operation of the same weighting process outside the lab.

8. General discussion

The research reported here provides support for our hypothesis regarding the relation between valence weighting bias and task delay. In Study 1, we found that people's weighting bias predicted the time at which they tended to submit their tax returns. Study 2 revealed that among those relatively low in trait self-control—an index of whether people believe they have sufficient motivation and mental resources for effective self-control—a more negative valence weighting bias was significantly associated with greater delay as students participated in research in exchange for course credit. Together, these findings suggest that weighting bias reliably predicts task delay, and this relation is particularly evident among those with relatively low motivation and/or opportunity to deliberate on their appraisals. Study 3 provided evidence that valence weighting bias exerts a causal influence on task delay. Recalibrating the valence weighting tendencies of those most likely to initially have a negative weighting bias and low motivation/mental resources for self-control led to a reduction in procrastination behavior. Such individuals earned more credits in the two-week period following the experiment and were propelled to achieve their goal (i.e., reaching the credit maximum) sooner. These findings also highlight the potential of the recalibration procedure as an intervention for those who struggle with postponing work to meet a deadline.

Together, these studies deepen our understanding of the mental processes underlying task delay by suggesting a link between existing work on the situational features that predict procrastination—e.g., task aversiveness and negative moods—and a fundamental individual difference variable—valence weighting bias. To be specific, this work suggests that when faced with having to complete a task by a certain deadline, individuals appraise whether they want to start or continue to engage in that task. It is as if people are driven to ask, "do I want to do this now?" We believe that constructing such an appraisal involves weighing positive (e.g., making progress toward the goal) and negative signals (e.g., the tediousness of the task). This assertion is consistent with the accumulated literature. Indeed, people appear to delay action partly because they seek to alleviate the negative feelings associated with the completion of an aversive task (Sirois & Pychyl, 2013; Tice & Bratslavsky, 2000). Our work adds to this knowledge by providing evidence that the extent to which people weigh the aversiveness of a task is a function of individual differences in attitude generalization—their valence weighting bias—and the extent to which these appraisals influence behavior is a function of their motivation and/or resources to deliberate. At the same time, this work also demonstrates the broad reach of valence weighting bias by documenting another domain in which it influences behavior. Valence weighting appears to be a critical component of self-regulation. Future work may more directly investigate the mediating mechanisms responsible for triggering the reduction in procrastination over time.

Importantly, although our findings speak most strongly to task delay—the behavioral component of the procrastination construct—several features of our research suggest that the results are relevant to the procrastination literature. Although our emphasis on observable behavior means that we have no knowledge regarding the extent to which participants who exhibited delays experienced subjective discomfort, we would argue that the participants in our studies were aware of the negative consequences associated with delaying. College students seem readily aware of the difficulties involved in managing the "end-of-semester crunch"—a problem that grows all the more intense if one needs to earn research participation credits during the crunch time. Even more directly, because we pre-selected participants in Study 1 who generally expected to receive a tax refund and there are virtually no other benefits to delaying tax submission (Reinicke, 2021), we can reasonably assume that the late filers in that study expected to be worse off as a result of putting off their taxes. Finally, Study 3 revealed that the trimmed measure of self-reported chronic procrastination significantly predicted task delay in the research experience program, suggesting that delaying research participation represents procrastination.

CRediT authorship contribution statement

Javier A. Granados Samayoa: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Russell H. Fazio:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing – review & editing.

Declaration of competing interest

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Data availability

Data, syntax, and materials have been posted on OSF (https://osf.io/jgue2/)

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