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EMPIRICAL ARTICLE

Uncertainty and Perceptions of Competence Under Pressure: Affective and Motivational Consequences of Relative Feedback During Cognitive Performance

Almaz Mesghina[1], Natalie Au Yeung[2], and Lindsey E. Richland[2]
[1] Department of Psychology, Northwestern University, United States
[2] School of Education, University of California, Irvine, United States

Performance-contingent pressure can incentivize cognitive performance by increasing motivation and task-directed effort, yet also threaten performance by increasing anxiety and worries that tax limited cognitive resources. Uncertainty during performance—namely, participants' perceptions of their competence—may affect whether pressure is experienced as incentivizing or threatning, which can predict changes in motivation, affect, and effort. We manipulated perceived competence by randomly assigning participants to receive falsified positive (n = 60) or negative (n = 63) relative feedback while performing under a performance-contingent pressure that we have previously found incentivizes cognitive performance. Receiving negative (vs. positive) relative feedback predicted higher state anxiety, more amotivation, lower intrinsic motivation, lower perceived performance, and greater metacognitive miscalibration. These effects occured despite no effects of feedback on effort or cognition. This indicates that the affective and cognitive implications of alignment between one's competency and pressure may follow distinct pathways and underscores the important subjective effects of uncertainty, even in the absence of objective performance differences.

General Audience Summary

Performing under pressure can sometimes boost cognitive performance by increasing one's motivation to exert more effort. Yet, it can also threaten cognitive performance by heightening anxiety, which can induce worries that consume the same limited cognitive resources that one needs to perform on cognitive tasks. One way to reconcile these perspectives is by considering the role of uncertainty during performance—specifically, how certain does one feel about their competencies on the task? Perceived competence information is often provided via feedback: Those who receive negative feedback often report feeling less motivated, more anxious, and more disengaged with a task—all of which predict lower cognitive performance. In this study, we considered the role of uncertainty via feedback information while participants completed cognitive tasks under performance pressure where they needed to achieve a certain score to obtain a reward for them and another participant. Throughout the study, we randomly assigned participants to receive relative feedback (RF) on their performance (i.e., bogus percentile rankings) that was either positive (e.g., ∼90th percentile) or negative (∼30th). Crucially, this means that we manipulated how participants perceived their competence incidentally, without directly indicating anything about their actual performance or their potential to meet the pressure goal. Compared to those receiving positive RF, we found that participants who received negative RF reported greater anxiety, lower adaptive and higher maladaptive types of motivation, lower perceptions of their performance, and more substantially misaligned perceptions of their performance, even though feedback did not change participants' exerted effort or performance on the cognitive tasks. Prior research has shown that perceptions of competence have clear impacts on experiences and engagement during cognitive testing. Our findings add to this by underscoring its role in pressured settings and showing that these motivational and affective effects manifest independent of objective performance indices.

Keywords: performance pressure, state anxiety, situational motivation, perceived competence, metacognition

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Almaz Mesghina https://orcid.org/0000-0003-4001-5541
Lindsey E. Richland https://orcid.org/0000-0003-1514-6013
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continued

Performance–Pressure Relations and Working Memory

Performance-contingent pressures—where rewards are provided only if one achieves a certain performance threshold—can incentivize cognitive performance via increases in task-directed motivation and effort (see Bonner & Sprinkle, 2002; Botvinick & Braver, 2015). During working memory (WM) tasks, individuals performing under pressure showed greater activation in brain regions implicated in WM and greater performance on the most WM-demanding trials than no-pressure controls (Heitz et al., 2008; Jimura et al., 2010; Mesghina et al., 2022; Pochon et al., 2002). Still, performance-contingent pressures can also predict increased anxiety, stress, and distraction by co-opting these same WM resources and, consequently, hindering cognitive performance (Beilock, 2008). Feeling pressured can draw attention toward the self and away from the task (Beilock et al., 2004). Here, too, the threatening effects of pressure on cognition have occurred where demands on WM were greatest (Beilock & DeCaro, 2007; Crouzevialle & Butera, 2013; Gimmig et al., 2006).

Uncertainty and Perceived Competence Under Performance Pressure

These incentivizing and threatening aspects, however, are not mutually exclusive (Hardy et al., 2007). Perceived uncertainty and, relatedly, competence during performance can address these equivocal findings. First, pressure–performance effects may not be evidenced in task scores, but rather in performance efficiency (i.e., effort; Eysenck et al., 2007). Feeling heightened pressure and anxiety (threat) can motivate increased effort exertion in a compensatory manner (incentive; Hayes et al., 2009; Putwain & Symes, 2018). Feeling pressure can incentivize individuals to deploy limited cognitive resources toward the task, with longer, more concerted time-on-task (Attali, 2016; Castro et al., 2018; Wise & Kong, 2005) and positive consequences for performance (see Bonner & Sprinkle, 2002).

Crucially, one would only increase effort under pressure if they feel certain more effort would help achieve the goal (Bonner & Sprinkle, 2002). According to expectancy value theory (Wigfield & Eccles, 2000) and theories of threat, stress, and performance (Blascovich & Tomaka, 1996; Lazarus & Folkman, 1984), individuals' appraisals of their ability and competencies relative to task demands are important for motivation, affect, effort, and, ultimately, performance. Those who feel uncertain they will succeed tend to experience increased amotivation and reduced intrinsic motivation via reduced perceptions of competence (Guay et al., 2000), particularly if tasks are not intrinsically valued (Wigfield & Eccles, 2000). Relatedly, self-determination theory posits that feeling competent is key for motivated behaviors and may buffer against the negative effects of reduced autonomy, like when performing for extrinsic reward (Deci & Ryan, 1985). Thus, to understand pressure–performance relations, the role of uncertainty in one's task-related competencies while performing must be considered. We propose that whether pressure is threatening versus incentivizing changes with how certain one feels about their task competency.

Studies that have indirectly manipulated perceived competence underscore its role in performing under performance-contingent pressure. Kang et al. (2015) found that, when under pressure, business students assigned to seemingly higher ability roles demonstrated greater negotiation performance than those in lower ability roles. These performance differences disappeared under low pressure and after self-affirmations, suggesting perceived competence was particularly influential under pressure. This was further supported by Mesghina et al. (2022): Compared to controls, participants who completed WM and verbal reasoning tasks under pressure exerted more effort and reported greater motivation and anxiety. All participants received performance feedback that largely indicated they were performing well; when that feedback was removed in a follow-up study, the effects of pressure on effort and performance decreased considerably and quadrupled for confidence (Mesghina et al., 2022; see Rouault et al., 2019, for similar findings in nonpressured contexts). Cross-study comparisons, though limited, suggested that changes in certainty about one's competence corresponded to changes in the effects of pressure on affect, motivation, and performance.

Feedback as Information About Competence

Theories of Feedback and Performance

One way to convey information about one's competence on a task is via feedback (Hattie, 2013). It is through changes in perceived competence that feedback can influence performance (Kluger & DeNisi, 1996), motivation (Vallerand & Reid, 1988), and perceptions of performance (Rouault et al., 2019). Feedback indicates the gap between one's current capacity and desired outcome, which can incentivize increased effort and promote performance when the gap is small (Hattie & Timperley, 2007). Feedback indicating a large gap between current and ideal performance has predicted reduced motivation, engagement, and performance (Kluger & DeNisi, 1996).

Feedback may threaten cognitive performance by drawing attention toward the self and away from the task (Butler, 1987; Kluger & DeNisi, 1996), which is exacerbated when the feedback is negative (Eskreis-Winkler & Fishbach, 2019). Receiving negative feedback is often interpreted as a personal failure, and during incentivized, performance-contingent trials, this ego-threatening

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Correspondence concerning this article should be addressed to Almaz Mesghina, Department of Psychology, Northwestern University, 2029 Sheridan Road, Evanston, IL 60208, United States. Email: mesghina@northwestern.edu

aspect predicts lower learning, presumably by withdrawing effort (Eskreis-Winkler & Fishbach, 2019). As such, negative feedback can prompt individuals performing cognitive tasks to redirect their cognitive resources from the task and toward emotion-regulatory aims (managing anxiety), especially when the feedback is intense or baseline motivation is low (Grundmann et al., 2021).

Relative Feedback: Affective, Motivational, and Performance Consequences

Feedback does not need to indicate one's absolute performance to show these effects: Compared to no feedback or positive feedback, receiving falsified negative relative feedback (RF; e.g., "others seem to be doing better than [you]"; Hodgues & Spielberger, 1969) has predicted lower intrinsic motivation and perceived competence (Vallerand & Reid, 1988; see Deci & Ryan, 1985) and lower WM performance (Acklin, 2012; Hodgues & Spielberger, 1969). Even where falsified negative (vs. positive) RF promotes greater performance, it has also predicted greater dissatisfaction in one's performance, which in turn motivates more ambitious goals (Podsakoff & Farh, 1989). These motivational changes are not always adaptive: Some have found increased adoption of performance-focused (vs. mastery-focused) goals following negative RF (Senko & Harackiewicz, 2005), which predicted increased negative affect like heightened anxiety (Pekrun et al., 2006, 2009).

Merely anticipating RF can predict increased anxiety via motivational changes: Compared to anticipating no feedback or mastery-focused feedback, students who expected to receive a percentile ranking of their test performance relative to their class reported increased performance-avoidance goal endorsement (Pekrun et al., 2014). These effects could be exacerbated under pressure inductions, which intentionally incite performance-related goals and where the imposed goal likely heightens uncertainty. Again, this may be particularly important if the RF content is negative (Eskreis-Winkler & Fishbach, 2019; Grundmann et al., 2021; Kluger & DeNisi, 1996).

The Present Study

Negative feedback has clear affective and motivational consequences during cognitive performance, likely by inducing uncertainty via competence information. However, less is known about the role of negative feedback during performance under pressure, and little, if any, research has examined the impacts of RF on cognition under pressure. Thus, we had participants complete cognitive tasks under performance-contingent pressure and manipulated perceived competence by randomly assigning participants to receive falsified RF that was either negative (e.g., "71% of people have scored better than you on these tasks") or positive (11%) at various times after the pressure induction. Importantly, RF did not indicate anything about participants' absolute performance (scores): We induced incidental uncertainty about their competence without suggesting anything about their potential to achieve the performance-contingent pressure goal. Therefore, negative RF would not be wholly amotivating, nor would positive RF indicate that continued effort was unnecessary.

This study extends Mesghina et al.'s (2022; Study 2; pressure condition) design. Here, participants completed the same two cognitive tasks—WM and verbal reasoning—first with no pressure, then under a performance-contingent pressure. We focused on WM as it is a key moderator of pressure–performance relations (Beilock, 2008) and responsive to relative and absolute feedback (Acklin, 2012; Adam & Vogel, 2016, 2018; Hodgues & Spielberger, 1969). Here, three updates were made to Mesghina et al. (2022): (a) the feedback manipulation, (b) validated measures of state motivation and anxiety, and (c) a third cognitive task to increase the feedback dosage.

Given feedback is a key source of competence information (Hattie, 2013; Kluger & DeNisi, 1996), we hypothesized that negative RFs would report lower perceived performance, lower adaptive motivation (specifically, reduced intrinsic motivation and higher amotivation; Guay et al., 2000), and higher anxiety (Eskreis-Winkler & Fishbach, 2019) than positive RFs. Moreover, given the theoretical (Bonner & Sprinkle, 2002; Deci & Ryan, 1985; Wigfield & Eccles, 2000) and empirical (Kang et al., 2015) links between perceived competence, deployment of cognitive resources, effort exertion, and cognitive performance, we hypothesized that negative RFs would demonstrate lower effort and performance than positive RFs.

Method

Participants

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study (Simmons et al., 2012). We recruited 132 participants from a large, public university in the western United States. Participants were dropped due to computer malfunction ($n = 4$), experimenter error ($n = 2$), or guessing the confederate ($n = 3$). Thus, 123 participants were included in the final analysis—all randomly assigned to either pressure with positive RF ($n = 63$) or with negative RF ($n = 60$). We were sufficiently powered to explore most main effects (see Supplemental Materials). The study was not preregistered, but all data are available on the Open Science Framework at https://osf.io/qh6za/?view_only=99b1c34730804c8d8840ecb8904b83dc.

Procedure and Pressure Manipulation

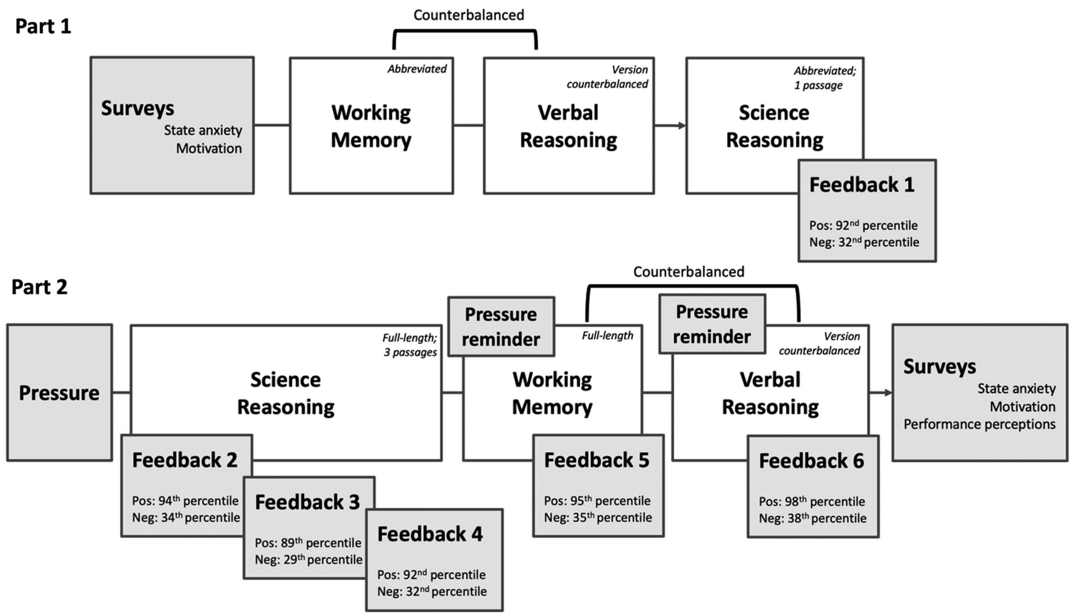
Figure 1 details the study procedure, including the timing of all measures and manipulations. The procedure largely replicated that of the pressure condition in Mesghina et al. (2022; Study 2). However, a few modifications to the study design are noted below.

All activities and prompts were programmed in E-Prime 3.0 and completed on a computer and individually. In Part 1, participants first reported their baseline state anxiety and situational motivation. Then, they completed an abbreviated WM task, verbal reasoning task, and science reasoning task. The first two were presented in counterbalanced order between participants (see below for the ordering of science reasoning task).

At the beginning of Part 2, we experimentally induced performance pressure for all participants. The pressure manipulation was a performance-contingent, social-evaluative threat induction that was modeled after other studies that successfully induced feelings of pressure during cognitive and WM task performance (Beilock et al., 2004; Mesghina et al., 2022; see Dickerson & Kemeny, 2004). Participants were told that they would have to "perform above 90% on all tasks during Part 2, otherwise you and the other participant cannot get an additional $5." The "other participant" was presumably the confederate in the laboratory waiting room who was pretending to be a volunteer waiting to participate in the study. After seeing this

Figure 1

Order of Administration of All Study Measures and Manipulations



Note. Relative feedback was provided after each of the three passages during the science reasoning task in Part 2. Bold text indicates study measures. Italicized text provides more detail about the length and order of said measures. Pos = positive relative feedback; Neg = negative relative feedback.

pressure prompt, participants completed the full-length WM task and verbal and science reasoning tasks, again counterbalancing the order of the former tasks. Reminders of the pressure were provided prior to each task. At the end of Part 2, participants again reported their anxiety and motivation and also reported their perceived performance on each of the three tasks. After Part 2, participants provided demographic information and were debriefed.

RF Manipulation

We imposed falsified RF to manipulate perceived competence. Feedback was provided once at the end of Part 1 and five more times throughout Part 2 (see Figure 1 for timing and full prompts). Participants saw social-comparative feedback prompts providing relative rankings:

> The program has automatically generated a score for your performance on the tasks so far. This score places you at the __th percentile of all participants who have taken these tasks to date. This means that __% of people have scored better than you on these tasks.[1]

These blanks were populated with falsified percentile scores that consistently reported participants were doing relatively poorer than (negative RF: 29th–38th percentile) or relatively better than (positive RF: 89th–98th percentile) all prior participants (for similar manipulations in WM contexts, see Acklin, 2012; Hodgues & Spielberger, 1969). All feedback prompts were identical across the tasks and between the two conditions with the exception of their percentile. No absolute performance feedback was provided at any point during the study—this RF was their only information regarding their performance.

Measures

WM Performance

We used the same WM tasks used in Mesghina et al. (2022). In Part 1, participants completed the shortened Operation Span Task (OSPAN; Foster et al., 2015), and in Part 2, the full-length OSPAN task (Unsworth et al., 2005). The OSPAN assessed WM capacity via a dual-task paradigm: Participants were presented with letters and tasked with holding them in mind while also making judgments as to whether arithmetic operations were true or false. Then, participants had to recall the letters in the order they were presented. The OSPAN was described as a "math task" to obscure our interest in their WM capacity and to ensure they paid equal attention to both portions of the task.

Trials varied in difficulty from three to seven items to recall. The shortened OSPAN had one block (set sizes 3, 4, 5, 6, and 7; a total of 25 items to recall). The full-length OSPAN had three blocks (75 items total). Scores were calculated as the proportion of items

[1] We added this last sentence to the feedback prompt given concerns during pilot testing that not all students would understand what "percentile" meant. We also added it to ensure that participants did not confuse their falsified percentile ranking with their absolute performance (scores on the tasks). Based on participants' answers to a free-response question posed during debriefing ("Do you think you performed above 90%? Why?"), we did not have reason to believe that participants confused their rankings with their scores. Rather, in the cases where some participants did reference their percentile rankings for the debriefing question, their use of the percentile was to inform, not determine, their perceived performance (e.g., "Yes, at the end of the task it told me what percentile I was in and it was pretty high so I assume I did pretty well"; "no. I think that seeing the percentage the amount of people who scored better than me made me feel nervous and doubt myself").

correctly recalled. Following Mesghina et al. (2022; Study 2), we removed all trial-by-trial performance feedback from the OSPAN—participants did not know how many items they successfully recalled, nor their arithmetic accuracy.

Verbal Reasoning Performance

Again, we used the same verbal reasoning tasks that Mesghina et al. (2022) used. Verbal reasoning was assessed to contrast changes in WM under pressure (much of the extant literature) from more multifaceted changes in cognition (see Mesghina et al., 2022, for a discussion). In Parts 1 and 2, the verbal reasoning task contained 18 sentence equivalence items from Magoosh, an online Graduate Record Exam practice software (Magoosh, n.d.). The sets were counterbalanced across participants, which did not predict performance (see Supplemental Materials). For each item, participants read a sentence that had two blanks in it and were asked to choose the two words (out of six) that best fit the sentence. For both Parts 1 and 2, we selected sentence equivalence items that were *easy* (4), *medium* (4), *hard* (5), or *very hard* (5) in difficulty, as determined by Magoosh. Part 1 and 2 scores were calculated as the proportion of correct responses.

Scientific Reasoning Performance

To circumvent a programming issue where we could only add feedback at the end of the WM and verbal reasoning tasks, we administered a new science reasoning task to increase the feedback dosage during Part 2, before participants completed the two tasks of interest. We also added it at the end of Part 1 for parity.

We used practice items from American College Testing preparation websites (see Supplemental Materials, e.g., items and sources). We selected "Evaluation of Models, Inferences, and Experimental Results" items assessing abilities to "judge the validity of scientific information and formulate conclusions and predictions" (American College Testing, n.d.). We chose this task (a) in accordance with our previous goal of contrasting WM versus non-WM-related changes in performance under pressure and (b) because performance would presumably be more responsive to effort as it was less reliant on prior knowledge than the verbal reasoning task (see Bonner & Sprinkle, 2002).

Each passage introduced a scientific topic followed by a scientist's arguments about said topic. Participants were asked to read each passage ($M = 264$ words) and answer three multiple-choice questions about the argument. Part 1 was abbreviated, with one passage and three multiple-choice items. Part 2 contained three passages (nine multiple-choice). RF was provided after each passage.

Effort

Time-on-task is a common and endorsed index of exerted effort (Bonner & Sprinkle, 2002; Wise & Kong, 2005), especially in studies examining performance under pressure (Attali, 2016; Castro et al., 2018; Mesghina et al., 2022). We programmed E-Prime to record time-on-task (in seconds) for the entirety of each of the three tasks and for both parts. The effort measure captured the amount of time (in seconds) participants spent on each test screen, meaning our measure of effort did not include how long participants spent reading the instruction slides.

State Anxiety

We assessed participants' state anxiety using an abbreviated version of the State Anxiety Inventory (Schmader & Johns, 2003; Spielberger et al., 1970). Participants were asked to reflect on how they were feeling right at that particular moment. Then, using a 7-point Likert scale (1 = *not at all*; 4 = *moderately*; 7 = *very much*), they rated their agreement with eight items (I feel worried, relaxed, calm, jittery, at ease, nervous, comfortable, anxious) assessing how they were feeling about the upcoming tasks (Part 1; $\alpha = .94$) and, retrospectively, their experience during the tasks (Part 2; $\alpha = .95$). We reverse coded the positively/neutrally worded items, then averaged responses to create two state anxiety measures.

State Motivation

We used the Situational Motivation scale (Guay et al., 2000) to measure participants' motivation to perform at the beginning of Part 1 and the end of Part 2. This scale is particularly suited for the present study because it (a) focuses on in-the-moment, state motivation and (b) considers multiple types of motivation, which is important as performance pressure and feedback have both been shown to have differential impacts on motivation outcomes and motivational approaches.

Specifically, the Situational Motivation scale consisted of 16 statements across four subconstructs. The intrinsic motivation subconstruct captured participants' intrinsic desires to participate in the activities because they wished to (e.g., "I am doing this activity because. … I think that this activity is interesting"). Conversely, extrinsic motivation is associated with the drive to complete an activity because of external reward or obligation, which is best captured by the external regulation subconstruct ("because it is something that I have to do"). Identified regulation is the extrinsic motivation construct corresponding to perceived value and choice toward an activity, even when performance goals are extrinsically dictated ("because I believe this activity is important for me"). Last, amotivation is the subconstruct associated with the absence of both intrinsic and extrinsic motivation for a task and often occurs when individuals feel helpless or purposeless (e.g., "I do this activity, but I am not sure if it is worth it").

Participants were asked to think about the task and why they were currently engaged in the study. Then, using a 7-point Likert scale (1 = *strongly disagree*; 4 = *neither agree nor disagree*; 7 = *strongly agree*), participants indicated their agreement with statements regarding the upcoming tasks (Part 1; $\alpha s = .62–.87$) and, retrospectively, their experiences during the tasks (Part 2; $\alpha s = .77–.92$). We averaged responses within each subconstruct to generate four measures of state motivation for both parts.

Perceived Performance and Metacognitive Calibration

At the end of Part 2, participants were asked: "If you were to take a guess, what do you think you scored on the [math/verbal/science] task?" Participants reported their perceived performance on a continuum (0–100) for each of the tasks. In an exploratory analysis, we grouped participants based on whether their perceived performance met the performance pressure criterion (above 90%). In another exploratory analysis, we computed metacognitive difference scores for each task (Part 2 perceived performance minus obtained performance) to better understand participants' calibration accuracy. A difference score of zero would indicate perfect metacognitive calibration, whereas a negative or positive score would indicate underconfidence and overconfidence, respectively.

Analytic Plan

We test whether receiving relatively positive or negative RF while performing under pressure predicted differences in performance, effort, anxiety, motivation, perceived performance, and metacognitive calibration. The analytic plan was modeled after Mesghina et al. (2022) and outlined in full detail here. Using multiple regressions, we examine the effects of condition on each Part 2 measure. Cohen's *d* effect sizes are reported.[2] For WM and verbal reasoning tasks, we ran repeated-measure analyses of covariance to test the interaction of condition (between subjects) and trial difficulty (within subjects) on performance, controlling for Part 1 scores. Throughout the results, partial correlations between relevant constructs of interest are reported. Where applicable, regressions and partial correlations controlled for baseline (Part 1) scores, and certain regressions controlled for demographic factors (race, gender, and whether the participant had previously taken the graduate record exam) that predicted task performance at baseline (see Supplemental Materials for balance checks and counterbalancing tests).

Results

Task Performance and Effort

Table 1 provides descriptive statistics for all measures, and Table 2 provides correlations among all Part 2 measures. Randomization to conditions was successful, and we collapsed counterbalanced conditions as there were no effects of order.

We found no effects of feedback on performance. See Table 3 for full regression outputs. For WM performance, there was no main effect of feedback ($d = -0.03$, $p = .83$). Further, the repeated-measure analyses of covariance revealed no significant interactions between condition and trial difficulty, $F(4, 480) = 0.03$, $p = .99$: RF had no effect on easy, medium, hard, and very hard trials. Similarly, we found no between-condition differences in either science reasoning ($d = -0.30$, $p = .10$) or verbal reasoning performance ($d = 0.03$, $p = .83$), and the latter also did not change with item difficulty, $F(3, 360) = 2.06$, $p = .11$. Last, regressions revealed no between-condition differences in participants' effort on either the WM[3] ($d = -0.09$, $p = .52$), verbal ($d = -0.23$, $p = .10$), or science reasoning tasks ($d = -0.10$, $p = .55$). Effort and performance were uncorrelated except for on the WM task, $r(119) = .24$, $p = .009$.

Perceived Performance

Despite no differences in cognitive performance or exerted effort between conditions, clear patterns in participants' affective and motivational experiences emerged with RF. The average participant did not believe they achieved the performance criterion of 90% (*M*s = 54%–80%), even though we did not provide any information about their absolute performance. Participants were more optimistic about their achieved scores on the verbal reasoning task ($M = 74\%$), followed by the science task (67%) and the WM task (64%). These perceptions of performance significantly changed with feedback condition: Compared to positive RF, receiving negative RF predicted a significant, negative impact on participants' perceived performance on all tasks, with the largest effects for WM ($d = -0.83$, $p < .001$) and science reasoning ($d = -0.75$, $p < .001$), followed by verbal reasoning ($d = -0.53$, $p = .004$; see Table 4). RF predicted participants' perceptions regardless of how well one performed, as these effects held after controlling for actual performance.

In an exploratory analysis, we dichotomized participants based on whether their perceived performance scores on each of the tasks met the 90% threshold criteria per the pressure induction. On all three tasks, a significantly greater proportion of individuals who received positive RF believed they met the performance criteria as compared to those in the negative RF condition, WM: $\chi^2(1) = 7.62$, $p = .006$; verbal reasoning: $\chi^2(1) = 9.09$, $p = .003$; science: $\chi^2(1) = 14.25$, $p < .001$. Notably, for the verbal reasoning task, half of all participants who received positive RF believed that they achieved 90% or higher on the task. This, again, despite no information about their actual obtained performance on the tasks. Conversely, only one negative RF participant rated their expected absolute scores to be above 90% on all three tasks, suggesting that the negative relative information was understood by most as meaning they were unlikely to reach the pressure threshold.

Metacognitive Calibration

Overall, however, participants' perceptions were not well calibrated with their performance. On each task, few participants (WM: $n = 11$; verbal: $n = 1$; science: $n = 5$) had obtained a score above 90% and perceived their performance to be above 90%. Therefore, we additionally explored whether RF condition predicted participants' metacognitive calibration of their perceived and actual scores on each of the tasks. See Table 1 for mean metacognitive calibration scores.

One-sample *t* tests showed that, on average, participants were significantly overconfident in their verbal reasoning performance, $t(121) = 7.66$, $p < .001$, and significantly underconfident in their WM, $t(122) = -9.25$, $p < .001$, and science reasoning performance, $t(122) = -5.98$, $p < .001$. Further, important between-condition differences in metacognitive calibration emerged (see Figure 2): Compared to positive RF, those receiving negative RF were even more underconfident in their WM: $t(121) = 3.91$, $p < .001$, $d = 0.71$, and science reasoning: $t(121) = 3.05$, $p = .003$, $d = 0.55$, performance. Negative RF participants were also somewhat less overconfident in their verbal reasoning performance compared to their positive RF counterparts; however, this difference was smaller in magnitude and did not achieve statistical significance, $t(120) = 1.93$, $p = .06$, $d = 0.35$.

These data coupled with the performance data above make clear that the aim to manipulate perceived competence through RF was evidenced in participants' perceived performance and metacognitive calibration accuracy, regardless of actual performance accuracy. In fact, perceived performance was unrelated to actual task

[2] For the regressions, we used the mces command in Stata (Shaw, 2022) to obtain the pooled standard deviation of the outcome to calculate the effect size (Cohen's *d*) for the marginal effects of relative feedback. That is, we calculated the effect size of relative feedback on each outcome controlling for the influence of relevant covariates.

[3] We also found no effect of relative feedback on effort using Mesghina et al.'s (2022) measure of effort (average time on the maintenance portion of the WM task; $d = -0.16$, $p = .20$).

Table 1
Descriptive Statistics for All Study Measures by Condition

Measure	Positive relative feedback (n = 60)		Negative relative feedback (n = 63)		Overall (N = 123)	
	Part 1	Part 2	Part 1	Part 2	Part 1	Part 2
State anxiety (out of 7)	2.93 (1.17)	3.09 (1.44)	2.71 (1.20)	3.90 (1.34)	2.82 (1.18)	3.50 (1.44)
Motivation (each out of 7)						
Intrinsic motivation	4.51 (1.02)	4.72 (1.10)	4.53 (0.85)	4.19 (1.14)	4.52 (0.93)	4.45 (1.15)
Identified regulation	4.90 (0.84)	4.99 (0.95)	4.75 (0.81)	4.50 (0.82)	4.82 (0.82)	4.74 (0.92)
External regulation	2.53 (1.16)	2.55 (1.41)	2.46 (1.29)	2.69 (1.36)	2.49 (1.22)	2.62 (1.38)
Amotivation	2.67 (0.98)	2.66 (1.18)	2.55 (0.89)	2.99 (1.03)	2.61 (0.94)	2.83 (1.11)
Working memory performance						
Set size 3	2.98 (0.13)	2.89 (0.48)	2.92 (0.24)	2.87 (0.33)	2.93 (0.36)	2.89 (0.29)
Set size 4	3.70 (0.81)	3.83 (0.75)	3.81 (0.42)	3.76 (0.64)	3.76 (0.78)	3.78 (0.54)
Set size 5	4.15 (1.54)	4.27 (1.43)	4.52 (0.66)	4.46 (0.79)	4.21 (1.48)	4.49 (0.73)
Set size 6	4.73 (1.75)	4.49 (1.80)	4.87 (1.17)	4.88 (1.41)	4.61 (1.77)	4.87 (1.29)
Set size 7	4.50 (2.07)	4.95 (2.14)	4.81 (1.56)	4.84 (1.69)	4.73 (2.11)	4.83 (1.62)
Overall % correct	0.81 (0.17)	0.84 (0.12)	0.82 (0.18)	0.83 (0.15)	0.81 (0.17)	0.84 (0.14)
Verbal reasoning performance						
Easy (out of 4)	3.50 (0.61)	3.53 (0.84)	3.14 (0.79)	3.15 (0.90)	3.32 (0.73)	3.33 (0.88)
Medium (out of 4)	2.62 (0.80)	2.49 (0.81)	2.47 (0.84)	2.50 (1.02)	2.54 (0.82)	2.50 (0.92)
Hard (out of 5)	2.51 (0.98)	2.65 (0.98)	2.33 (0.94)	2.46 (1.25)	2.42 (0.96)	2.55 (1.13)
Very hard (out of 5)	1.83 (0.88)	1.95 (0.89)	1.85 (0.99)	2.01 (1.11)	1.84 (0.94)	1.98 (1.00)
Overall % correct	0.58 (0.14)	0.59 (0.14)	0.54 (0.16)	0.57 (0.18)	0.56 (0.15)	0.58 (0.16)
Science reasoning performance						
Overall % correct	0.81 (0.26)	0.80 (0.14)	0.78 (0.26)	0.75 (0.17)	0.80 (0.26)	0.78 (0.16)
Effort (in seconds)						
Working memory task	141.06 (39.51)	373.51 (106.79)	144.06 (44.93)	372.04 (110.36)	142.58 (42.18)	372.75 (108.19)
Verbal reasoning task	529.66 (211.49)	486.00 (207.20)	506.03 (229.15)	426.54 (193.02)	517.56 (220.13)	455.55 (201.46)
Science reasoning task	206.21 (965.68)	555.11 (217.04)	241.54 (200.64)	552.95 (249.86)	224.31 (159.00)	554.00 (233.48)
Perceived performance (%)						
Working memory task		0.71 (0.20)		0.54 (0.22)		0.62 (0.23)
Verbal reasoning task		0.80 (0.17)		0.69 (0.20)		0.74 (0.19)
Science reasoning task		0.75 (0.17)		0.60 (0.18)		0.67 (0.19)
Proportion who perceived performance at or above 90%						
Working memory task		0.27 (0.45)		0.08 (0.27)		0.17 (0.38)
Verbal reasoning task		0.50 (0.50)		0.24 (0.43)		0.37 (0.48)
Science reasoning task		0.33 (0.48)		0.06 (0.25)		0.20 (0.40)
Metacognitive calibration (perceived performance minus Part 2 performance)						
Working memory task		−0.13 (0.20)		−0.30 (0.27)		−0.21 (0.26)
Verbal reasoning task		0.21 (0.21)		0.12 (0.25)		0.16 (0.24)
Science reasoning task		−0.05 (0.16)		−0.16 (0.21)		−0.11 (0.20)

Note. Values are means and standard deviations.

performance, except for science reasoning, $r(119) = .37$, $p < .001$, which was also the only task where effort was predicted by any motivation index, amotivation; $r(119) = -.29$, $p = .01$; Table 2.

State Anxiety and Motivation

Much like perceptions of performance, medium-to-large effects of feedback emerged on state anxiety and motivation during the tasks (see Table 4 for regression outputs). Negative RFs reported significantly higher state anxiety than positive RFs ($d = 0.64$, $p < .001$). Negative RFs also reported lower intrinsic motivation ($d = -0.48$, $p < .001$) and identified regulation ($d = -0.43$, $p = .001$) and significantly higher amotivation ($d = 0.38$, $p = .01$) than positive RFs. No effects of feedback emerged for participants' external regulation ($d = 0.13$, $p = .36$).

Those who were more anxious tended to report more maladaptive motivations (higher external regulation and amotivation) and fewer adaptive motivations (lower intrinsic motivation and identified regulation). These correlations, however, were small and did not achieve statistical significance (see Table 2). Experiencing higher state anxiety did predict lower perceived performance on all tasks, rs(119) ≤ .26, ps < .004, whereas motivation was unrelated to perceptions of performance. All motivation indices were moderately to strongly related to each other in predicted ways, with the exception of external regulation, which showed no relation to other motivation indices nor anxiety. This may be because all participants completed under the same extrinsic reward and thus were similarly motivated in that regard. Though relations among affective and motivational measures were evidenced, for the most part, motivation and anxiety indices were not related to any actual performance measures or effort (see Table 2).

Table 2
Partial Correlations Among Part 2 Outcomes, Conditional on Part 1 Scores

Outcome	State anxiety	Intrinsic motivation	Identified motivation	External motivation	Amotivation	Perceived performance	Effort
State anxiety							
Motivation							
Intrinsic	−.15						
Identified	−.13	.51***					
External	.08	−.05	−.05				
Amotivation	.08	−.25**	−.30***	.37***			
Perceived performance							
Working memory	−.26**	−.03	.17	.008	−.12		
Verbal reasoning	−.28**	−.06	.12	−.13	−.13		
Science reasoning	−.29**	.06	.18	−.06	−.16		
Effort							
Working memory	−.08	.002	.03	.0002	−.11	.10	
Verbal reasoning	−.01	.13	.08	−.13	−.14	.17	
Science reasoning	.05	.16	.09	−.009	−.29*	.03	
Performance							
Working memory	.05	−.01	−.03	−.08	−.01	.07	.24**
Verbal reasoning	.03	−.06	−.12	−.16	−.008	.18	.15
Science reasoning	.01	.009	.14	−.11	−.07	.37***	−.07

Note. Degrees of freedom for all partial correlations are 119. All partial correlations control for the two relevant Part 1 scores, except for perceived performance, which controls for Part 2 performance as this was only assessed once.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Discussion

Documented effects of pressure on performance, affect, and engagement have been equivocal. We considered uncertainty in one's perceived competence as one reconciliation point for the inconsistent findings. Participants in this study performed three cognitive tasks under a pressure induction that has previously predicted lower confidence and motivation, yet higher anxiety, relative to controls (Mesghina et al., 2022). Here, by manipulating perceived competence with falsified RF, we found divergent patterns under pressure. Negative (vs. positive) RF predicted higher anxiety, lower perceived performance, and poorer metacognitive calibration, supporting arguments that negative feedback can draw attention inwards and increase negative affect (Eskreis-Winkler & Fishbach, 2019; Grundmann et al., 2021; Kluger & DeNisi, 1996). We extend these accounts by incidentally manipulating perceived competence and examining these effects in pressured contexts.

We further nuance extant pressure research by considering the types of motivation experienced under pressure and their relations to other performance-relevant measures. Motivational perspectives (Deci & Ryan, 1985; Wigfield & Eccles, 2000) posit that individuals' task-related intrinsic motivation and identified regulation are positively related to their perceived competence and positive emotions, whereas their external regulation and amotivation are negatively related to both

Table 3
Results From the Regression Analyses of Part 2 Task Performance and Effort on Condition

Outcome	Predictor	*b* (*SE*)	*d*	*t*	Significance
Working memory performance	Part 1 performance	0.52 (0.06)		9.30	<.001
	Black	−0.23 (0.07)		−3.07	.003
	Hispanic/Latiné	−0.03 (0.02)		−1.25	.21
	Other	−0.10 (0.07)		−1.33	.19
	White	−0.009 (0.03)		−0.34	.73
	Negative feedback	−0.004 (0.02)	−0.03	−0.22	.83
Verbal reasoning performance	Part 1 performance	0.73 (0.08)		9.14	<.001
	Man	−0.01 (0.03)		−0.51	.61
	Taken GRE	−0.00001 (0.04)		0.00	1.00
	Negative feedback	0.005 (0.02)	0.03	0.22	.83
Science reasoning performance	Part 1 performance	0.10 (0.06)		1.89	.06
	Negative feedback	−0.05 (0.03)	−0.30	−1.68	.10
Working memory effort	Part 1 effort	0.002 (0.0002)		10.57	<.001
	Negative feedback	−9.13 (14.28)	−0.09	−0.64	.52
Verbal reasoning effort	Part 1 effort	0.0006 (0.00001)		9.53	<.001
	Negative feedback	−45.40 (27.38)	−0.23	−1.66	.10
Science reasoning effort	Part 1 effort	0.0006 (0.0001)		4.85	<.001
	Negative feedback	−23.28 (39.08)	−0.10	−0.60	.55

Note. Nonmen, Asian, and those who have not taken GRE are the reference categories for gender, race/ethnicity, and Taken GRE, respectively. *SE* = standard error; GRE = Graduate Record Exam.

Table 4

Results From the Regression Analyses of Part 2 State Anxiety, Motivation, and Perceived Performance on Condition

Outcome	Predictor	*b* (*SE*)	*d*	*t*	Significance
State anxiety	Part 1 state anxiety	0.38 (0.10)		3.79	<.001
	Negative feedback	**0.89 (0.24)**	**0.64**	**3.71**	**<.001**
Intrinsic motivation	Part 1 intrinsic	0.73 (0.09)		8.36	<.001
	Negative feedback	**−0.53 (0.16)**	**−0.48**	**−3.30**	**.001**
Identified regulation	Part 1 identified	0.78 (0.07)		11.59	<.001
	Negative feedback	**−0.38 (0.11)**	**−0.43**	**−3.43**	**.001**
External regulation	Part 1 external	0.70 (0.08)		8.73	<.001
	Negative feedback	0.18 (0.20)	0.13	0.92	.36
Amotivation	Part 1 amotivation	0.73 (0.08)		8.55	<.001
	Negative feedback	**0.42 (0.16)**	**0.38**	**2.63**	**.01**
Perceived performance: working memory	Part 2 performance	0.14 (0.14)		0.99	.32
	Negative feedback	**−0.17 (0.04)**	**−0.83**	**−4.59**	**<.001**
Perceived performance: verbal reasoning	Part 2 performance	0.12 (0.11)		1.17	.25
	Negative feedback	**−0.10 (0.03)**	**−0.53**	**−2.97**	**.004**
Perceived performance: science reasoning	Part 2 performance	0.40 (0.09)		4.27	<.001
	Negative feedback	**−0.14 (0.03)**	**−0.75**	**−4.48**	**<.001**

Note. Significant effects of condition are in bold. *SE* = standard error.

(Guay et al., 2000). This was supported in the present study: Negative RFs reported lower intrinsic motivation and higher amotivation than positive RFs, presumably because they perceived themselves as less competent (Vallerand & Reid, 1988). Unexpectedly, negative RF also negatively predicted individuals' identified regulation, suggesting participants felt more agentic and identified with the tasks when their feedback indicated relatively good performance. This may be particularly important when under pressure—a source of extrinsic motivation that predicts lower intrinsic and identified regulation (Deci et al., 1999; Guay et al., 2000). Notably, higher identified regulation tended to correlate with higher perceived performance, albeit weakly.

Effects of RF on motivation, anxiety, perceived performance, and metacognitive calibration under pressure were medium to large and consistent, yet their relations to performance and effort were less so: Correlations did not provide much evidence for indirect effects of anxiety or motivation on cognition. Further, there were no main effects of RF on participants' performance or effort, contrasting findings on WM (Acklin, 2012; Hodgues & Spielberger, 1969) and cognitive performance (Podsakoff & Farh, 1989). It is likely that the effects of the pressure superseded any impacts of feedback on performance. Across two previous studies (Mesghina et al., 2022), this same pressure manipulation predicted increased WM and verbal performance and smaller decreases in effort and buffered from the decrease in motivation relative to controls. Therefore, despite affective and motivational changes due to RF, all participants may have been maximally incentivized to perform due to the pressure.

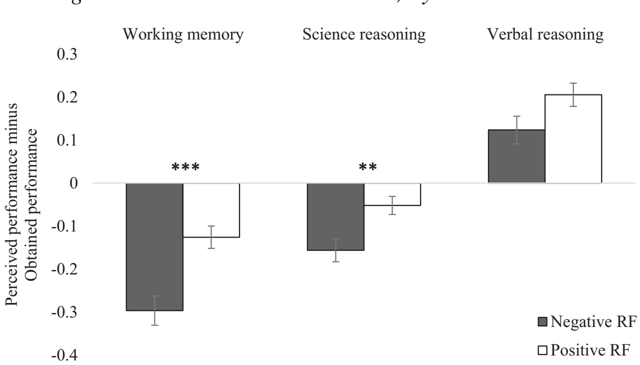
Still, we exercise caution without a control group, which was not our objective. Relatedly, it remains a question whether negative RF is threatening and/or positive RF is incentivizing. We focused on the former, congruent with much of the extant theoretical (Grundmann et al., 2021) and empirical (Eskreis-Winkler & Fishbach, 2019) evidence. Our metacognitive calibration analysis, where negative RF participants deviated the furthest from the accurate calibration, also provides some directional evidence in support of the former. Still, future research should consider a no-RF control.

Another explanation for the null effects of RF may be that consistently receiving ego-threatening information made individuals withdraw their task-directed attention (Eskreis-Winkler & Fishbach, 2019) and incited alternate goals like managing (Grundmann et al., 2021, 2024) or compensating for (Hayes et al., 2009) their higher anxiety. Presumably, then, participants' performance and time-on-task would be similar, but less efficient (Eysenck et al., 2007). Still, average anxiety was below the scale's midpoint. Effects of RF on performance may manifest under higher stakes (e.g., personally relevant pressure; Kang et al., 2015), where pressure would likely be more threatening, and performance outcomes more sensitive, to the competence manipulation.

Nonetheless, in this study, participants' affective experiences while performing under pressure were highly sensitive to cues about relative performance, above their obtained performance. This work is an important step toward understanding the role of perceived competence in pressure–performance relations. Researchers have touted challenge appraisals as integral for succeeding under pressure (e.g., Jamieson et al., 2018; see Blascovich & Tomaka, 1996), yet this appraisal is infrequently endorsed (Liu et al., 2017), and not always adaptive nor easy to deploy (Ford & Troy, 2019).

Figure 2

Metacognitive Calibration on Each Task, by Condition



Note. Metacognitive calibration was calculated as the participants' perceived performance on the Part 2 task minus their actual performance. Both are out of 100. RF = relative feedback.
** $p < .01$. *** $p < .001$.

Conversely, providing feedback is a more common, ecologically valid way to change how one appraises themselves (Hattie, 2013; Kluger & DeNisi, 1996).

RF was falsified for this study, but it does not need to be (e.g., Tran & Zeckhauser, 2012). Competence manipulations can also be self-initiated: Having students reaffirm their values eliminated the competence-related performance differences under pressure (Kang et al., 2015). Indeed, value affirmation interventions have predicted greater WM performance (Logel & Cohen, 2012) and efficiency in nonpressured settings, likely via motivational pathways (Harris et al., 2017). Combined with the present findings, this suggests that reminding individuals of their competence prior to performing could help them better calibrate their emotions, motivation, and metacognition. This could matter more in everyday, pressured contexts (e.g., standardized tests, final exams; Callender et al., 2015; Miller & Geraci, 2011), where baseline uncertainty is elevated due to high stakes and no feedback, and is an important future direction for related work.

References

Acklin, W. T. (2012). *The effects of feedback on working memory capacity* [Master's thesis, University of Georgia]. Ex Libris.

Adam, K. C. S., & Vogel, E. K. (2016). Reducing failures of working memory with performance feedback. *Psychonomic Bulletin & Review*, *23*(5), 1520–1527. https://doi.org/10.3758/s13423-016-1019-4

Adam, K. C. S., & Vogel, E. K. (2018). Improvements to visual working memory performance with practice and feedback. *PLOS ONE*, *13*(8), Article e0203279. https://doi.org/10.1371/journal.pone.0203279

American College Testing. (n.d.). *Science test description for the ACT*. https://www.act.org/content/act/en/products-and-services/the-act/test-preparation/description-of-science-test.html

Attali, Y. (2016). Effort in low-stakes assessments: What does it take to perform as well as in a high-stakes setting? *Educational and Psychological Measurement*, *76*(6), 1045–1058. https://doi.org/10.1177/0013164416634789

Beilock, S. L. (2008). Math performance in stressful situations. *Current Directions in Psychological Science*, *17*(5), 339–343. https://doi.org/10.1111/j.1467-8721.2008.00602.x

Beilock, S. L., & DeCaro, M. S. (2007). From poor performance to success under stress: Working memory, strategy selection, and mathematical problem solving under pressure. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*(6), 983–998. https://doi.org/10.1037/0278-7393.33.6.983

Beilock, S. L., Kulp, C. A., Holt, L. E., & Carr, T. H. (2004). More on the fragility of performance: Choking under pressure in mathematical problem solving. *Journal of Experimental Psychology: General*, *133*(4), 584–600. https://doi.org/10.1037/0096-3445.133.4.584

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental Social Psychology*, *28*, 1–51. https://doi.org/10.1016/S0065-2601(08)60235-X

Bonner, S. E., & Sprinkle, G. B. (2002). The effects of monetary incentives on effort and task performance: Theories, evidence, and a framework for research. *Accounting, Organizations and Society*, *27*(4–5), 303–345. https://doi.org/10.1016/S0361-3682(01)00052-6

Botvinick, M., & Braver, T. (2015). Motivation and cognitive control: From behavior to neural mechanism. *Annual Review of Psychology*, *66*(1), 83–113. https://doi.org/10.1146/annurev-psych-010814-015044

Butler, R. (1987). Task-involving and ego-involving properties of evaluation: Effects of different feedback conditions on motivational perceptions, interest, and performance. *Journal of Educational Psychology*, *79*(4), 474–482. https://doi.org/10.1037/0022-0663.79.4.474

Callender, A. A., Franco-Watkins, A. N., & Roberts, A. S. (2015). Improving metacognition in the classroom through instruction, training, and feedback. *Metacognition and Learning*, *11*(2), 215–235. https://doi.org/10.1007/s11409-015-9142-6

Castro, J. F., Yamada, G., Contreras, H., Linares, F., & Watson, H. (2018). *The effect of monetary incentives on cognitive effort, emotions and test-solving performance* (Working Paper No. 131). Peruvian Economic Association. https://perueconomics.org/wp-content/uploads/2018/12/WP-131.pdf

Crouzevialle, M., & Butera, F. (2013). Performance-approach goals deplete working memory and impair cognitive performance. *Journal of Experimental Psychology: General*, *142*(3), 666–678. https://doi.org/10.1037/a0029632

Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychological Bulletin*, *125*(6), 627–668. https://doi.org/10.1037/0033-2909.125.6.627

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Springer Science+Business Media. https://doi.org/10.1007/978-1-4899-2271-7

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin*, *130*(3), 355–391. https://doi.org/10.1037/0033-2909.130.3.355

Eskreis-Winkler, L., & Fishbach, A. (2019). Not learning from failure—The greatest failure of all. *Psychological Science*, *30*(12), 1733–1744. https://doi.org/10.1177/0956797619881133

Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and cognitive performance: Attentional control theory. *Emotion*, *7*(2), 336–353. https://doi.org/10.1037/1528-3542.7.2.336

Ford, B. Q., & Troy, A. S. (2019). Reappraisal reconsidered: A closer look at the costs of an acclaimed emotion-regulation strategy. *Current Directions in Psychological Science*, *28*(2), 195–203. https://doi.org/10.1177/0963721419827526

Foster, J. L., Shipstead, Z., Harrison, T. L., Hicks, K. L., Redick, T. S., & Engle, R. W. (2015). Shortened complex span tasks can reliably measure working memory capacity. *Memory & Cognition*, *43*(2), 226–236. https://doi.org/10.3758/s13421-014-0461-7

Gimmig, D., Huguet, P., Caverni, J. P., & Cury, F. (2006). Choking under pressure and working memory capacity: When performance pressure reduces fluid intelligence. *Psychonomic Bulletin & Review*, *13*(6), 1005–1010. https://doi.org/10.3758/BF03213916

Grundmann, F., Epstude, K., & Scheibe, S. (2024). Whether and how to regulate: Emotion regulation in negative-feedback situations. *Journal of Experimental Psychology: General*, *153*(5), 1281–1308. https://doi.org/10.1037/xge0001566

Grundmann, F., Scheibe, S., & Epstude, K. (2021). When ignoring negative feedback is functional: Presenting a model of motivated feedback disengagement. *Current Directions in Psychological Science*, *30*(1), 3–10. https://doi.org/10.1177/0963721420969386

Guay, F., Vallerand, R. J., & Blanchard, C. (2000). On the assessment of situational intrinsic and extrinsic motivation: The Situational Motivation scale (SIMS). *Motivation and Emotion*, *24*(3), 175–213. https://doi.org/10.1023/A:1005614228250

Hardy, L., Beattie, S., & Woodman, T. (2007). Anxiety-induced performance catastrophes: Investigating effort required as an asymmetry factor. *British Journal of Psychology*, *98*(1), 15–31. https://doi.org/10.1348/000712606X103428

Harris, P. S., Harris, P. R., & Miles, E. (2017). Self-affirmation improves performance on tasks related to executive functioning. *Journal of Experimental Social Psychology*, *70*, 281–285. https://doi.org/10.1016/j.jesp.2016.11.011

Hattie, J. (2013). Calibration and confidence: Where to next? *Learning and Instruction*, *24*, 62–66. https://doi.org/10.1016/j.learninstruc.2012.05.009

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, *77*(1), 81–112. https://doi.org/10.3102/003465430298487

Hayes, S., MacLeod, C., & Hammond, G. (2009). Anxiety-linked task performance: Dissociating the influence of restricted working memory capacity and increased investment of effort. *Cognition and Emotion*, *23*(4), 753–781. https://doi.org/10.1080/02699930802131078

Heitz, R. P., Schrock, J. C., Payne, T. W., & Engle, R. W. (2008). Effects of incentive on working memory capacity: Behavioral and pupillometric data. *Psychophysiology*, *45*(1), 119–129. https://doi.org/10.1111/j.1469-8986.2007.00605.x

Hodgues, W. F., & Spielberger, C. D. (1969). An indicant of trait or state anxiety? *Journal of Consulting and Clinical Psychology*, *33*(4), 430–434. https://doi.org/10.1037/h0027813

Jamieson, J. P., Hangen, E. J., Lee, H. Y., & Yeager, D. S. (2018). Capitalizing on appraisal processes to improve affective responses to social stress. *Emotion Review*, *10*(1), 30–39. https://doi.org/10.1177/1754073917693085

Jimura, K., Locke, H. S., & Braver, T. S. (2010). Prefrontal cortex mediation of cognitive enhancement in rewarding motivational contexts. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(19), 8871–8876. https://doi.org/10.1073/pnas.1002007107

Kang, S. K., Galinsky, A. D., Kray, L. J., & Shirako, A. (2015). Power affects performance when the pressure is on: Evidence for low-power threat and high-power lift. *Personality and Social Psychology Bulletin*, *41*(5), 726–735. https://doi.org/10.1177/0146167215577365

Kluger, A. N., & DeNisi, A. S. (1996). The effects of feedback interventions on performance: A historical review, a meta-analysis, and a preliminary feedback intervention theory. *Psychological Bulletin*, *199*(2), 254–284. https://doi.org/10.1037/0033-2909.119.2.254

Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer.

Liu, J. J. W., Vickers, K., Reed, M., & Hadad, M. (2017). Re-conceptualizing stress: Shifting views on the consequences of stress and its effects on stress reactivity. *PLOS ONE*, *12*(3), Article e0173188. https://doi.org/10.1371/journal.pone.0173188

Logel, C., & Cohen, G. L. (2012). The role of the self in physical health: Testing the effect of a values-affirmation intervention on weight loss. *Psychological Science*, *23*(1), 53–55. https://doi.org/10.1177/0956797611421936

Magoosh. (n.d.). *Magoosh online GRE prep & graduate admissions*. https://gre.magoosh.com

Mesghina, A., Au Yeung, N., & Richland, L. E. (2022). Performing up to par? Performance pressure increases undergraduates' cognitive performance and effort. *Journal of Applied Research in Memory and Cognition*, *11*(4), 554–568. https://doi.org/10.1037/mac0000023

Miller, T. M., & Geraci, L. (2011). Training metacognition in the classroom: The influence of incentives and feedback on exam predictions. *Metacognition and Learning*, *6*(3), 303–314. https://doi.org/10.1007/s11409-011-9083-7

Pekrun, R., Cusack, A., Murayama, K., Elliot, A. J., & Thomas, K. (2014). The power of anticipated feedback: Effects on students' achievement goals and achievement emotions. *Learning and Instruction*, *29*, 115–124. https://doi.org/10.1016/j.learninstruc.2013.09.002

Pekrun, R., Elliot, A. J., & Maier, M. A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology*, *98*(3), 583–597. https://doi.org/10.1037/0022-0663.98.3.583

Pekrun, R., Elliot, A. J., & Maier, M. A. (2009). Achievement goals and achievement emotions: Testing a model of their joint relations with academic performance. *Journal of Educational Psychology*, *101*(1), 115–135. https://doi.org/10.1037/a0013383

Pochon, J. B., Levy, R., Fossati, P., Lehericy, S., Poline, J. B., Pillon, B., Le Bihan, D., & Dubois, B. (2002). The neural system that bridges reward and cognition in humans: An fMRI study. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(8), 5669–5674. https://doi.org/10.1073/pnas.082111099

Podsakoff, P. M., & Farh, J.-L. (1989). Effects of feedback sign and credibility on goal setting and task performance. *Organizational Behavior and Human Decision Processes*, *44*(1), 45–67. https://doi.org/10.1016/0749-5978(89)90034-4

Putwain, D. W., & Symes, W. (2018). Does increased effort compensate for performance debilitating test anxiety? *School Psychology Quarterly*, *33*(3), 482–491. https://doi.org/10.1037/spq0000236

Rouault, M., Dayan, P., & Fleming, S. M. (2019). Forming global estimates of self-performance from local confidence. *Nature Communications*, *10*(1), Article 1141. https://doi.org/10.1038/s41467-019-09075-3

Schmader, T., & Johns, M. (2003). Converging evidence that stereotype threat reduces working memory capacity. *Journal of Personality and Social Psychology*, *85*(3), 440–452. https://doi.org/10.1037/0022-3514.85.3.440

Senko, C., & Harackiewicz, J. M. (2005). Achievement goals, task performance, and interest: Why perceived goal difficulty matters. *Personality and Social Psychology Bulletin*, *31*(12), 1739–1753. https://doi.org/10.1177/0146167205281128

Shaw, B. P. (2022). Effect sizes for contrasts of estimated marginal effects. *The Stata Journal*, *22*(1), 134–157. https://doi.org/10.1177/1536867X221083901

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2012). *A 21 word solution*. Social Science Research Network. https://doi.org/10.2139/ssrn.2160588

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the State-Trait Anxiety Inventory*. Consulting Psychologists Press.

Tran, A., & Zeckhauser, R. (2012). Rank as an inherent incentive: Evidence from a field experiment. *Journal of Public Economics*, *96*(9–10), 645–650. https://doi.org/10.1016/j.jpubeco.2012.05.004

Unsworth, N., Heitz, R. P., Schrock, J. C., & Engle, R. W. (2005). An automated version of the Operation Span Task. *Behavior Research Methods*, *37*(3), 498–505. https://doi.org/10.3758/BF03192720

Vallerand, R. J., & Reid, G. (1988). On the relative effects of positive and negative verbal feedback on males' and females' intrinsic motivation. *Canadian Journal of Behavioural Science/Revue canadienne des sciences du comportement*, *20*(3), 239–250. https://doi.org/10.1037/h0079930

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Wise, S. L., & Kong, X. (2005). Response time effort: A new measure of examinee motivation in computer-based tests. *Applied Measurement in Education*, *18*(2), 163–183. https://doi.org/10.1207/s15324818ame1802_2

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