**Online Supplement**

In this supplement we present additional analyses and information on the five studies reported in the main text.

**Study 1**

**Missing Data and Data Exclusions**

Excluded participants did not differ from included participants on baseline demographics such as school district site, χ2(1) = 1.67, *n.s*., gender, χ2(1) = 0.95, *n.s*., or ethnicity (White vs. non-White), χ2(1) = 0.79, *n.s*. Excluded participants did have lower GPAs, *t*(956)= -2.08, *p* = .04*.*

**Study 2**

**Effectiveness of Random Assignment**

Random assignment was effective. Participants in the treatment condition did not differ significantly from participants in the control condition on prior achievement (as measured by math pretest), *t*(207)= 1.56, *n.s*., or gender, χ2(1) = 2.89, *n.s*. Participants in the control condition were slightly more likely to be White than non-White, χ2(1) = 3.96, *p =* .05.We controlled for ethnicity across analyses to ensure this did not confound any of the results.

**Developing the Intervention Content**

After deciding on the main concepts we wished to convey in the intervention (both treatment and control conditions), our lab undertook a series of iterative attempts to craft an intervention that was attractive and interesting to students. We ran focus groups at participating schools to test the materials and then revised the modules based on student feedback. During focus groups, the research team gauged if there was (1) anything students did not like, and (2) whether there was anything students found confusing. Focus groups consisted of meeting in groups of 2-5 students at a time. To make sure that students in focus groups were as similar as possible to the final population, whenever possible, we conducted these focus groups with students who were one grade level above or one grade level below the students to whom the intervention would be delivered.

Through this process we changed many aspects of the intervention including the order in which topics were presented, the examples that were used to convey information, the language, the images that accompanied text, and even the amount of text that was displayed in each page. Through this iterative process, we created at an intervention that communicated the core concepts we wished to convey in a way that was appealing to students.

Several pilot studies were also run as part of our R&D process. The intervention used in these pilot studies was similar to the final intervention, but had not yet taken its final form. The four full-scale interventions reported in the paper are the only studies that were run using the finalized interventions described in the paper, and in which objective measures of achievement were collected (e.g., Khan Academy performance, GPA).

See **Table 1S** for a summary of the concepts communicated in the intervention and illustrative examples of how each was discussed (taken from the slightly revised intervention that we ran in Studies 4 and 5). To see the full text for the treatment condition see the Appendix (again, this text is the slightly adapted version of the intervention used in Studies 4 and 5).

**Timing of Administration and Outcomes**

Students took the intervention and signed into Khan Academy towards the end of the fourth quarter of the academic year. To ease the burden on participating schools, administrators were not required to send any information from school records (e.g., GPA). The intervention was administered so close to the end of the academic year that it seemed unrealistic to expect the intervention to change end-of-quarter achievement.

**Full Regression Output**

To see the full output from the regressions (the main effect and the interaction) see **Table 2S.**

**Study 3**

**Effectiveness of Random Assignment**

Random assignment was effective. Participants in the treatment condition did not differ significantly from participants in the control condition on prior achievement (as measured by midterm and fall GPA at the two respective colleges), *t*(118)= 0.29, *n.s*., gender, χ2(1) = 0.42, *n.s*., or ethnicity (White vs. non-White) χ2(1) = 1.64, *n.s*.

**Full Regression Output**

To see the full output from the regressions (the main effect and the interaction) see **Table 3S.**

**Study 4**

**Missing Data and Data Exclusions**

Sixth graders were not included in intervention analyses if they did not take the full intervention. Students were considered “non-completers” if they finished none or one of the two intervention modules. Non-completers did not complete the modules for a number of reasons: Either they opted out, experienced technological difficulties (e.g., computer crashed), or were absent. Completers did not differ from non-completers on prior achievement (as measured by 2nd quarter GPA), *t*(558)= -0.45, *n.s*., or baseline demographics such as gender, χ2(1) = 2.36, *n.s*., or ethnicity (White vs. non-White), χ2(1) = 0.58, *n.s*.

DPT data was missing for participants who did not participate in follow-up sessions, and was excluded for students whose participation was interrupted by snow days (approximately 40% of the sample). Participants with missing DPT data did not differ from participants who had DPT data on either prior (2nd quarter) GPA, *t*(425)= 0.47, *n.s*. or gender, χ2(1) = 0.68, *n.s*. By contrast, those with excluded DPT data were more likely to be White (72%) than included students (60%), χ2(1) = 6.44, *p* = .01. To ensure results were not confounded by this difference, ethnicity was controlled for in all analyses (for full list of covariates, see paper).

Participants who were missing self-report data (e.g., frustration tolerance) at any of the three time points (approximately 6-7% of participants) did not differ from participants with full data on any of the following: prior GPA,*t*(1279)= -1.17, *n.s*., gender, χ2(1) = 0.95, *n.s*., or ethnicity, χ2(1) = 0.94, *n.s*.

**Further Detail on the Linear Mixed Effects Models**

Beliefs and behaviors were analyzed with a linear mixed model in R statistical software. Parameter estimates were calculated using restricted maximum likelihood (REML). All individuals providing usable data were included in the analyses under the assumption that data were missing at random (MAR) (6). Repeated Level 1 measures were nested within students at Level 2. Given that trajectories across the three time points were expected to be nonlinear, time was treated as a three-level categorical variable. Treatment contrasts were used to compare mean levels of the dependent variable at both post-intervention follow-up assessments to the pre-intervention assessment, controlling for baseline levels of covariates. Random coefficients were used to capture between-student variability around the mean intercept (e.g., pre-intervention levels of the outcome variable) and in the mean slopes associated with the time contrasts (e.g., rates of change between pre-intervention and post-intervention assessments). Our model was comprised of level 1 predictors, including time contrasts and total time-focused (for DPT time focused analyses only), as well as level 2 predictors (condition, gender, and ethnicity), all possible cross-level, two-way interactions with time, and three-way interactions of condition\*time\*baseline grades when testing moderation hypotheses. Finally, a categorical variable coding school was included to account non-independence due to setting-level clustering.

**Effectiveness of Random Assignment**

Random assignment was effective. Participants in the treatment condition did not differ significantly from participants in the control condition on prior achievement (as measured by 2nd quarter GPA), *t*(425)= -0.62, *n.s*., gender, χ2(1) = 1.66, *n.s*., or ethnicity (White vs. non-White) χ2(1) = 0.28, *n.s*.

**Other Results for Self-Reported Beliefs**

As noted briefly in the main text, the intervention’s effect on practice-specific beliefs was not consistently moderated by incoming achievement; nor did the intervention reliably change non-practice-specific beliefs. Full results for these analyses are reported here.See **Figure 1S** and **Figure 2S** for the intervention’s main effect on practice-specific expectancies (deliberate practice beliefs) and practice-specific costs (frustration tolerance).

**Practice-specific beliefs**

***Deliberate practice beliefs.***There was no Condition X Prior grades interaction at Follow-up 1, *b* = 0.06, *SE* = 0.18, *t*(750) = 0.32, *p* = .75, or Follow-up 2, *b* = -0.17, *SE* = 0.20, *t*(750) = -0.87, *p* = .38. Rather, the intervention improved deliberate practice beliefs for students regardless of their incoming levels of achievement.

***Frustration tolerance.***There was no Condition X Prior grades interaction at Follow-up 1, *b* = 0.00, *SE* = 0.01, *t*(748) = 0.09, *p* = .93, or Follow-up 2, *b* = 0.00, *SE* = 0.01, *t*(748) = 0.36, *p* = .72. Rather, the intervention improved frustration tolerance for students regardless of their incoming levels of achievement.

**Non-practice-specific beliefs**

***Growth mindset.*** The intervention had no effect on growth mindset at Follow-up 1, *b* = 0.07, *SE* = 0.10, *t*(751) = 0.71, *n.s.*, or Follow-up 2, *b* = -0.06, *SE* = 0.09, *t*(751) = -0.67, *n.s*. There was also no Condition X Prior grades interaction at Follow-up 1, *b* = -0.00, *SE* = 0.01, *t*(749) = -0.10, *n.s*. , or Follow-up 2, *b* = -0.01, *SE* = 0.01, *t*(749) = 0.45, *n.s*.

***Locus of control.*** The intervention had no effect on locus of control at Follow-up 1, *b* = 0.04, *SE* = 0.07, *t*(751) = 0.61, *n.s.*, or Follow-up 2, *b* = 0.05, *SE* = 0.07, *t*(751) = 0.68, *n.s*. There was also no Condition X Prior grades interaction at Follow-up 1, *b* = -0.01, *SE* = 0.01, *t*(749) = -.96, *n.s*., or Follow-up 2, *b* = -0.01, *SE* = 0.01, *t*(749) = -1.49, *n.s*.

***Distress tolerance.*** The intervention had no effect on distress tolerance at Follow-up 1, *b* = 0.11, *SE* = 0.09, *t*(750) = 1.26, *n.s.*, but did have an effect at Follow-up 2, *b* = 0.28, *SE* = 0.10, *t*(750) = 2.83, *p* < .01. Because there was no change in distress tolerance immediately after the intervention, we expect that the change at Follow-up 2 was a statistical artifact. There was no Condition X Prior grades interaction at Follow-up 1, *b* = 0.02, *SE* = 0.01, *t*(748) = 1.17, *n.s*. , or Follow-up 2, *b* = 0.00, *SE* = 0.01, *t*(748) = 0.02, *n.s*.

**Other Results for Deliberate Practice Behavior**

See **Figure 3S** for the intervention’s main effect on deliberate practice behavior.

**Time Focused.** There were significant three-way interactions between Condition, Prior Grades, and both Time contrasts: Pre vs. Follow-up 1 (*b* = 13.39, *SE* = 6.29, *t*(378) = 2.13, *p* = .03) and Pre vs. Follow-up 2 (*b* = 13.54, *SE* = 6.20, *t*(378) = 2.18, *p* = .03). Unexpectedly, the intervention improved Time Focused more for higher-achievers than lower-achievers. The Johnson-Neyman method was used to identify the precise levels of baseline grades at which the effect of Condition on Time Focused was significant. At Follow-up 1, the effect of Condition on Time Focused was not significant at any levels of baseline grades; however, among those with high levels of baseline achievement (i.e., 1 SD above the mean or higher), there was a trend (*p* <.10) for intervention participants to have higher levels of Time Focused than control. At Follow-up 2, the effect of Condition on Time Focused was positive and significant among students scoring between the 58.55th and 83.84th percentiles on baseline grades (25.29% of the sample).

**Further Detail on Moderated Mediation**

Because the intervention’s effect on end-of-quarter achievement was driven by lower-achievers, we only expected changes in beliefs and behaviors to mediate the intervention’s effect in this lower-performing sub-group. Unfortunately, the current sample was underpowered to test for moderated mediation (Fritz & MacKinnon, 2007). Nevertheless, we conducted several exploratory analyses to examine the moderated-mediation hypothesis. That is, we examined whether there was an indirect effect of condition on achievement through the mediator (either deliberate practice beliefs, frustration tolerance, or time focused in the Deliberate Practice Task) at low or high levels of prior achievement using a cross-lagged panel model (Cole & Maxwell, 2003). Specifically, we expected that the effect of condition on the mediator would be significant at low, but not high, levels of prior grades. We included all covariates from the main model (e.g., gender, ethnicity). Using formulas provided by Preacher, Rucker, & Hayes (2007), we calculated the indirect effect at low (-1 *SD*) and high (+1 *SD*) incoming grades: *ab* = (*a*1 + *a*3\**w*)\**b*, where a1 represents the regression of the mediator (deliberate practice beliefs, frustration tolerance, or deliberate practice behavior as measured by the DPT) on condition, a3 represents the regression of the mediator on the interaction of condition\*prior grades, w represents the level of grades at which the indirect effect is being tested (e.g., -1 *SD*), and b represents the regression of end-of-quarter grades (the DV) on the mediator. Given that the sample was underpowered to conduct this test (Fritz & MacKinnon, 2007), it is not surprising that no evidence of moderated mediation was found.

**Full Regression Output**

To see the full output from the regressions (effects on beliefs, behaviors, and achievement) see **Table 4S** and **Table 5S.**

**Study 5**

**Missing Data and Data Exclusions**

Seventh graders were not included in intervention analyses if they did not take the full intervention. Students were considered “non-completers” if they finished none or one of the two intervention modules. As in Study 4, non-completers did not complete the modules for a number of reasons: Either they opted out, experienced technological difficulties (e.g., computer crashed), or were absent. Administrators in this district made every effort to schedule make-ups, thus minimizing the number of non-completers. Completers did not differ from non-completers on prior achievement (as measured by first quarter GPA), *t*(245)= -0.75, *n.s*., or baseline demographics such as gender, χ2(1) = 3.79, *n.s*., or ethnicity (White vs. non-White), χ2(1) = 0.02, *n.s*.

DPT data was missing for participants who did not participate in follow-up sessions, and was excluded for students whose participation was interrupted by snow days (approximately 60% of the sample). Participants missing DPT data did not differ from participants who had DPT data on prior (first quarter) GPA, *t*(230)= -0.89, *n.s*., gender, χ2(1) = 1.63, *n.s*, or ethnicity, χ2(1) = 0.26.

Participants who were missing data on self-reported beliefs (e.g., frustration tolerance) at any of the three time points (approximately 4-13% of participants) did not differ from participants with non-missing self-report data on any of the following: prior GPA,*t*(694)= 0.04, *n.s*., gender, χ2(1) = 0.01, *n.s*., or ethnicity, χ2(1) = 0.15, *n.s*.

**Effectiveness of Random Assignment**

Random assignment was effective. Across conditions, participants did not differ on prior achievement (as measured by 2nd quarter GPA), *F*(2,229) = 1.88, *n.s*., gender, χ2(1) = 2.64, *n.s*., or ethnicity (White vs. non-White) χ2(1) = 1.16, *n.s*.

**Other Results for Self-Reported Beliefs**

As in Study 4, the intervention’s effect on practice-specific beliefs was not consistently moderated by incoming achievement; nor did the intervention reliably change non-practice-specific beliefs. Full results for these analyses are reported here. See **Figure 1S** and **Figure 2S** for the intervention’s main effect on practice-specific expectancies (deliberate practice beliefs) and practice-specific costs (frustration tolerance).

**Practice-specific beliefs**

***Deliberate practice beliefs.***This measure was not administered prior to the intervention. Nevertheless, to maintain consistency across models, we used linear mixed model in R to examine effects at Follow-up 1 (one model) and Follow-up 2 (a separate model). The dependent variable (deliberate practice beliefs) was only measured at one time point in each of these models. We re-ran both models as ANOVAs and obtained virtually identical results.

There was no Full treatment X Prior achievement interaction at Follow-up 1, *b* = 0.39, *SE* = 0.34, *t*(206) = 1.13, *p* = .26, or Follow-up 2, *b* = -0.20, *SE* = 0.56, *t*(186) = -0.35, *p* = .73. Nor were there any Half treatment X Prior achievement interactions at Follow-up 1 [*b* = 0.44, *SE* = 0.33, *t*(206) = 1.36, *p* = .17] or Follow-up 2 [*b* = -0.06, *SE* = 0.54, *t*(186) = -0.11, *p* = .92].

***Frustration tolerance.***There was no Full treatment X Prior achievement interaction at Follow-up 1, *b* = -0.03, *SE* = 0.02, *t*(392) = -1.61, *p* = .11, or Follow-up 2, *b* = -0.02, *SE* = 0.02, *t*(392) = -1.06, *p* = .29. Nor were there any Half treatment X Prior achievement interactions at Follow-up 1 [*b* = -0.02, *SE* = 0.02, *t*(392) = -1.02, *p* = .31] or Follow-up 2 [*b* = -0.01, *SE* = 0.02, *t*(392) = -0.61, *p* = .54].

**Non-practice-specific beliefs**

***Growth mindset.*** The intervention had an effect on growth mindset at Follow-up 1, for both the full treatment, *b* = 0.32, *SE* = 0.15, *t*(396) = 2.16, *p* < .05*,* and half treatment condition, *b* = 0.35, *SE* = 0.14, *t*(396) = 2.43, *p* < .05*.* At Follow-up 2, this effect was still present for the half treatment group, *b* = 0.40, *SE* = 0.15, *t*(396) = 2.69, *p* < .01, but not the full treatment group, *b* = 0.15, *SE* = 0.15, *t*(396) = 0.98, *n.s*. There were no Condition X Prior achievement interactions at Follow-up 1 or Follow-up 2, for full treatment participants [Follow-up 1, *b* = -0.03, *SE* = 0.02, *t*(392) = -1.46, *p* = .14; Follow-up 2, *b* = -0.04, *SE* = 0.02, *t*(392) = -1.79, *p* = .07] or half treatment participants [Follow-up 1, *b* = 0.01, *SE* = 0.02, *t*(392) = -0.47, *p* = .64; Follow-up 2, *b* = 0.00, *SE* = 0.02, *t*(392) = 0.10, *p* = .92].

***Locus of control.*** The intervention had no effect on locus of control at Follow-up 1, for participants in either the full treatment, *b* = -0.01, *SE* = 0.11, *t*(396) = -0.10, *p* = .92 or half treatment condition, *b* = 0.13, *SE* = 0.11, *t*(396) = 1.22, *p* = .22*.* At Follow-up 2, there was likewise no effect for the full treatment group, *b* = -0.20, *SE* = 0.11, *t*(396) = -1.79, *p* = .07 or the half treatment group, *b* = 0.14, *SE* = 0.11, *t*(396) = 1.33, *n.s*. There were no Condition X Prior achievement interactions at Follow-up 1 or Follow-up 2, for full treatment participants [Follow-up 1, *b* = -0.01, *SE* = 0.02, *t*(392) = -0.84, *p* = .40; Follow-up 2, *b* = 0.02, *SE* = 0.02, *t*(392) = 1.30, *p* = .19] or half treatment participants [Follow-up 1, *b* = -0.01, *SE* = 0.02, *t*(392) = -0.54, *p* = .59; Follow-up 2, *b* = 0.03, *SE* = 0.02, *t*(392) = 1.64, *p* = .10].

***Distress tolerance.*** The intervention had no effect on distress tolerance at Follow-up 1, for participants in either the full treatment, *b* = -0.29, *SE* = 0.16, *t*(396) = -1.82, *p* = .07 or half treatment condition, *b* = 0.02, *SE* = 0.15, *t*(396) = 0.15, *p* = .88*.* At Follow-up 2, there was likewise no effect for the full treatment group, *b* = -0.12, *SE* = 0.16, *t*(396) = -0.71, *p* = .48, or the half treatment group, *b* = -0.11, *SE* = 0.16, *t*(396) = -1.39, *p* = .17. There were no Condition X Prior achievement interactions at Follow-up 1 or Follow-up 2, for full treatment participants [Follow-up 1, *b* = -0.02, *SE* = 0.02, *t*(392) = -0.79, *p* = .43; Follow-up 2, *b* = 0.02, *SE* = 0.03, *t*(392) = 0.74, *p* = .46] or half treatment participants [Follow-up 1, *b* = -0.03, *SE* = 0.02, *t*(392) = -1.40, *p* = .16; Follow-up 2, *b* = -0.01, *SE* = 0.02, *t*(392) = -0.39, *p* = .70].

**Other Results for Deliberate Practice Behavior**

See **Figure 3S** for the intervention’s main effect on deliberate practice behavior.

**Time Focused.** For the full treatment condition, the Condition X Prior achievement interaction was not significant at Follow-up 1, *b* = 3.53, *SE* = 17.97, *t*(92) = 0.20, *p* = .84, or Follow-up 2, *b* = -14.57, *SE* = 16.14, *t*(92) = -0.90, *p* = .37. Likewise, for students in the half treatment condition, the Condition X Prior achievement interactions were not significant at Follow-up 1 [*b* = -6.70, *SE* = 15.98, *t*(92) = -0.42, *p* = .68] or Follow-up 2 [*b* = -21.82, *SE* = 15.08, *t*(92) = -1.45, *p* = .15].

Because these interactions were of only marginal significance in Study 4 and they did not replicate here, the interaction finding in Study 4 was most likely a fluke; however, future research ought to examine this further to see if the finding in Study 4 replicates.

**Tests of Moderated Mediation**

As in Study 4, the current sample was underpowered to test for moderated mediation (Fritz & MacKinnon, 2007). Regardless, we conducted the same set of exploratory analyses detailed in the supplemental materials for Study 4 (refer there for details). As in Study 4, no evidence of moderated mediation was found. This was unsurprising given that the sample was underpowered to detect an effect.

**Full Regression Output**

To see the full output from the regressions (effects on beliefs, behaviors, and achievement) see **Table 6S,** **Table 7S** and **Table 8S.**

**References**

Cole, D.A., Maxwell, S.E. (2003) Testing mediational models with longitudinal data: Questions and tips in the use of Structural Equation Modeling. *Journal of Abnormal Psychology, 112*(4), 558-577.

Fritz, M.S., MacKinnon, D.P. (2007) Required sample size to detect the mediated effect. *Psychological Science, 18*(3), 233-239.

Preacher, K.J., Rucker, D.D., Hayes, A.F. (2007) Addressing moderated mediation hypotheses: Theory, methods, and prescriptions. *Multivariate Behavioral Research, 42*(1),185-227.

Table 1S

*Sample Intervention Content*

|  |  |
| --- | --- |
| Intervention Content Categories | Sample Content |
| **Tenets of Deliberate Practice** |  |
| Feedback | “To do deep practice, you also need to get immediate feedback.  Feedback means finding out what you got right and what you got wrong as soon as possible.” |
| Work on weaknesses | “Working on your weaknesses means doing things that are hard for you, instead of doing the things you already do well” |
| Concentrate 100% | “To do deep practice, you also need to focus.  Deep practice requires 100% attention.” |
| Repeat until mastery | “The last part of deep practice is that you need to repeat!  After you work on your weaknesses, focus, and get feedback, you need to keep working on your weaknesses, keep focusing, and keep asking for feedback.” |
| **Motivating beliefs** |  |
| Expectancies | “Once you start to think about it, you'll see lots of examples of things in the world around you that you thought were due to talent, but really, they come from deep practice and hard work.” |
| Values/Costs | “If you are frustrated or confused while practicing, it can mean that you are doing deep practice.  It can mean you are working on your weaknesses, and focusing really hard.” |

Table 2S

*Study 2 Results: Regression Models Predicting Khan Academy Performance*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Main effect** | | **Interaction** | |
| **Variable** | ***B*** | ***SE*** | ***B*** | ***SE*** |
| Condition | 0.09 | 0.14 | 0.09 | 0.14 |
| Math pretest | 0.07 | 0.07 | 0.25\* | 0.10 |
| Female | 0.19 | 0.14 | 0.18 | 0.14 |
| Ethnicity |  |  |  |  |
| Black | -0.09 | 0.20 | -0.16 | 0.20 |
| Hispanic | 0.16 | 0.22 | 0.19 | 0.21 |
| Asian | 0.76\* | 0.30 | 0.64\* | 0.30 |
| Other | -0.47\* | 0.21 | -0.45\* | 0.21 |
| School site 1 | 0.28 | 0.23 | 0.30 | 0.23 |
| School site 2 | -0.01 | 0.17 | -0.01 | 0.17 |
| School site 3 | -0.01 | 0.24 | 0.11 | 0.24 |
| Condition X Math pretest |  |  | -0.37\*\* | 0.14 |

\**p* < .05. \*\**p* < .01.

Table 3S

*Study 3 Results: Regression Models Predicting End-of-Semester Grades*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Main effect** | | **Interaction** | |
| **Variable** | ***B*** | ***SE*** | ***B*** | ***SE*** |
| Condition | 0.30\* | 0.15 | 0.31\* | 0.14 |
| Prior achievement | 0.62\*\*\* | 0.08 | 0.81\*\*\* | 0.11 |
| Female | 0.07 | 0.18 | 0.11 | 0.17 |
| Ethnicity |  |  |  |  |
| Black | -0.19 | 0.28 | -0.16 | 0.27 |
| Hispanic | -0.12 | 0.27 | -0.05 | 0.26 |
| Asian | 0.06 | 0.23 | 0.14 | 0.23 |
| Other | -0.38 | 0.47 | -0.47 | 0.46 |
| School site 1 | -0.04 | 0.17 | 0.02 | 0.16 |
| Condition X Prior achievement |  |  | -0.37\* | 0.15 |

\**p* < .05. \*\*\**p* < .001.

Table 4S

*Study 4 Results: Regression Models Predicting Beliefs and Deliberate Practice Behavior*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Frustration tolerance** | | **Deliberate practice beliefs** | | **Deliberate**  **practice behavior** | |
| **Variable** | ***B*** | ***SE*** | ***B*** | ***SE*** | ***B*** | ***SE*** |
| Condition | -0.08 | 0.06 | -0.15 | 1.22 | -39.89 | 29.49 |
| Prior achievement | 0.02\*\* | 0.01 | 0.39\*\* | 0.12 | 8.75\*\* | 2.91 |
| Standardized math achievement | 0.00 | 0.00 | 0.03 | 0.04 | -0.42 | 0.85 |
| Female | 0.00 | 0.06 | 3.63\*\* | 1.23 | 116.05\*\*\* | 29.99 |
| Ethnicity |  |  |  |  |  |  |
| Black | 0.14 | 0.15 | 2.24 | 3.00 | -10.00 | 73.25 |
| Hispanic | 0.18 | 0.12 | 0.23 | 2.41 | 90.74 | 57.06 |
| Asian | 0.20\* | 0.08 | 1.03 | 1.59 | 93.07\* | 38.46 |
| Other | -0.05 | 0.19 |  |  | -2.08 | 87.92 |
| School site 1 | 0.00 | 0.06 | -0.61 | 1.31 | 17.53 | 32.75 |
| School site 2 | 0.09 | 0.08 | -1.75 | 1.71 | 153.47\*\*\* | 38.46 |
| Time 2 X Condition | 0.42\*\*\* | 0.07 | 2.59\* | 1.25 | 92.48\* | 42.46 |
| Time 2 X Prior achievement | -0.01 | 0.01 | 0.06 | 0.12 | -1.65 | 4.37 |
| Time 2 X Standardized math  achievement | 0.01\* | 0.00 | -0.01 | 0.04 | 2.11 | 1.33 |
| Time 2 X Female | 0.13 | 0.07 | 1.46 | 1.26 | -6.91 | 43.31 |
| Time 2 X Black | -0.04 | 0.17 | -0.75 | 3.09 | 20.90 | 109.24 |
| Time 2 X Hispanic | 0.04 | 0.14 | 2.14 | 2.49 | -71.62 | 81.03 |
| Time 2 X Asian | 0.01 | 0.09 | 3.34\* | 1.58 | -70.30 | 51.49 |
| Time 2 X Other | 0.19 | 0.22 |  |  | 63.07 | 113.66 |
| Time 3 X Condition | 0.37\*\*\* | 0.07 | 3.21\* | 1.39 | 108.41\*\* | 40.50 |
| Time 3 X Prior achievement | 0.00 | 0.01 | -0.01 | 0.13 | -7.12 | 4.11 |
| Time 3 X Standardized math  achievement | 0.00 | 0.00 | -0.07 | 0.04 | 4.98\*\*\* | 1.25 |
| Time 3 X Female | 0.12 | 0.07 | 1.14 | 1.40 | 87.34\* | 41.48 |
| Time 3 X Black | -0.13 | 0.16 | -1.63 | 3.33 | -40.86 | 108.50 |
| Time 3 X Hispanic | 0.06 | 0.13 | 0.90 | 2.75 | -96.74 | 75.05 |
| Time 3 X Asian | 0.09 | 0.08 | 3.12 | 1.76 | -124.36\* | 48.31 |
| Time 3 X Other | 0.14 | 0.21 |  |  | -148.51 | 102.45 |

\**p* < .05. \*\**p* < .01. \*\*\**p* < .001.

Table 5S

*Study 4 Results: Regression Models Predicting End-of-Quarter GPA*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Main effect** | | **Interaction** | |
| **Variable** | ***B*** | ***SE*** | ***B*** | ***SE*** |
| Condition | 1.03\* | 0.46 | 1.05\* | 0.46 |
| Prior achievement | 0.93\*\*\* | 0.05 | 7.25\*\*\* | 0.41 |
| Standardized math achievement | 0.01 | 0.01 | 0.01 | 0.01 |
| Female | 0.80 | 0.47 | 0.84 | 0.47 |
| Ethnicity |  |  |  |  |
| Black | -0.88 | 1.11 | -0.59 | 1.11 |
| Hispanic | -0.60 | 0.90 | -0.52 | 0.90 |
| Asian | 1.04 | 0.61 | 1.05 | 0.61 |
| Other | 0.98 | 1.42 | 0.87 | 1.41 |
| School site 1 | 0.29 | 0.68 | 0.36 | 0.68 |
| School site 2 | 0.97 | 0.53 | 1.04\* | 0.53 |
| Condition X Prior achievement |  |  | -1.14\* | 0.47 |

\**p* < .05. \*\*\**p* < .001.

Table 6S

*Study 5 Results: Regression Models Predicting Beliefs and Deliberate Practice Behavior*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Frustration tolerance** | | **Deliberate practice behavior** | |
| **Variable** | ***B*** | ***SE*** | ***B*** | ***SE*** |
| Full treatment | 0.18 | 0.13 | 20.85 | 48.98 |
| Half treatment | 0.05 | 0.12 | -0.86 | 49.13 |
| Prior achievement | 0.02 | 0.01 | 15.00\*\*\* | 3.94 |
| Standardized math achievement | 0.00 | 0.00 | 0.03 | 0.15 |
| Female | 0.11 | 0.11 | 99.23\* | 41.24 |
| Ethnicity |  |  |  |  |
| Black | -0.10 | 0.16 | 6.48 | 60.71 |
| Hispanic | -0.15 | 0.18 | -107.16 | 68.76 |
| Asian | 0.01 | 0.17 | 2.18 | 67.62 |
| Othera | 0.42 | 0.78 |  |  |
| School site 1 | -0.15 | 0.10 | -204.35\*\*\* | 47.06 |
| Time 2 X Full treatment | 0.23\* | 0.11 | 170.11 | 92.44 |
| Time 2 X Half treatment | -0.02 | 0.11 | -52.06 | 86.00 |
| Time 2 X Prior achievement | 0.00 | 0.01 | -17.65\*\* | 6.57 |
| Time 2 X Standardized math  achievement | 0.00\* | 0.00 | -0.01 | 0.26 |
| Time 2 X Female | -0.20\* | 0.09 | -2.78 | 73.58 |
| Time 2 X Black | 0.35\* | 0.14 | -195.66 | 115.05 |
| Time 2 X Hispanic | -0.13 | 0.16 | 153.00 | 93.48 |
| Time 2 X Asian | 0.28 | 0.15 | -290.70\* | 127.58 |
| Time 2 X Other | -0.07 | 0.67 |  |  |
| Time 3 X Full treatment | -0.02 | 0.13 | 48.65 | 95.68 |
| Time 3 X Half treatment | -0.09 | 0.13 | -32.97 | 93.31 |
| Time 3 X Prior achievement | -0.01 | 0.01 | -12.47 | 7.04 |
| Time 3 X Standardized math  achievement | 0.00\* | 0.00 | 0.43 | 0.27 |
| Time 3 X Female | -0.22 | 0.11 | 27.02 | 80.98 |
| Time 3 X Black | 0.32 | 0.17 | -210.05 | 116.85 |
| Time 3 X Hispanic | 0.05 | 0.19 | 124.87 | 103.72 |
| Time 3 X Asian | 0.43\* | 0.18 | -210.75 | 121.27 |
| Time 3 X Other | -1.14 | 0.80 |  |  |

\**p* < .05. \*\**p* < .01. \*\*\**p* < .001.

a Because no individuals who took the Deliberate Practice Task were of “Other” racial status, this variable was not included in the regression model for deliberate practice behaviors (as measured on the Deliberate Practice Task).

Table 7S

*Study 5 Results: Regression Models Predicting Deliberate Practice Beliefs*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Follow-up 1** | | **Follow-up 2** | |
| **Variable** | ***B*** | ***SE*** | ***B*** | ***SE*** |
| Full treatment | 4.82\* | 2.20 | 4.10 | 3.59 |
| Half treatment | 6.23\*\* | 2.16 | 5.32 | 3.60 |
| Prior achievement | 0.15 | 0.17 | 0.24 | 0.29 |
| Standardized math achievement | 0.02\*\* | 0.01 | 0.01 | 0.01 |
| Female | 2.02 | 1.85 | 0.80 | 3.09 |
| Ethnicity |  |  |  |  |
| Black | 3.25 | 2.74 | 1.95 | 4.44 |
| Hispanic | 2.75 | 3.10 | 0.23 | 5.28 |
| Asian | 5.60 | 2.96 | 9.09 | 4.83 |
| Other | 8.68 | 13.23 | 5.28 | 20.85 |
| School site 1 | -1.66 | 2.13 | -10.07\*\* | 3.48 |

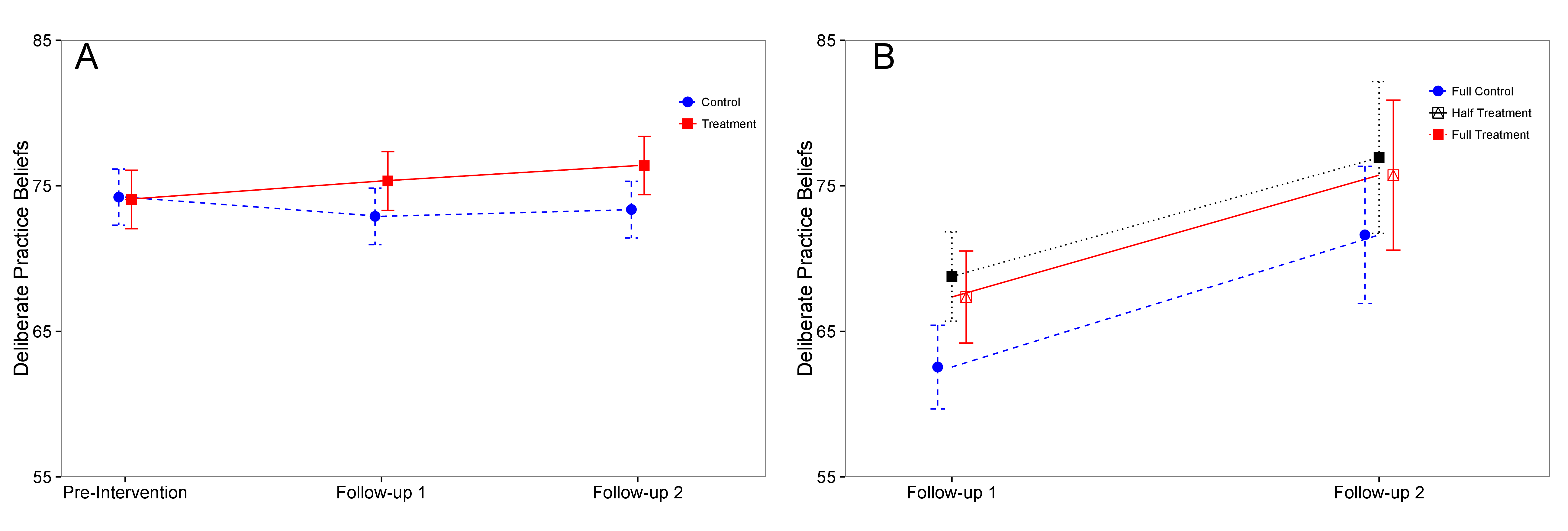
\**p* < .05. \*\**p* < .01.

Table 8S

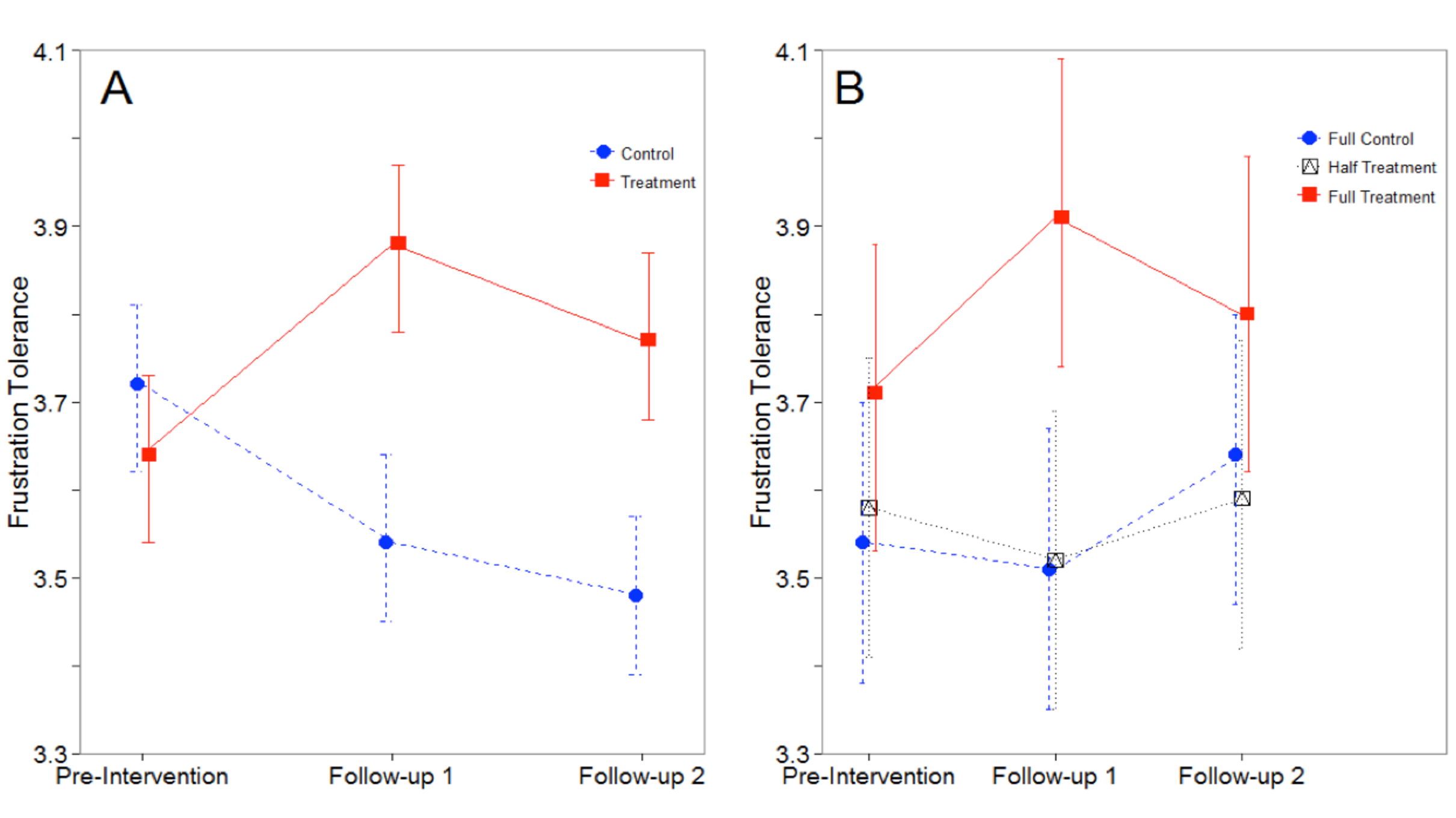
*Study 5 Results: Regression Models Predicting End-of-Quarter GPA*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Main effect** | | **Interaction** | |
| **Variable** | ***B*** | ***SE*** | ***B*** | ***SE*** |
| Full treatment | 1.09 | 0.74 | 1.18 | 0.74 |
| Half treatment | 0.19 | 0.73 | 0.17 | 0.73 |
| Prior achievement | 0.91\*\*\* | 0.06 | 1.03\*\*\* | 0.09 |
| Standardized math achievement | 0.01\*\*\* | 0.00 | 0.01\*\*\* | 0.00 |
| Female | 0.17 | 0.62 | 0.29 | 0.63 |
| Ethnicity |  |  |  |  |
| Black | 0.98 | 0.91 | 1.07 | 0.91 |
| Hispanic | -0.77 | 1.02 | -0.76 | 1.01 |
| Asian | 0.78 | 1.02 | 0.73 | 1.03 |
| Other | 3.50 | 4.57 | 3.47 | 4.56 |
| School site 1 | 2.19\*\* | 0.71 | 2.36\*\* | 0.72 |
| Full treatment X Prior achievement |  |  | -0.19 | 0.12 |
| Half treatment X Prior achievement |  |  | -0.16 | 0.11 |

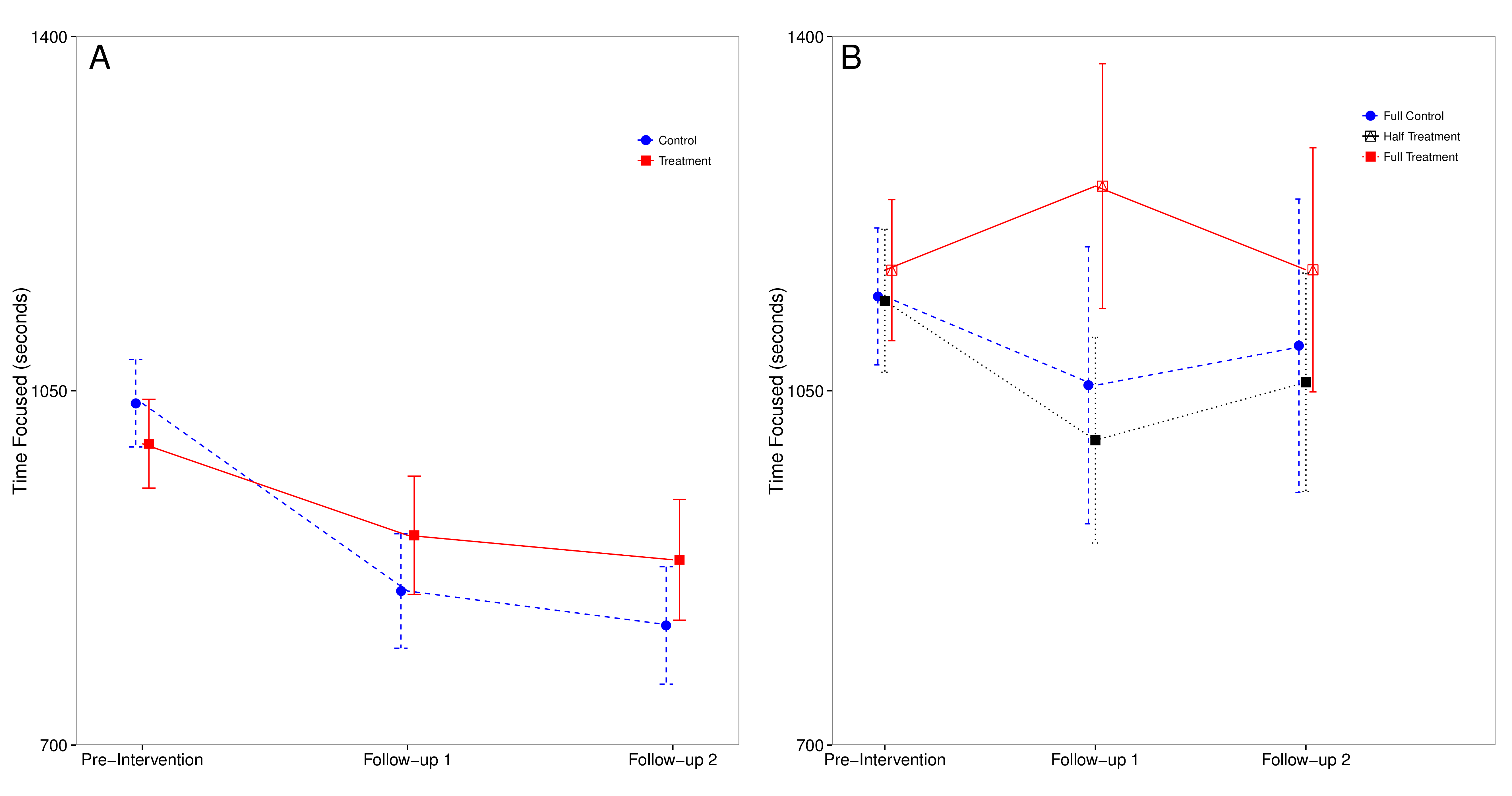
\*\**p* < .01. \*\*\**p* < .001.



*Figure 1S*. In Study 4 (Panel A), the intervention increased deliberate practice beliefs at Follow-up 1 (several days later) and Follow-up 2 (one month later). In Study 5 (Panel B), for participants in the full treatment and half treatment conditions, the intervention increased deliberate practice beliefs at Follow-up 1 (several days later) but not Follow-up 2 (four months later). Error bars represent ± 2 SEM.



*Figure 2S*. In Study 4 (Panel A), the intervention increased frustration tolerance at Follow-up 1 (several days later) and Follow-up 2 (one month later). In Study 5 (Panel B), full treatment participants had higher levels of frustration tolerance at Follow-up 1 (several days later) but not Follow-up 2 (four months later). There was no effect of half treatment. Error bars represent ± 2 SEM.



*Figure 3S*. In Study 4 (Panel A), the intervention increased time focused on the Deliberate Practice Task at Follow-up 1 (several days later) and Follow-up 2 (one month later). In Study 5 (Panel B), full treatment participants demonstrated increased time focused at Follow-up 1 (several days later) but not Follow-up 2 (four months later). There was no effect of half treatment. Error bars represent ± 2 SEM.

**APPENDIX**

**Deliberate Practice Treatment Condition Text**

*Find below the exact text for Module 1 and Module 2 of the deliberate practice intervention, administered in Studies 4 and 5. A condensed version of these materials was administered in Studies 2 and 3.*

**Text for Module 1 (45 minutes)**

Today we would like you to do some activities for our study. First, put on your headphones.

All of the pages on this website have sound. Please keep your headphones on so that you can hear them. When you have your headphones on, press the "Next" button below to continue.

**[page break]**

Athletes practice their sports.  Musicians practice their instruments.  You're a student.  Studying for school is the way you practice.  
  
There are two main types of practice you will learn about today.  Shallow practice and deep practice.

**[page break]**

When students study, they often do shallow practice.  This means that when they practice, they work on what they already know and tend to not pay attention 100% of the time.   
  
Deep practice is just the opposite! The next few slides will tell you how it is different and why it is the best kind of practice.

**[page break]**

New scientific research shows that to do deep practice, you need to do four things:

         1. Work on your weaknesses  
         2. Concentrate 100%  
         3. Get feedback  
         4. Repeat until mastery   
  
Today we'll tell you exactly what these four things mean and how to do them.

**[page break]**

1. Work on your weaknesses

Working on your weaknesses means doing things that are hard for you, instead of doing the things you already do well.

**[page break]**

Imagine that you just took a spelling quiz and got the following feedback:  
  
You got five words RIGHT.  
You got six words WRONG.  
  
If you want to do deep practice, what should you do next? [multiple choice]

-Practice the five words you got right.

-Practice the six words you got wrong.

-Practice all the words equally.

**[page break]**

Yes, you're right!  If you want to do deep practice, you should practice the six words that you got wrong.

You've been a student now for several years.  Based on your experience, why do you think that working on your weaknesses might be a good idea?

Just write one sentence in the box below. [text box]

**[page break]**

2. Concentrate 100%

To do deep practice, you also need to focus.  Deep practice requires 100% attention.   
  
When you are studying, distractions like texting, Facebook, or even other people in the room make it hard to pay attention 100%.

**[page break]**

Where is the best location to do deep practice? [multiple choice]

-In a quiet room by yourself.

-At the mall with your phone ready in case your friends want to text you.

-In the cafeteria, with lots of people around who are making noise.

**[page break]**

Yes, you're right!  The best location to do deep practice is in a quiet room by yourself.   
  
Based on your experience, why do you think concentrating 100% might be a good idea?

Just write one sentence in the box below. [text box]

**[page break]**

3. Get feedback

To do deep practice, you also need to get immediate feedback.  Feedback means finding out what you got right and what you got wrong as soon as possible.  
  
To get feedback, you could check your work against an answer key, or ask an adult to look at your work.  Another way to get feedback is to quiz yourself.

**[page break]**

If you just studied a list of vocabulary words, and wanted to get feedback, which of the following could you do? [multiple choice]

-Think about the words.

-Quiz yourself to see if you know what the vocabulary words mean.

-Watch TV.

**[page break]**

Yes, you're right!  Quizzing yourself to see if you know what the vocabulary words mean is one way you could get feedback.   
  
Based on your experience, why do you think getting feedback might be a good idea?

Just write one sentence in the box below. [text box]

**[page break]**

4. Repeat until mastery

The last part of deep practice is that you need to repeat!  After you work on your weaknesses, focus, and get feedback, you need to keep working on your weaknesses, keep focusing, and keep asking for feedback.

Deep practice is not just doing something once, but doing it over and over until you are a master.

**[page break]**

Imagine you just sat down to study a bunch of math problems you were confused about in class.  You are focusing really hard on your weak spots, and checking all the work you do against an answer key.  It can take a really long time.  
  
What now? [multiple choice]

-Since you got a couple right in a row, you stop practicing.

-Since you got most of the problems right, you move on to do something else and figure you’re done.

-You decide to practice more math problems until you can do them without making any mistakes.

**[page break]**

Yes, you're right!  You should decide to practice more math problems until you can do them without making any mistakes to really do deep practice.   
  
Based on your experience, why do you think repeating something you were confused about is a good idea?

Just write one sentence in the box below. [text box]

**[page break]**

Great, now you know all about deep practice.  Here is a summary of the four steps you just learned about:

1.  Work on your weaknesses  
2.  Concentrate 100%  
3.  Get feedback  
4.  Repeat until mastery

**[page break]**

Ready to see what deep practice looks like in action?

Click "next" to watch a video.

**[page break]**

Short GoAnimate Video

**[page break]**

The next part of today's lesson is all about you!  You're going to answer a few questions about the way you study and practice, and then we'll tell you about the type of studier you are.  
  
Be honest!  Your answers will not be shown to parents, teachers, or friends.  This is just a way for you to learn more about yourself!

**[page break]**

Short self-quiz that asks students about how they study.

**[page break]**

Click to the next page to hear what a student your age has to say about how they changed their study habits after learning about deep practice!

**[page break]**

"*While doing my math homework, I used to study with the TV on and text my friends when I was bored and didn't get it.  But since I learned about deep practice, I realized I wasn't concentrating 100% on math.  Now I study in my room and leave my phone in my bag so I don't have those distractions*." - Student 475

**[page break]**

*"I used to study spelling lists until I thought I knew all the words really well.  But when I took the test,  I would do just ok.  When I learned about deep practice, I realized that I wasn't getting feedback on what words I was getting wrong.  I quiz myself on my spelling lists now, so that I know the words better for my test.  I also quiz myself several times until I make no mistakes.  I do much better on my spelling tests now than before."* - Student 108

**[page break]**

Not all students know about how important deep practice is.  We want to get your help so we can teach other 6th and 7th graders about deep practice.

**[page break]**

In the space below, write a short letter (4-5 sentences) that we can give to other students to teach them about deep practice.  Explain in your own words what deep practice is, why it's important, and how students can do more deep practice in their own lives.    
  
Don't worry about writing a perfect letter.  Your letter also doesn't have to discuss all four parts of deep practice that you learned about today.  We just want to know how you would tell one or two things you learned about to another student in your own words.  Since your letter may be given to next year's students, please start your letter with "Dear student". [text box]

**[page break]**

On a scale from 0 to 100, how interesting did you find today's lesson?  Drag the bar to answer the question. [slider scale, Not at all interesting to Very interesting]

**[page break]**

Thanks for participating.  We hope you enjoyed learning about deep practice!

**Text for Module 2 (45 minutes)**

Last time you learned about deep practice and shallow practice.  
  
In deep practice, you do the following four things:

1.  Work on your weaknesses  
2.  Concentrate 100%  
3.  Get feedback  
4.  Repeat until mastery

**[page break]**

There is an obvious question to ask.  If deep practice is so great, why doesn't everyone do it all the time?

**[page break]**

What do you think?  Why do you think students often do shallow practice instead of deep practice?

Tell us what you think.  Don't take too long on this question.  Just write one sentence. [text box]

**[page break]**

Research shows that there are three main reasons students choose not to do deep practice.

1) Deep practice involves failure.  
2) Deep practice is frustrating.  
3) Students think talent is all that matters.  
  
In today's lesson, you'll learn more about each of these three things.

**[page break]**

1) Deep practice involves failure

As you learned last lesson, deep practice means working on your weaknesses.  When people work on their weaknesses, they make a lot of mistakes.  They fail a lot.   
  
Many students choose to do shallow practice because they don't like making mistakes.  They don't like failing.

**[page break]**

But the failure and mistakes that happen during deep practice are necessary to success.  As you'll see in the video on the next page, almost all successful people failed before they succeeded.

**[page break]**

Video about Failure and Success

**[page break]**

The video you just watched showed that famous people failed a lot before they succeeded.  When studying for a test or doing your homework, you may experience failure just like these celebrities.  Not giving up when you experience failure is an incredibly important part of deep practice!

**[page break]**

2) Deep practice is frustrating

Because people work on their weaknesses and make mistakes during deep practice, deep practice can be frustrating and confusing.

**[page break]**

In the next video, you'll hear from someone who went from living in poverty and being in the lowest level classes in elementary school to, eventually, graduating from MIT -- the best university for computer science in the world.   
  
Listen closely to what he says about the "stretch zone."  The stretch zone is where frustration and confusion take place.  Click next to watch the video.

**[page break]**

Video of student

**[page break]**

By now you probably understand why most people don't do as much deep practice as they should.  They don't like feeling frustrated or confused.

**[page break]**

One of the reasons people hate these feelings is because they think when they are frustrated or confused that it is a bad sign.  They think it's a sign that they should give up, or that they'll never succeed.

**[page break]**

Actually, frustration and confusion are a part of learning!  
  
If you are frustrated or confused while practicing, it can mean that you are doing deep practice.  It can mean you are working on your weaknesses, and focusing really hard.  
  
When you practice and everything goes perfectly, it may feel good, but it's probably a sign that you're not challenging yourself.  You're probably doing shallow practice.

**[page break]**

Scientists have a special term for people who continue to do deep practice even when they are frustrated and confused.  Scientists say that these people have high FRUSTRATION TOLERANCE.  
  
This means that even when they are really frustrated, they keep going.  They don't give up.  The most interesting thing about frustration tolerance is that it can change.  You could have low frustration tolerance to do homework when you are younger, but have high frustration tolerance to do homework when you are older.

**[page break]**

Students who want to can also decide to grow their frustration tolerance muscles.  They do this by practicing hard, frustrating things, without giving up.

**[page break]**

3) The third reason people often choose not to do deep practice is because they think talent is all that matters.  
  
They think the kids in their math class who do better at math and the kids on their sports teams who are better at sports are simply more talented.  If talent is all that matters, they say, why practice?

Actually, scientific evidence suggests that practice is incredibly important to success and improvement.

**[page break]**

You're now going to hear from people who have succeeded at very different things in life.  They all have one thing in common: they say that practice is what led to their success.  They don't mention talent at all.

**[page break]**

Choose one video to watch by clicking on a button below.  After you select a video, click the next button. [multiple choice, choices: Actor, Athlete, or Band Musician]

**[page break]**

If talent isn't so important, why do people think it is?

One reason is because you rarely see other people practice.  When all you see is a great singer performing, or a great movie star acting, you assume they are talented because you don't see all the hours (and sometimes years) of work that went into their performance.

**[page break]**

Once you start to think about it, you'll see lots of examples of things in the world around you that you thought were due to talent, but really, they come from deep practice and hard work.

**[page break]**

It's really amazing how people can improve in any domain they choose if they just work hard and practice.  Sports, dance, music, the list goes on.

**[page break]**

You might think that students in your class who get straight A's have it easy.  But just like the talented actors and dancers you learned about today, successful students study for hours and hours doing deep practice, you just don't see it!  
  
Click to the next page to hear what students your age say about talent and deep practice.

**[page break]**

*"I thought the kids who were good at fractions were just smarter than me.  But in the past couple of months, I realized that by doing deep practice, I could get just as many fraction problems right as they could.  When I work hard and do deep practice on my fractions homework, I come to class being able to answer just as many problems as the other kids."* - Student 749

**[page break]**

*"This year was the first time I started doing deep practice.  I always thought that there was nothing I could do to get any better at soccer, which is my favorite sport.  I thought the kids on my soccer team were just better than me, so I never really practiced so hard at soccer.  But then when I started doing deep practice I realized that if I practice as much as the other kids, I do great in soccer games!"* - Student 114

**[page break]**

Time for the last activity of today's lesson.  
  
We want to get your help so we can teach other 6th and 7th graders everything you learned about today.  Here's a quick summary of the three things you learned:  
  
1) Deep practice involves failure.  Students shouldn't let this stop them!  Failing and making mistakes are signs that deep practice is being done.  It's only in shallow practice that everything works perfectly.  
  
2) Deep practice involves frustration.  Students shouldn't let this bother them!  Frustration is a sign that deep practice is being done.  
  
3) People sometimes mistakenly think that talent is more important than practice.  But nearly all famous people say practice is what led to their success.

**[page break]**

Many students don't know about deep practice and the things you learned about today. In the space below, write a short letter (4-5 sentences) to teach these students what you learned.

Don't worry about writing a perfect letter.  Your letter doesn't have to discuss everything you learned about deep practice today.  We just want you to know how you would tell another student about one or two things you learned about today.  Since your letter may be given to next year's students, start your letter with the words "Dear student". [text box]

**[page break]**

On a scale from 0 to 100, how interesting did you find today's lesson?  Drag the bar to answer the question. [slide scale, Not at all interesting to Very interesting]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

**[page break]**

On a scale from 0 to 100, do you think what you learned about today will help you succeed in school? [slide scale, No it will not help to Yes it will help]

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |

**[page break]**

This is the end of today's lesson, and it is the last lesson you'll be getting on deep practice.  Thank you and we hope that you will continue to do deep practice!