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Achieving important goals is widely assumed to require confronting obstacles, failing repeatedly, and persisting in the face of frustration. Yet empirical evidence linking achievement and frustration tolerance is lacking. To facilitate work on this important topic, we developed and validated a novel behavioral measure of frustration tolerance: the Mirror Tracing Frustration Task (MTFT). In this 5-min task, participants allocate time between a difficult tracing task and entertaining games and videos. In two studies of young adults (Study 1: $N = 148$, Study 2: $N = 283$), we demonstrated that the MTFT increased frustration more than 18 other emotions, and that MTFT scores were related to self-reported frustration tolerance. Next, we assessed whether frustration tolerance correlated with similar constructs, including self-control and grit, as well as objective measures of real-world achievement. In a prospective longitudinal study of high-school seniors ($N = 391$), MTFT scores predicted grade-point average and standardized achievement test scores, and—more than 2 years after completing the MTFT—progress toward a college degree. Though small in size (i.e., *r*s ranging from .10 to .24), frustration tolerance predicted outcomes over and above a rich set of covariates, including IQ, sociodemographics, self-control, and grit. These findings demonstrate the validity of the MTFT and highlight the importance of frustration tolerance for achieving valued goals.

Keywords: frustration tolerance, academic performance, grit, growth mindset, self-control

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Common sense and casual observation suggest that the ability to persist despite frustration is critical for achievement. Though much is known about frustration tolerance and negative life outcomes (Berkowitz, 1989; Harrington, 2006), little is known about the role of frustration tolerance in achieving valued goals, including performing well in school. One reason for this dearth is the absence of validated behavioral measures of frustration tolerance. In this paper, we validated a novel behavioral measure of frustration

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tolerance and examined its ability to predict consequential, objective indicators of academic achievement.

Frustration Tolerance and Its Nomological Network

Frustration is the emotion experienced when obstacles impede progress toward valued and seemingly achievable goals (Anderson & Bushman, 2002; Stein & Levine, 1991). Notably, the presence of obstacles alone is insufficient; people must at the same time perceive that they lack control over these obstacles (Pekrun, 2006). Frustration tolerance is the capacity to pursue valued goals despite experiencing frustration (Jonassen & Grabowski, 2012; Leyro, Zvolensky, & Bernstein, 2010). On this conceptualization, frustration tolerance is a form of behavioral control and is related to, but distinct from, regulating frustration. Whereas frustration tolerance entails withstanding frustration, no matter how much frustration is experienced, frustration regulation entails reducing the experience of frustration.

Frustration tolerance is related to, but distinct from, other self-regulation constructs. For example, it is a subcomponent of distress tolerance; like sadness and physical exhaustion, frustration is one form of distress. Grit, or the tendency to sustain commitment and effort toward long-term goals (Duckworth, Peterson, Matthews, & Kelly, 2007), is related to frustration tolerance because accomplishing long-term goals requires the ability to overcome frustrating obstacles. Growth mindset, i.e., the belief that abilities are malleable rather than fixed (Dweck, 1999), is related in that it should dispose students to interpret frustration as less ego-threatening. And given that we define frustration tolerance as a type of behavioral control, it is a component of trait self-control, or "voluntary self-governance in the service of personally valued goals and standards" (Duckworth & Kern, 2011).

Frustration Tolerance and Achievement

To examine the relevance of frustration tolerance to consequential real-world achievement, we focused on education. Academic achievement predicts important life outcomes, including future earnings (United States Department of Commerce, Census Bureau, 2015; United States Department of Labor, Bureau of Labor Statistics, 2015; Table 502.30), subjective well-being (Witter, Okun, Stock, & Haring, 1984), and physical health (Ross & Wu, 1996). The educational domain also offers a wide range of objective achievement measures, such as grade-point average (GPA), standardized test scores, and enrollment in college.

Why might frustration tolerance be important for academic achievement? Frustration is one of the most frequent emotions experienced by students (D'Mello, 2013; D'Mello & Graesser, 2012; Pekrun, Frenzel, Goetz, & Perry, 2007; Pekrun, Muis, Frenzel, & Goetz, 2017). By enduring frustration and sticking to challenging tasks, students can make breakthroughs in their understanding of difficult academic material. The ability to push through sustained periods of frustration might also be a key to persisting long enough to attain a long-term goal like a college degree. Conversely, failure to overcome frustration is linked to a host of maladaptive academic behaviors, including avoiding challenging material (Walonoski & Heffernan, 2006), putting off studying, and procrastinating on assignments (Harrington, 2005b), quitting difficult tasks (Hoza, Waschbusch, Owens, Pelham, & Kipp, 2001), and behaving disruptively (Dollard, Miller, Doob, Mowrer, & Sears, 1939).

Surprisingly little research has examined frustration in the academic context. In fact, we could only identify three relevant publications. The earliest revealed a positive relationship between elementary school students' self-reported frustration tolerance and self-control on the Child Behavior Rating Scale (Humphrey, 1982). More recently, a study found that among college students, GPAs were related to three of the Frustration Discomfort Scale's (FDS; Harrington, 2005a) four dimensions (Entitlement, Emotional Intolerance, and Achievement Frustration, but not Distress Intolerance; Wilde, 2012). A separate study of undergraduates revealed that students who reported procrastinating more than their peers rated themselves lower on the FDS's Achievement Frustration dimension (e.g., "I can't stand doing a job if I'm unable to do it well"); no other FDS dimensions predicted procrastination (Harrington, 2005b).

The Mirror Tracing Frustration Task

One reason for the paucity of work on this topic is that existing measures of frustration tolerance suffer from serious limitations. Self-report questionnaires like the FDS suffer from an array of well-documented biases (e.g., memory bias, social desirability bias, and reference bias), not to mention fakeability (Duckworth & Yeager, 2015; Paulhus & Vazire, 2007). Behavioral measures are not only less susceptible to these biases but, in addition, may be more sensitive to changes over time (Duckworth & Yeager, 2015). A behavioral measure of frustration tolerance would address the pressing need for more studies of actual behavior, rather than hypothetical behavior or subjective judgments of behavior (Baumeister, Vohs, & Funder, 2007). To our surprise, we found only two behavioral tasks that researchers have used to measure frustration tolerance. Neither was designed to assess trait-level frustration tolerance. One, the Mirror Tracing Persistence Task (Quinn, Brandon, & Copeland, 1996), was designed to assess general persistence. The other, the Frustration Intolerance Task (Rodriguez, Russa, & Kircher, 2015), was designed to specifically assess parents' ability to tolerate crying children. Furthermore, validity evidence has not been thoroughly reported on either task.

Given the need for a behavioral measure of frustration tolerance, we developed the Mirror Tracing Frustration Task (MTFT). This task was inspired by the original mirror-tracing task (Snoddy, 1920), which requires tracing the outline of a shape (e.g., a star) by looking at its reflection through a physical mirror. The mirror reflection reverses the direction of movements, such that movements to the left are reflected as movements to the right, making it difficult to trace even simple shapes. We created the MTFT by modifying a computerized version of this mirror-tracing task (Strong et al., 2003) to simulate everyday decisions between worthwhile but frustrating activities and, alternatively, frivolous but effortless activities. Specifically, we designed an interface that offered games and videos as alternatives to the frustrating mirror-tracing activity. We also explained that practicing the tracing activity could improve valued skills that rely on hand–eye coordination (e.g., playing the violin). Persistence on the tracing task served as a measure of trait-level frustration tolerance.

Overview of Current Studies

We developed and validated the MTFT in three studies. In Study 1, we assessed whether the MTFT evoked frustration more than other emotions, including anger and anxiety. In Study 2, we tested the relationship between MTFT scores and self-reported frustration tolerance. In Study 3, with a demographically diverse sample of high school seniors, we explored the nomological network of the MTFT by investigating how it related to self-reported and teacher-rated student attributes, including self-control, growth mindset, and grit. Finally, in Study 3, we examined the extent to which frustration tolerance prospectively predicted academic achievement. Whereas previous research analyzed the relationship between self-reported frustration tolerance and GPA, we looked at the MTFT's ability to predict an array of additional indicators of academic achievement, including standardized test scores and college persistence. We also tested whether frustration tolerance predicted these outcomes even when controlling for several covariates with known relationships to academic achievement, including grit, growth mindset, general intelligence, academic motivation, and sociodemographic characteristics.

Study 1: Does the MTFT Evoke Frustration More Than Other Emotions?

After creating the MTFT, we began to examine its validity. As a first step, we designed Study 1 to test how strongly the MTFT evoked frustration relative to other commonly experienced emotions. This study was approved by University of Pennsylvania Internal Review Board (IRB, Protocol 823240).

Method

Participants. We recruited 190 young adults in the United States between the ages of 18 and 22 via Amazon's Mechanical Turk (MTurk). A power analysis using G*power (Heinrich-Heine-Universität Düsseldorf) indicated that a sample size of 151 would be required to detect the smallest effect of interest ($d = .30$, based on pilot studies) using a two-tailed paired-samples t-test ($\alpha = .05$, power = 95%). Each participant received $1.50.

Because we paid people for their participation in Studies 1 and 2, they had an incentive to complete these studies more than once. For this reason, we retained data from the first case associated with each Internet Protocol (IP) address and deleted subsequent cases. In the current study, we deleted one case for this reason. We also excluded participants who did not successfully complete the practice trial ($n = 13$) or who successfully traced the star ($n = 10$), reasoning that participants who traced the entire star would be less likely to experience frustration. This latter exclusion reduced the likelihood that frustration tolerance (i.e., amount of time spent on the task) was confounded with participants' skill or performance on the task. In addition, we excluded participants who experienced technical difficulties or did not spend a full 5 min on the MTFT ($n = 17$). Finally, we excluded one participant who failed an attention-check item.[1]

Women comprised 39.2% of the final sample ($N = 148$, $M_{age} = 21.05$, $SD = 0.96$). The final sample had a majority of Caucasian participants (75.0%), 9.5% African American, 6.8% Asian, and 6.1% Hispanic. Most (98.0%) were native English speakers, and 27.1% had a college degree.

Procedure. Participants completed a demographics questionnaire, followed by a baseline emotion assessment. Participants then completed the MTFT and a follow-up emotion assessment that retrospectively measured participants' emotions while they completed the MTFT's tracing task.

MTFT. Unlike Strong et al.'s (2003) computerized version of the mirror-tracing task, our task incorporated distracting videos and games as alternatives to mirror tracing. Figure 1 provides a screenshot of the interface. The videos and games used varied from study to study. We chose distractors that we expected would interest participants, which, typically, were videos and games that were popular at the time of the study. We also tried to find distractors that would appeal to a variety of people. Participants had the option to switch back and forth between the tracing and distractors as often as they pleased, but they could not do both simultaneously. We measured frustration tolerance as the percentage of time participants spent actively working on the mirror-tracing activity versus engaging with the distractors (e.g., playing games).

Participants began by reading a cover story that emphasized the value of completing the task. Presented as a news article, the cover story provided examples of how hand–eye coordination could improve performance on valued everyday tasks, such as writing and playing sports. Participants were also told that the mirror-tracing task was a tool for developing and practicing hand–eye coordination.

Next, participants read instructions and completed a practice trial in which they traced a short line using reversed movements to simulate mirror tracing. If cursor movements deviated from the outline of the shape, or if a participant idled for 2 s or more without making any cursor movements, a buzzer sounded and the task restarted. The practice trial did not include distractors, making it easier for participants to become familiar with the task. Participants advanced upon successfully tracing the line or after 2 min elapsed. Participants then learned about the main trial and the option to watch videos or play games.

Unlike in the practice, in the main trial we explicitly altered expectancies of success and controllability—two key appraisals that distinguish frustration from other emotions (Pekrun, 2006; Smith & Ellsworth, 1985). We did this in two ways. Whereas the practice trial was deceptively easy, the main trial required participants to trace a complicated star shape. At this stage, we also introduced random drift to cursor movements. This made it nearly impossible to trace the star. We anticipated that the complexity of the shape and the cursor drift would be unexpected and unpredict-

[1] The attention-check item stated the following.

> People vary in the amount they pay attention to these kinds of surveys. Some take them seriously and read each question, whereas others go very quickly and barely read the questions at all. If you have read this question carefully, please write the word "yes" in the blank box below labeled "Other." There is no need for you to respond to the scale below.

Directly following this item were six response options ranging from 0, *Not at all*, to 5, *A lot*. These items were followed by a fill-in-the-blank response box labeled "Other." We excluded participants from the analyses presented in the paper if they either clicked on one of the multiple-choice options or did not write "yes" in the blank box.

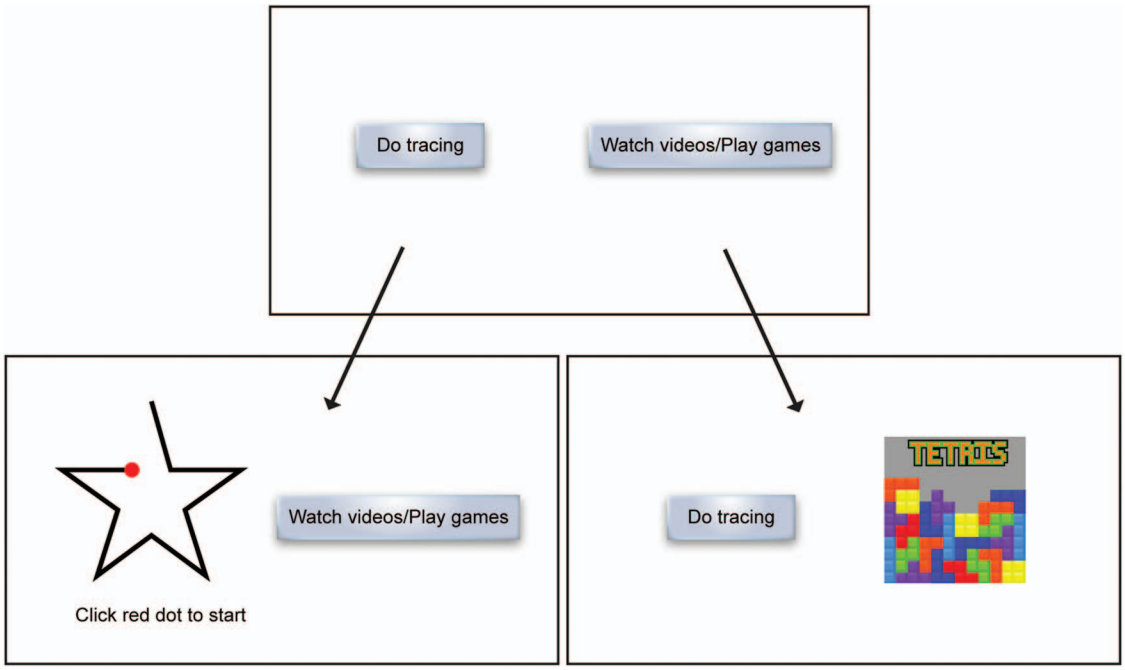

Figure 1. In the MTFT, participants have the choice to "do tracing" or "watch videos/play games." If they click "do tracing," they can trace the outline of a star using reversed movements. If they click "watch videos/play games," they see a pull-down menu that contains distracting video clips and games. At any point during the activity, students are free to either focus on the skill-building task or engage with the distractions. See the online article for the color version of this figure.

able, thereby increasing the intensity of frustration. The main trial lasted 5 min.

Assessments of baseline and follow-up emotions. For both emotion assessments, participants completed a 19-item self-report inventory intended to assess levels of frustration, as well as amusement, anger, anxiety, confusion, contempt, disgust, embarrassment, fear, guilt, happiness, interest, joy, love, pride, sadness, shame, surprise, and unhappiness. We culled these emotion terms from multiple measures of affect (e.g., Gross & Levenson, 1995).

In the baseline assessment, we asked participants to report "what you're experiencing ***right now***. Please indicate how much you ***currently*** feel each of the following emotions" [emphasis in the original]. In the follow-up assessment, we asked participants to "indicate how much you felt each emotion **while you were attempting to trace *the star***" [emphasis in the original]. Response options in this study and the next ranged from *Not at all* to *Extremely*; numbers corresponding to these options were not displayed. Correlations between Time-2 emotions (Table S1) and between changes in emotions (Table S2) can be found on p. 5 and p. 6 of our online supplemental material, respectively.[2]

Results and Discussion

Descriptive statistics. As intended, the mirror-tracing activity was extremely difficult, but not impossible. On average, participants made 13.4 errors (SD = 10.2). Percent of time spent tracing the star varied considerably. Some participants spent 100% of the time tracing the star whereas others spent 100% of the time watching videos or playing games. On average, participants spent 37.8% (SD = 27.0%) of the time, or 1 min, 53 s, tracing the star. To test the MTFT's internal consistency, we computed percent of time tracing in five 1-min segments. For these five segments, α = .79.[3]

Change in emotions. The MTFT increased frustration by 1.1 SDs. Paired-samples t-tests comparing pretest and posttest values revealed that all but three other emotions shifted (sadness, fear, and guilt; Table 1), but paired-samples t-tests also confirmed that frustration increased more than any other emotion (for all comparisons, $p \leq .002$). Posttask frustration was also higher than posttask values for all other emotions (ds = 0.32 to 1.66, ps $< .001$). Additional analyses can be found on pp. 2–3 of our online supplemental materials. None of our results differed between excluded and included participants, and each difference remained significant after applying Bonferroni adjustments. These results confirm that the MTFT task increases frustration more than other emotions (even similar emotions, such as anger).

[2] This supplement can be accessed at https://osf.io/syr7v/?view_only=739d6333368744b398fc5c55f1a254a0.

[3] In a pilot study conducted in a large middle school, we tested the MTFT's test–retest reliability. At two time points 7 weeks apart, 78 sixth, seventh, and eighth graders completed the task. The correlation between these time points was .64, which compares favorably to the test–retest reliability of similar performance measures (Buelow & Barnhart, 2018; Weafer, Baggott, & de Wit, 2013).

Table 1
Emotion Scores, Pre- and Post-MTFT, Study 1 (N = 148)

Variable	M_{pre}	SD_{pre}	M_{post}	SD_{post}	$M_{difference}$	*d*	95% $CI_{difference}$	
Frustration	1.59	.94	3.36	1.39	1.77***	1.10	1.50	2.04
Anger	1.28	.68	2.29	1.25	1.01***	.80	.79	1.22
Unhappiness	1.41	.68	2.27	1.24	.86***	.73	.65	1.06
Confusion	1.33	.67	2.05	1.23	.72***	.60	.51	.93
Embarrassment	1.28	.73	1.93	1.15	.65***	.62	.47	.82
Anxiety	1.72	.92	2.26	1.26	.54***	.45	.34	.74
Disgust	1.24	.71	1.76	1.08	.52***	.47	.34	.70
Shame	1.22	.63	1.64	.98	.42***	.46	.26	.57
Contempt	1.74	1.16	2.02	1.11	.28**	.23	.08	.49
Surprise	1.64	1.02	1.82	1.09	.18*	.17	.01	.35
Sadness	1.41	.73	1.56	.91	.15†	.15	−.02	.31
Fear	1.27	.66	1.40	.86	.13†	.17	.00	.26
Guilt	1.20	.49	1.25	.63	.05	.07	−.07	.16
Amusement	2.36	1.21	1.97	1.14	−.39**	−.29	−.61	−.17
Interest	3.34	1.06	2.73	1.29	−.61***	−.50	−.81	−.41
Pride	2.53	1.35	1.66	1.14	−.88***	−.72	−1.08	−.68
Joy	2.78	1.24	1.69	1.19	−1.08***	−.87	−1.28	−.87
Love	2.84	1.32	1.57	1.15	−1.27***	−1.03	−1.47	−1.07
Happiness	3.19	1.12	1.86	1.23	−1.33***	−1.15	−1.51	−1.14

Note. Possible emotion scores ranged from 1–5. $M_{difference}$ was calculated by subtracting Time-1 emotion scores (M_{pre}) from Time-2 scores (M_{post}).
† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Study 2: Are MTFT Scores Related to Self-Reported Frustration Tolerance?

In Study 1 the MTFT evoked frustration more than other emotions. But if the MTFT is a valid measure of frustration *tolerance*, MTFT scores should also relate to self-perceived frustration tolerance. The primary aim of Study 2 was to examine this relationship. This study was approved by University of Pennsylvania IRB (Protocol 823240).

Method

Participants. We recruited 361 young adults in the United States between the ages of 18 and 22 from MTurk. A power analysis using G*power indicated that a sample size of 63 would be required to detect the estimated effect ($r = .42$, based on pilot studies) using a two-tailed Pearson correlation ($\alpha = .05$, power = 95%). Each participant received $1.20.

Four cases were deleted because IP addresses were repeatedly used. As in Study 1, we also excluded participants who did not successfully solve the practice trial ($n = 9$) and/or successfully traced the star ($n = 8$). In addition, we excluded participants who experienced technical difficulties or did not complete the MTFT for another reason ($n = 35$). Finally, we cut participants who failed to correctly respond to an attention-check question ($n = 22$). With one exception (i.e., the relationship between skill level and MTFT scores), results did not differ between excluded and included participants.

Women comprised 44.9% of the final sample ($N = 283$; $M_{age} = 20.98$, $SD = 1.01$). Most participants were Caucasian (70.3%), 9.5% were African American, 7.8% were Asian, and 10.2% were Hispanic; 99.6% were native English speakers and 26.2% had a college degree.

Procedure. Each participant completed the MTFT used in Study 1. They then answered six follow-up questions. The first item asked, "**While you were attempting to trace *the star***, how FRUSTRATED did you feel?" [emphasis in original]. Participants completed this item using five response options that ranged from *Not at all* to *Extremely*. Next, participants completed five face-valid items ($\alpha = .93$) designed to assess self-perceived frustration tolerance during the MTFT (e.g., "How well did you do at *tolerating* the frustration you experienced while attempting to trace the star?" and "How well did you do at *enduring* the frustration you experienced while attempting to trace the star?" Exact items are included in Appendix SA of our Online supplemental material). Participants completed these items using five response options that ranged from *Not at all well* to *Extremely well*. Participants then completed the same attention-check item used in Study 1.

Results and Discussion

Descriptive statistics. As in Study 1, the mirror-tracing activity was extremely difficult, but not impossible: On average, participants made 11.36 errors ($SD = 9.3$). Percent of time spent tracing the star varied widely. On average, participants spent 37.6% of the time ($SD = 26.8\%$), or 1 min and 53 s tracing the star. To test the MTFT's internal consistency, we split overall scores into five 1-min segments. For these segments, $\alpha = .78$.

MTFT scores and self-reported frustration tolerance. MTFT scores positively related to self-reported frustration tolerance, $r(281) = .39$, $p < .001$, 95% CI [.29, .48]. The relationship between frustration tolerance and MTFT scores was nearly identical when partialing out frustration scores, $r(280) = .42$, $p < .001$. Following conventional classifications, these relationships were medium to large in size (Cohen, 1988). Furthermore, they compare favorably with correlations between other self-report and behavioral measures. For instance, the correlations between self-reported intelligence and IQ test scores are much lower ($rs = .20$ to .25; Paulhus, Lysy, & Yik, 1998). More germane to the current project, relationships between self-report and behavioral measures of self-

control tend to be even lower (average for delay-discounting tasks: $r = .15$; average for executive functioning tasks: $r = .10$; Duckworth & Kern, 2011).

Study 3: Testing the MTFT's Nomological Network and Predictive Power

Having established that the MTFT induces frustration more than other emotions (Study 1), and that its scores are related to self-perceived frustration tolerance (Study 2), we aimed to explore its nomological network and test its incremental predictive validity. We took the latter step by assessing the MTFT's ability to predict academic achievement over and above academic motivation. This study was approved by University of Pennsylvania IRB (Protocol 814991).

Method

Participants. We recruited 513 high-school seniors attending a public school in northeastern United States. Because of resource limitations common to school-based research, Study 3's sample size was not determined by a power analysis. Instead, we collected data from as many students as our resources allowed. The study was adequately powered for small to medium effects.

As in Studies 1 and 2, we excluded participants who did not successfully solve the practice trial ($n = 37$) and/or who successfully traced the star ($n = 9$). In addition, we excluded participants who experienced technical difficulties or did not complete the MTFT for other reasons ($n = 76$). In the results section that follows, we report only one result of the 103 analyses that differed between participants who were included in analyses and those who were not (i.e., the relationship between MTFT scores and senior GPA when controlling for demographics and teacher ratings of grit).

The final sample ($N = 391$; $M_{age} = 17.90$, $SD = 0.48$) was socioeconomically and ethnically diverse—53.7% were girls/young women, 40.4% were Caucasian, 36.8% were African American, 20.2% were Asian, 2.6% were Hispanic. Nearly half of participants (49.0%) were from low-income households, as indicated by their participation in the federal lunch program.

Procedure. We collected academic performance and demographic data from official school records. Participants completed an intelligence measure, followed by measures designed to test the MTFT's nomological network, as well as academic motivation. Participants also completed measures of a number of other variables unrelated to the current investigation because the study was part of a larger project. Next, they completed the MTFT. Separately, teachers completed questionnaires online.

Measures

MTFT. The MTFT used in Study 3 was identical to the task in Studies 1 and 2, with two exceptions. First, we only offered entertaining videos as an alternative to tracing. We included video games in Studies 1 and 2, but not 3, because Study 3 was conducted with younger participants. We expected that fewer temptations would be needed to reach appropriate levels of distraction in this younger sample. Second, we embedded additional questions in the task. One question asked, "How important is it for you to trace the shape all the way to the end?" and was used to assess task motivation prior to the main trial. Another question asked, "How frustrated were you by tracing during the last session?" This question was presented after both the practice trial and the main trial. A 5-point scale (1 = *Not at all*, 5 = *Very*) was used for each item.

Demographics. We used school data to control for gender and race. We also used school records of whether students were eligible for free or reduced meals as a proxy for socioeconomic status.

Intelligence. Participants completed the Matrix Reasoning subtest of the Kaufman Brief Intelligence Test (KBIT; Kaufman & Kaufman, 1990). This subtest includes a series of patterns in which one section of the pattern is missing. From a set of response options, participants choose the picture that completes the pattern. The task includes a total of 36 matrix reasoning problems, and ends after the completion of all problems, or four consecutive incorrect responses. The number of correct answers provided by participants constituted a raw score, which we then converted to an age-normed scaled score. This measure of fluid intelligence correlates strongly with other measures of general intelligence (Canivez, 1996) and has been used in numerous other studies (e.g., Galla & Duckworth, 2015; Miciak, Fletcher, Stuebing, Vaughn, & Tolar, 2014).

Constructs in frustration tolerance's nomological network. We used a combination of teacher ratings and self-report questionnaires to assess distress tolerance, grit, growth mindset, and self-control. Unless otherwise specified, questionnaire items in Study 3 were endorsed on a 5-point scale, from 1 = *Not at all true* to 5 = *Completely true*.

Distress Tolerance. Participants completed three items ($\alpha = .82$) from the Distress Tolerance Scale (DTS; Simons & Gaher, 2005). We used these specific items because they make up the Tolerance dimension of the DTS (i.e., they measure people's perceived ability to tolerate emotional distress and their ability to endure difficult and upsetting situations, e.g., "Feeling distressed or upset is unbearable to me"). The DTS's other items measured constructs that differ slightly from what we intended to assess, namely "subjective appraisal of distress, attention being absorbed by negative emotions, and regulation efforts to alleviate distress" (Simons & Gaher, 2005, p. 94). All items were reverse-coded so that higher scores represented higher distress tolerance.

Grit. Participants completed five items ($\alpha = .81$) of the Grit Scale, adapted from Duckworth et al. (2007). This scale measures passion and perseverance for long-term goals (e.g., "I finish whatever I begin," "I keep working hard even when I feel like quitting").

Growth Mindset. We administered a three-item measure of growth mindset ($\alpha = .80$; Dweck, Chiu, & Hong, 1995) to measure the degree to which people believe their intelligence is fixed versus malleable (e.g., "Your intelligence is something about you that you can't change very much"). Participants indicated their agreement with each item on a 6-point scale, from 1 = *Strongly Disagree* to 6 = *Strongly Agree*.

Self-Control. We administered an eight-item measure of self-control designed specifically for school-age children and adolescents (e.g., "I come to class prepared," "I allow others to speak without interruption;" $\alpha = .78$; Park, Tsukayama, Goodwin, Patrick, & Duckworth, 2017). Participants also completed five items ($\alpha = .74$) from the Brief Self-Control Scale (Tang-

ney, Baumeister, & Boone, 2004). We combined responses to both measures to create a single score ($\alpha = .86$). When these two scales were used in analyses separately, results remained consistent.

Teacher ratings. Following Galla and Duckworth (2015), we asked three teachers to rate each student on items pertaining to grit and self-control. Because distress tolerance and growth mindset are not observable behaviors, teachers were not asked to rate their students on these variables. Teachers saw the same items that students completed and rated how much these items as a whole described each student using a 5-point Likert scale (1 = *Not at all like this student* to 5 = *Very much like this student*). The three teacher ratings for grit (rs = .29 to .40, ps < .001; $\alpha = .56$) and self-control (rs = .27 to .45, ps < .001; $\alpha = .56$) were positively correlated. Thus, following Eid and Diener (2006), we averaged scores to increase reliability and minimize multicollinearity.

Academic motivation. To control for motivational confounds, we measured an array of academic motivation constructs. These covariates were not included in our analysis of the MTFT's nomological network, mainly because they are all academic-specific constructs that are probably only indirectly related to frustration tolerance.

Academic amotivation. Participants completed four items ($\alpha = .82$) translated from the amotivation subscale of the French Academic Motivation Scale (Vallerand, Blais, Brière, & Pelletier, 1989). These items measure the extent to which students see their education as something that occurs out of their control and lacks purpose (e.g., "Honestly I don't know, I really feel that I am wasting my time in school").

Academic locus of control. Participants completed four items ($\alpha = .58$) modeled after the Students' Perception of Control Questionnaire (Wellborn, Connell, & Skinner, 1989) to measure perceptions of their own control over academic outcomes (e.g., "Getting good grades is a matter of luck"). Participants indicated their agreement with each item on a 6-point scale, from 1 = *Strongly Disagree* to 6 = *Strongly Agree*, and items were reverse-coded so that higher scores indicated higher internal locus of control.

Academic self-efficacy. Participants completed three-items ($\alpha = .88$) from the Expectancy–Value–Cost Scale (Kosovich, Hulleman, Barron, & Getty, 2015) to assess their academic self-efficacy (e.g., "I believe that I can be successful in my classes"). Academic self-efficacy refers to the belief in one's own abilities to complete tasks and achieve goals (Bandura, 1986).

Self-interested motives for learning. Participants completed four items ($\alpha = .48$) from the extrinsic motives subset of a scale measuring motives for going to school (Yeager et al., 2014). Items measured students' self-interested motives for learning (e.g., "I want to get a good job"), as opposed to self-transcendent motives (see below).

Self-transcendent motives for learning. Participants completed three items ($\alpha = .73$) from the "self-transcendent motives" subset of a scale measuring motives for going to school (Yeager et al., 2014). These items measure a desire to learn in order to benefit the greater good (e.g., "I want to become an educated citizen that can contribute to society").

Academic Outcomes

Grade Point Average (GPA). We collected high-school GPAs and senior-year GPAs from official school records.

Standardized achievement test scores. We collected scores on standardized science, math, and reading state exams from school records.

College progress. More than 2 academic years after students completed the MTFT, we gathered data from the National Student Clearinghouse[4] (NSC) on how many months our participants had enrolled in 2- or 4-year colleges or universities since graduating from high school. We used months as the unit of analysis because the term lengths at the schools in which our participants were enrolled were as short as 1 month in duration. We used a continuous variable instead of a dichotomous variable, such as whether or not students were continuously enrolled full-time, in an attempt to accurately capture the amount of variability that existed in students' college progress.

Our analyses included participants with all levels of enrollment (quarter-time, half-time, three-quarter-time, and full-time). To account for variability in students' level of enrollment, we created a weighted score for each participant, whereby each month students were enrolled quarter-time was multiplied by 0.25, each half-time month was multiplied by 0.50, and each three-quarter-time month was multiplied by 0.75. Each full-time month was left unchanged.

Results

Descriptive statistics. On average, participants made 18 errors ($SD = 11.6$) on the MTFT's tracing task. As in Studies 1 and 2, percentage of time spent tracing the star varied widely ($M = 54.9\%$, $SD = 27.2\%$). To assess the MTFT's internal consistency, we once again split overall scores into five 1-min segments. The α for these five segments was .78. Additional descriptive statistics are included in Table 2.

Change in emotions. The MTFT increased frustration by 1.29 *SD*, from $M = 2.71$ ($SD = 1.22$) after the practice trial to $M = 4.20$ ($SD = 1.09$), after the main trial, $t(390) = 21.13$, $p < .001$, $d = 1.29$, 95% CI [−1.63, −1.35].

The MTFT's nomological network. Zero-order correlations revealed that students with higher frustration tolerance (i.e., those who spent a higher percentage of time tracing the shape) exhibited higher growth mindset, self-reported and teacher-rated self-control, and self-reported and teacher-rated grit (see Table 3). These relationships were small but consistently significant (rs = .11–.22, ps < .03). In contrast, the relationship between frustration tolerance and distress tolerance did not reach significance, $r(389) = .07$, $p = .16$, 95% CI [–.03, .17]. This weak relationship might have resulted from the difficulty of measuring distress tolerance; self-report measures of distress tolerance do not even correlate with performance measures of distress tolerance (which includes tolerance of any aversive state, including exhaustion and physical discomfort; Anestis et al., 2012; Leyro et al., 2010), let alone specifically frustration tolerance (McHugh et al., 2011). Our

[4] The NSC is the leading provider of data for collegiate electronic student records (see http://www.studentclearinghouse.org/about/). NSC data have previously been used in related studies to track college progress (Dynarski, Hemelt, & Hyman, 2013).

Table 2
Descriptive Statistics, Study 3 (N = 391)

Constructs and variables	*M*	*SD*	Possible range	Observed range
Mirror Tracing Frustration Tolerance test				
Frustration tolerance (% of time on task)	54.91	27.21	.00–100.00	.00–100.00
Task ability (no. of errors)	17.99	11.64	N/A	1.00–63.00
Task motivation	3.15	1.18	1.00–5.00	1.00–5.00
Intelligence	96.52	20.07	40.00–160.00	40.00–132.00
Nomological network				
Distress tolerance	3.29	1.08	1.00–5.00	1.00–5.00
Grit (self-report)	3.76	.71	1.00–5.00	1.00–5.00
Grit (teacher rating)	3.58	.86	1.00–5.00	1.00–5.00
Growth Mindset	4.16	1.13	1.00–6.00	1.33–6.00
Self-control (self-report)	3.62	.60	1.00–5.00	1.00–5.00
Self-control (teacher rating)	3.75	.90	1.00–5.00	1.00–5.00
Academic motivation				
Academic amotivation	1.34	.62	1.00–5.00	1.00–4.50
Academic locus of control	4.60	.74	1.00–6.00	2.50–6.00
Self-efficacy	4.12	.76	1.00–5.00	1.00–5.00
Self-interested motives for learning	4.07	.60	1.00–5.00	1.00–5.00
Self-transcendent motives for learning	4.23	.72	1.00–5.00	1.00–5.00
Academic outcomes				
Standardized math achievement test	1538.43	49.88	1,200.00–1,800.00	1,402.00–1,661.00
Standardized reading achievement test	1535.49	46.89	1,200.00–1,800.00	1,400.00–1,706.00
Standardized science achievement test	1501.98	40.21	1,200.00–1,800.00	1,410.00–1,678.00
Senior-year GPA	85.56	7.68	.00–100.00	55.00–100.00
Cumulative GPA	85.61	6.99	.00–100.00	66.00–100.00

Note: GPA = grade-point average.

use of the tolerance subscale of Simons and Gaher's (2005) original Distress Tolerance Scale could have also contributed to this weak relationship.

Predictive and Incremental Validity of Frustration Tolerance for Academic Outcomes

Academic achievement. Zero-order correlations indicated that frustration tolerance predicted standardized math scores, reading scores, science scores, senior-year GPA, and 4-year GPA (rs = .20–.28, ps < .005). We next fit a series of regression models designed to test whether frustration tolerance predicted academic achievement even when controlling for likely confounding variables. We first regressed different academic outcomes on sociodemographic variables. We then tested 14 additional models for each outcome variable in which we added either a single personality variable, intelligence, task ability, or task motivation to the existing models. Notably, as

Table 3
Correlations, Study 3

Constructs and variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Frustration tolerance														
2. Intelligence	.22***													
Tracing variables														
3. Task ability	−.15**	−.12*												
4. Task motivation	.17**	.04	−.08											
Nomological network														
5. Distress tolerance	.07	.02	−.06	.00										
6. Grit (self–report)	.22***	−.03	.01	.14**	.14**									
7. Grit (teacher rating)	.16**	.02	−.04	−.01	−.02	.23***								
8. Growth mindset	.11*	.01	−.03	−.01	.22***	.10†	.03							
9. Self–control (self–report)	.22***	−.03	.00	.11*	.11*	.63***	.24***	.14**						
10. Self–control (teacher rating)	.15**	.05	−.07	−.04	−.01	.18***	.86***	−.02	.25***					
Academic motivation														
11. Academic amotivation	−.24***	−.08	−.11*	−.05	−.16**	−.24***	−.23***	−.10†	−.18***	−.17**				
12. Academic locus of control	.19***	.02	.01	.14**	.27***	.28***	.11*	.33***	.29***	.06	−.34***			
13. Self–efficacy	.19***	.07	−.04	.14**	.22***	.49***	.16**	.18***	.42***	.12*	−.23***	.37***		
14. Self–interested motives	−.10†	−.06	−.11*	.01	−.05	.11*	−.07	.00	.04	−.09†	−.03	.01	.12*	
15. Self–transcendent motives	.17**	−.03	−.01	.13*	−.03	.29***	.09†	.19***	.32***	.08	−.27***	.23***	.28***	.22***

† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

shown in Table 4, frustration tolerance predicted all academic outcomes in each model.

College progress. To test the MTFT's ability to predict college progress, we used zero-inflated negative binomial regression, because months of enrollment is a count variable and 81 participants (20%) did not enroll in a single month of college. Both a Vuong test, $\chi^2(1) = 233.34$, $p < .001$, and a likelihood-ratio test, $z = 34.63$, $p < .001$, confirmed that zero-inflated negative binomial regression was more appropriate than standard negative binomial regression or zero-inflated Poisson regression (see Atkins & Gallop, 2007). Frustration tolerance predicted college progress, IRR = 1.10, $p = .001$, 95% CI [1.04, 1.17]. The IRR (Incidence Rate Ratio) indicates that among students who matriculated, a 1-*SD* increase in MTFT scores was associated with 10% more months of college enrollment.

Next, we regressed college progress on frustration tolerance when controlling for demographic variables and then tested 14 additional models in which we added either a single personality variable, intelligence, task ability, or task motivation to this model. As we report in Table 4, frustration tolerance significantly predicted college progress in all models except one: When controlling for demographics and academic amotivation, the relationship was marginal, IRR = 1.06, $p = .06$, 95% CI [1.00, 1.12].

General Discussion

Our findings have opened new avenues for research on frustration tolerance by validating a novel behavioral measure, the MTFT. This 5-min task simulates a common dilemma: When making little headway toward a difficult goal, do we try to slog our way toward the goal, or do we give in to the promise of instant gratification? The results of three studies show that the way one resolves this dilemma speaks to their frustration tolerance. Participants reported experiencing frustration when completing the MTFT's tracing task (Studies 1, 2, and 3), this frustration was stronger than other emotions (Study 1), and self-reported frustration tolerance predicted MTFT performance (Study 2). We also found that individual differences in MTFT performance were associated with theoretically related constructs, including grit, growth mindset, and self-control (Study 3).

Our results also demonstrate that frustration tolerance—a capacity typically studied in the context of addiction, psychopathology, and other negative life outcomes—reliably predicts a consequential positive life outcome: academic achievement (Study 3). Students who persisted on the MTFT's mirror-tracing activity earned higher GPAs and standardized test scores in math, reading, and science, and even persevered longer toward a college degree. The MTFT predicted these objective, real-world academic outcomes over and above potentially confounding variables, including demographic characteristics and an array of other personal characteristics related to academic achievement, including academic motivation and intelligence. Notably, the predictive power of the MTFT compared favorably with other constructs considered to be important predictors of academic achievement (e.g., grit, Duckworth et al., 2007; growth mindset, Blackwell, Trzesniewski, & Dweck, 2007; self-control, Tangney et al., 2004; and socioeconomic status: Sirin, 2005). We propose that frustration tolerance should be discussed in the same breath as these better-known predictors of academic achievement. What makes these findings especially exciting is that frustration tolerance may prove amenable to psychologically wise interventions (Walton, 2014). For instance, attaching prosocial purpose to frustrating school activities might boost frustration tolerance in the same way it builds tolerance for boring learning tasks (Yeager et al., 2014).

Improving the measurement of personal qualities other than intelligence is a priority for both educational researchers and practitioners (Duckworth & Yeager, 2015). The development and

Table 4
Predictive Validity of Mirror Tracing Frustration Tolerance Controlling for Relevant Variables and Constructs

Covariates	Senior GPA	Cumulative GPA	Math score	Reading score	Science score	College progress
Intelligence	.15**	.12*	.20***	.12*	.16**	1.09**
Tracing variables						
Tracing ability	.16**	.14**	.22***	.13**	.16**	1.08*
Tracing motivation	.16**	.15**	.27***	.17**	.21***	1.09**
Nomological network						
Distress tolerance	.16**	.14**	.24***	.14**	.18***	1.08**
Grit (self-report)	.11*	.10*	.26***	.15**	.19***	1.07*
Grit (teacher rating)	.10**	.10*	.21***	.12*	.16**	1.07*
Growth Mindset	.16**	.15**	.25***	.15**	.20***	1.08**
Self-control (self-report)	.12*	.11*	.26***	.14**	.19***	1.08**
Self-control (teacher rating)	.11**	.10*	.22***	.12*	.16**	1.07*
Academic motivation						
Academic amotivation	.10*	.10*	.24***	.15**	.19***	1.06†
Academic locus of control	.14**	.13**	.24***	.15**	.18***	1.08**
Self-efficacy	.12*	.10*	.22***	.12*	.15**	1.08*
Self-interested motives for learning	.15**	.14**	.24***	.16**	.20***	1.09**
Self-transcendent motives for learning	.14**	.12*	.23***	.13*	.18**	1.09**

Note. Coefficients listed above indicate the relationship between MTFT scores and academic outcomes when controlling for demographics (gender, race, and socioeconomic status) and the covariate listed in the left-hand column. All coefficients are standardized regression coefficients, with the exception of those listed in the college progress column; these are IRR coefficients. GPA = grade-point average.
† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

validation of the MTFT advances the measurement of frustration tolerance in several ways. First, the MTFT is easy to use at scale. It is designed to be administered online, it is freely available for public use (www.noncog.org), and it is customizable: Researchers can replace the mirror-tracing task with other frustrating tasks or swap out the videos and games to fit their needs. Second, the MTFT is ecologically valid. As is the case in the real world, participants can switch back and forth between a frustrating task and a more enjoyable option. Previous mirror-tracing tasks (e.g., Quinn et al., 1996) do not allow for this type of toggling. Third, because performance tasks are likely more sensitive to within-person changes in behavior than self-report questionnaires (Duckworth & Yeager, 2015), the MTFT may be ideally suited for assessing the impact of future interventions aimed at improving frustration tolerance. As a result, the MTFT offers a paradigm that, like the Balloon Analogue Reasoning Test (Lejuez et al., 2002) and Preschool Delay of Gratification Task (also known as the "marshmallow test"; Mischel, Shoda, & Rodriguez, 1989), should facilitate experimental research.

The current investigation has several limitations. First, we validated our task with samples of high-school students and young adults. Frustration tolerance could be a stronger (or weaker) predictor of academic achievement at younger ages. Second, although we showed that the MTFT induced frustration more than a large set of other common emotions, we cannot rule out the possibility that the task elicited emotions that we did not measure. Third, though we found that MTFT scores predicted later academic outcomes, even when controlling for a variety of confounds, experimental studies are needed to confirm causal relations between frustration tolerance and achievement.

It has been said that "there is nothing so theoretical as a good method" (Greenwald, 2012, p. 99). In the absence of a trusted method of assessing frustration tolerance, much has remained unknown about this construct. What contributes to frustration tolerance, and how can it be developed? What are its boundary conditions? For example, is frustration tolerance less relevant in impoverished contexts in context opportunities to improve are severely limited? Are there forms of achievement that are *not* predicted by the ability to withstand frustration? And are there potential drawbacks to frustration tolerance? The MTFT offers researchers the chance to find out.

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