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Analysis of a mindset intervention

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ABSTRACT

Mindset refers to a person's beliefs about the nature of their abilities—whether they believe their ability in a given domain is malleable or fixed. We investigated whether a brief, online intervention could alter ability and non-ability traits, including mindset of intelligence, locus of control, challenge-approach motivation, grit, and performance on cognitive ability tests. Exploratory factor analysis indicated that measures of mindset, grit, and locus of control loaded onto a common self-determination factor, which was independent of a second factor reflecting fluid intelligence and crystallized intelligence. Multilevel modeling further revealed that participants who received a mindset intervention reported more growth mindset, internal locus of control, challenge-approach motivation, and self-determination. The mindset intervention did not alter cognitive ability scores or grittiness.

1. Introduction

There has recently been a great deal of scientific interest in the impact of *mindset*—a person's beliefs about whether their abilities are fixed or malleable (Dweck & Leggett, 1988)—on academic achievement and other real-world outcomes. As originally argued by Dweck and colleagues, people who believe that their ability in a domain can be improved with effort possess a *growth mindset* (also called an incremental theory), whereas people who believe that their ability in a domain is unchangeable possess a *fixed mindset* (also called an entity theory; Dweck, Chiu, & Hong, 1995). Dweck has argued that mindset has "profound effects" on achievement (Dweck, 2008).

The effect of mindset on outcomes is assumed to be mediated through self-regulatory processes (Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013). That is, people with a growth mindset are hypothesized to approach challenges, because challenges are construed as learning opportunities that can be overcome with effort. By contrast, people with a fixed mindset and low perceived ability are hypothesized to avoid challenges, because challenges are interpreted as an indication that one lacks the natural ability necessary to succeed (Yeager & Dweck, 2012).

Consistent with the theoretical model, there is evidence that when students with a fixed mindset are confronted with setbacks, they tend to experience withdrawal and demotivation (Aditomo, 2015; Blackwell, Trzesniewski, & Dweck, 2007; Robins & Pals, 2002; Weiner, 1985). By contrast, evidence suggests that students with a growth mindset are more likely to engage in challenge-approach behaviors in response to setbacks. For instance, Hong, Chiu, Dweck, Lin, and Wan (1999) surveyed incoming freshmen at a university in Hong Kong who had received a C grade or lower in English on their recent School Certificate Examination. Participants were told that English proficiency was essential for academic success, and informed of a remedial English course that had proven to be effective for other students. Participants with a growth mindset were significantly more inclined to take the remedial English course than participants with a fixed mindset.

1.1. Should mindset be considered a marker of 'self-determination'?

A critical question involves how mindset relates to other motivational factors. More specifically, should mindset be considered a marker of a broad *self-determination* factor, reflecting how much control individuals feel they have in their skill development? Addressing this question is important to further refine our understanding of the construct validity of mindset, and more specifically, how it fits in the broader nomological network of non-ability factors (Cronbach & Meehl, 1955).

Mindset would seem to be related to self-determination because people with a growth mindset believe that they can develop their abilities with effort. For example, individuals with a growth mindset agree with statements such as "you can change even your basic

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intelligence level considerably" (Dweck, 1999), and tend to endorse learning goals (Dweck & Leggett, 1988). By contrast, people with a fixed mindset may feel that they have little control over the development of their abilities. For instance, they agree with statements such as "you have a certain amount of intelligence, and you can't really do much to change it," and tend to avoid challenging learning opportunities (Dweck & Leggett, 1988; Dweck, 1999).

A number of other non-ability factors might be considered indicators of self-determination. One such factor is *grit*—a person's perseverance and passion for long-term goals (Duckworth, Peterson, Matthews, & Kelly, 2007). Grit seems to be related to self-determination because gritty individuals persevere towards goals despite challenges and setbacks (Eskreis-Winkler, Shulman, Beal, & Duckworth, 2014). This suggests that gritty people possess a strong sense of agency; that is, they believe that with persistent effort, they can achieve their goals.

Grit can also be interpreted within the context of mindset theory. Individuals with a growth mindset may be more likely to pursue long-term goals despite setbacks, because they construe setbacks as surmountable learning opportunities. On the other hand, individuals with a fixed mindset may be more likely to give up on long-term goals when confronted by setbacks, because they construe setbacks as insurmountable indicators of personal deficiency (Dweck & Leggett, 1988).

Another factor that may be related to self-determination is *locus of control*—an individual's tendency to attribute success and failure to internal or external factors (Rotter, 1966). Individuals with an internal locus of control may have greater self-determination because they feel that their efforts can lead to improvements within a domain. By contrast, people with an external locus of control may have less self-determination because they feel that their efforts cannot affect their outcomes.

The results of a recent study by Tucker-Drob, Briley, Engelhardt, Mann, and Harden (2016) suggest that some of the above constructs are indeed related. In a sample of 811 students, Tucker-Drob et al. (2016) found that growth mindset and grit were positively correlated. Furthermore, mastery goal orientation, which is related to challenge-approach motivation, was positively correlated with mindset and grit. Finally, mindset, mastery orientation, and grit all loaded positively onto a common factor with other measures including educational attitudes and need for cognition.

1.2. How generalizable are the effects of mindset?

In addition to the above question about the extent to which mindset should be considered a marker of self-determination, more recent research has suggested that the effects of mindset on various outcomes may also be less generalizable than previously thought. Indeed, several studies have failed to find positive effects of mindset on achievement (e.g., Shedlosky-Shoemaker & Fautch, 2015; Sriram, 2014; Dommett, Devonshire, Sewter, & Greenfield, 2013).

To better understand these discrepant results, Sisk, Burgoyne, Sun, Butler, and Macnamara (2018) conducted two meta-analyses assessing the relationship between mindset and academic achievement, one evaluating correlations between mindset and achievement and the other evaluating experimental effects of mindset interventions on achievement. In the correlational meta-analysis (129 studies and 273 effects; total $N = 365{,}915$), the average correlation between mindset and academic achievement was $\bar{r} = 0.10$, indicating a small advantage of a growth mindset. Moderator analyses further revealed that the correlation was greater for children ($\bar{r} = 0.19$) than for adults ($\bar{r} = 0.02$).

In the meta-analysis of experimental effects (29 studies and 43 effects; total $N = 57{,}155$), Sisk et al. (2018) found a small but significant effect of mindset interventions on academic achievement, $\bar{d} = 0.08$. However, even here, the findings were less straightforward than it might seem. Of the studies that included a manipulation check to test whether the intervention successfully altered mindset, the effect of the intervention on academic achievement was only significant when the manipulation check *failed*. In other words, when the intervention successfully altered mindset, academic performance was unaffected; when the intervention failed to alter mindset, academic performance improved. Thus, in these cases, the intervention effect on academic performance cannot be attributed to mindset. For studies that did not conduct a manipulation check, the intervention effect was significant but the mediating mechanism is unclear. Nevertheless, subsequent moderator analyses in Sisk et al. identified what could be an important moderator of mindset effects: socioeconomic status (SES). Namely, the mindset interventions tended to be more effective for low-SES students ($d = 0.34$) and for students who were academically high-risk ($d = 0.19$).

Recently, Yeager et al. (2016) designed mindset induction materials for administration to students transitioning into high school. Students were presented with content suggesting that intelligence is developed from stimulating environments and can be improved with hard work, help, and improved strategies (e.g., "the brain is like a muscle—it gets stronger (and smarter) when you exercise it"). Yeager and colleagues found that the mindset intervention group reported a greater increase in growth mindset than a placebo control group following the intervention. Furthermore, the mindset intervention group demonstrated less challenge-avoidant motivation relative to controls, as indicated by the proportion of students who said they would prefer an easy math homework assignment rather than a hard math assignment. Consistent with the results of Sisk et al.'s (2018) meta-analysis, the effects of the intervention on academic achievement were significant for students who were performing below average ($d = 0.10$), but not for students who were performing above average ($d = 0.03$).

1.3. Present study

The goals of the present study were to investigate (1) whether mindset should be considered an element of self-determination, and (2) whether the brief online intervention adapted from Yeager et al. (2016) could alter participants' mindset of intelligence and other potential measures of a self-determination factor (i.e., locus of control, challenge-approach motivation, and grit). The intervention consisted of a brief mindset induction (see Yeager et al., 2016). A sample of emerging adults was randomly assigned to either a growth mindset intervention condition or an active control condition. The effects of the intervention were assessed using multilevel modeling by comparing scores on pre- and post-intervention measures of mindset, locus of control, challenge-approach motivation, and grit. We also examined fluid intelligence and crystallized intelligence, with the primary goals of (1) determining whether cognitive ability was distinct from self-determination, and (2) examining whether performance on cognitive ability tests also improved with a mindset manipulation, given arguments that mindset has profound effects on achievement (Dweck, 2008).

Based on the theoretical overlap between mindset, challenge-approach motivation, grit, and locus of control, we predicted that these measures would load onto a common "self-determination" factor. We further predicted that measures of cognitive ability would load onto a separate factor. For the second question, we predicted that participants receiving the growth mindset intervention would report greater gains in growth mindset, grit, locus of

control, and challenge-approach motivation, relative to baseline and relative to participants in the active control condition. Relatedly, we predicted that participants receiving the growth mindset intervention would have higher scores on a composite factor representing self-determination relative to baseline and relative to controls. We did not expect our brief intervention to alter scores on the cognitive ability measures. However, given arguments made by prominent mindset researchers (e.g., Dweck, 2008), we examined whether there was any effect of the intervention on achievement. We also evaluated whether participants worked harder (spending more time) on specific items on those cognitive ability measures.

2. Method

2.1. Participants

The participants were 488 emerging adults (age range: 17–24 years, $M = 21.9$) recruited through the Amazon Mechanical Turk participant pool.[1] Recruiting participants through MTurk allowed us to test whether the mindset intervention is also effective outside of school contexts, as we would expect if mindset effects generalize in the assumed ways. The mean annual household income for participants was approximately $37,500 and ranged from $10,000 to $80,000. Participants were selected with the goal of increasing the proportion of lower SES participants in our sample, using income as an approximate indicator of SES. We used the Qualtrics randomizer option to randomly assign participants to either the growth mindset intervention condition or the active control condition. Neither age nor income varied across conditions prior to the intervention ($ps > .05$).

2.2. Measures

2.2.1. Mindset

This 3-item questionnaire assesses whether the participant believes that their intelligence is fixed or malleable (Yeager et al., 2016). Participants respond to items such as "You have a certain amount of intelligence and you really can't do much to change it" using a 6-point Likert scale, with response options ranging from "Strongly disagree" to "Strongly agree." Higher scores on this measure correspond to more growth mindset.

2.2.2. Grit

This 8-item questionnaire assesses trait-level perseverance and passion for long-term goals (Duckworth & Quinn, 2009). Participants respond to items such as "I often set a goal but later choose to pursue a different one" using a 5-point Likert scale, with response options ranging from "Very much like me" to "Not like me at all." Higher scores on this measure correspond to more grit.

2.2.3. Locus of control

This 28-item questionnaire assesses the extent to which the participant believes that their academic performance is a result of internal or external factors (Trice, 1985). Participants report whether items such as "College grades most often reflect the effort you put into classes," or "I have taken a course because it was an easy good grade at least once" are true or false as they relate to themselves. Higher scores on this measure correspond to more internal attributions.

2.2.4. Make-A-Math Worksheet

The participant is asked to construct a math worksheet by selecting a set of math problems from 3 different content areas. This task was previously used by Yeager et al. (2016) as a measure of challenge-approach motivation. Participants are provided with the following description of the task:

> *What kind of math worksheet would you prefer? We are interested in what kinds of problems students prefer to work on. On the next few pages, we would like you to create your own math worksheet. If there is time, at the end of the session you will have the opportunity to answer these math problems. There are problems from 4 different math chapters. Choose between 2 and 6 problems for each chapter. You can choose from problems that are: very challenging but you might learn a lot; somewhat challenging and you might learn a medium amount; not very challenging and you probably won't learn very much. Do not try to answer the math problems. Just click on the problems you'd like to try later if there's time.*

The math problems are labeled with the descriptors "Very challenging problem," "Somewhat challenging problem," and "Not very challenging problem." An overall challenge score, representing challenge-approach motivation, was calculated for each participant by subtracting the number of easy problems selected for the worksheet from the number of very challenging problems selected for the worksheet. This is the same scoring method used by Yeager et al. (2016). After completing the Make-A-Math Worksheet, participants are provided with the following statement:

> *Thank you for selecting the problems. Unfortunately, there is not enough time for you to complete the problems that you selected. However it is very helpful to know what kinds of problems you would have liked to work on, if there had been enough time. Thank you for your responses.*

2.2.5. Shipley-2 vocabulary

This measure of crystallized intelligence consists of 40 items (Shipley, Gruber, Martin, & Klein, 2009). The participant must identify the word most similar in meaning to the target word out of 4 options. At pre-test, participants were presented with the 20 odd-numbered items; at post-test, participants were presented with the 20 even-numbered items.

2.2.6. Shipley-2 block design

This measure of fluid intelligence consists of 26 items (Shipley et al., 2009). The participant must identify the missing section(s) of an abstract design from a set of options, such that the completed design matches the target design. The same 26 items were presented to participants at pre-test and at post-test. No accuracy feedback was provided.

2.3. Mindset intervention

The mindset intervention was adapted from Yeager et al. (2016)[2] and included two conditions: a growth mindset condition and an active control condition. In both conditions, participants were

[1] Prior to random assignment, 114 participants dropped out of the experiment. Following random assignment, 51 participants dropped out of each condition. For all pre-test measures (i.e., mindset, grit, locus of control, overall challenge score, vocabulary, block design), participants who dropped out of the mindset intervention condition were not significantly different from participants who dropped out of the active control condition ($ps > 0.05$). We measured the amount of time that each participant spent on each item in the intervention, and excluded participants who were clearly clicking through without reading the stimuli prior to conducting data analyses. Results are reported for the 488 participants who completed the experiment. This study was not preregistered. The data are openly available at https://osf.io/atdnm/.

[2] Researchers can obtain the complete mindset intervention materials for free by contacting David Yeager.

presented with a lay-person "scientific review" article complete with graphics, compelling stories (e.g., Phineas Gage), and celebrity quotes. Participants were asked to read the entire article and remember the main points for a memory test. After reading the article, participants were asked to write a summary of the article and to rate the extent to which the article was difficult to read, credible, and persuasive, and how much they agreed with the article's points.

The two conditions differed in terms of the content presented to participants. In the growth mindset condition, participants were presented with content suggesting that intelligence is developed from stimulating environments and can be improved with hard work (e.g., "the brain is like a muscle—it gets stronger (and smarter) when you exercise it") (Fig. 1). In the active control condition, participants were presented with content that reviewed basic findings about the human brain (e.g., "the parietal lobe is where the brain interprets the sense of touch") (Fig. 2).

2.4. Procedure

All participants provided informed consent at the outset of the experiment. Participants were randomly assigned to either the growth mindset intervention condition (n = 242) or the active control condition (n = 246).

The experiment was conducted online via Qualtrics in a single session with three phases. In the first phase, participants completed the following pre-test measures, listed in order of administration: vocabulary, block design, mindset, grit, locus of control, and the Make-A-Math Worksheet. In the second phase, participants were given either the growth mindset intervention or the active control materials. In the third phase, participants completed the following post-test measures: vocabulary, block design, mindset, grit, locus of control, and the Make-A-Math Worksheet. Following the third phase, all participants were debriefed. Participants in the active control condition were provided with the growth mindset intervention materials.

2.5. Analyses

To illuminate the nomological network of mindset, we used exploratory factor analysis (EFA) with Promax rotation to allow the factors to correlate with one another. EFA allowed us to investigate the factor structure of the following pre-test measures: mindset, grit, locus of control, the overall challenge score from the Make-A-Math Worksheet task, vocabulary, and block design.

We then used multilevel modeling to assess the main effects of phase (pre-test vs. post-test) and experimental condition (growth mindset intervention vs. active control), as well as the interaction between phase and condition, on the dependent measures of interest. In the models, phase (level 1) was nested in participant (level 2). Phase, condition, and the phase × condition interaction were treated as fixed coefficients. Age and income were treated as fixed covariates in the models. Our primary question is most directly tested via the phase × condition interaction, which specifically indicates whether the intervention altered responses relative to baseline, and did so differentially for those assigned to the growth mindset intervention condition versus the active control condition. We also conducted within-subjects t-tests, and computed standardized effect sizes using the following formula for Cohen's d: $d = (M_{\text{post-test}} - M_{\text{pre-test}})/SD_{\text{pre-test}}$.

3. Results

3.1. Mindset as an element of self-determination

The correlation matrix for the pre-test measures is presented in Table 1. As predicted, growth mindset was correlated with internal

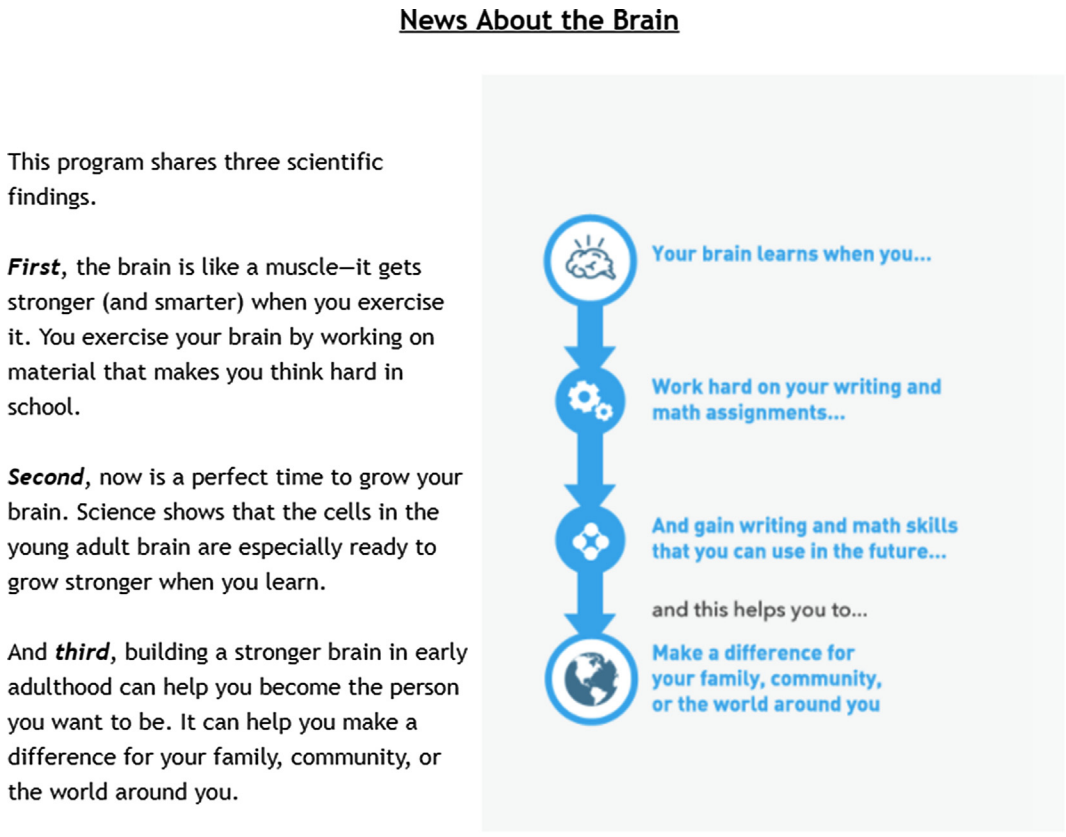

Fig. 1. Screenshot from the growth mindset intervention.

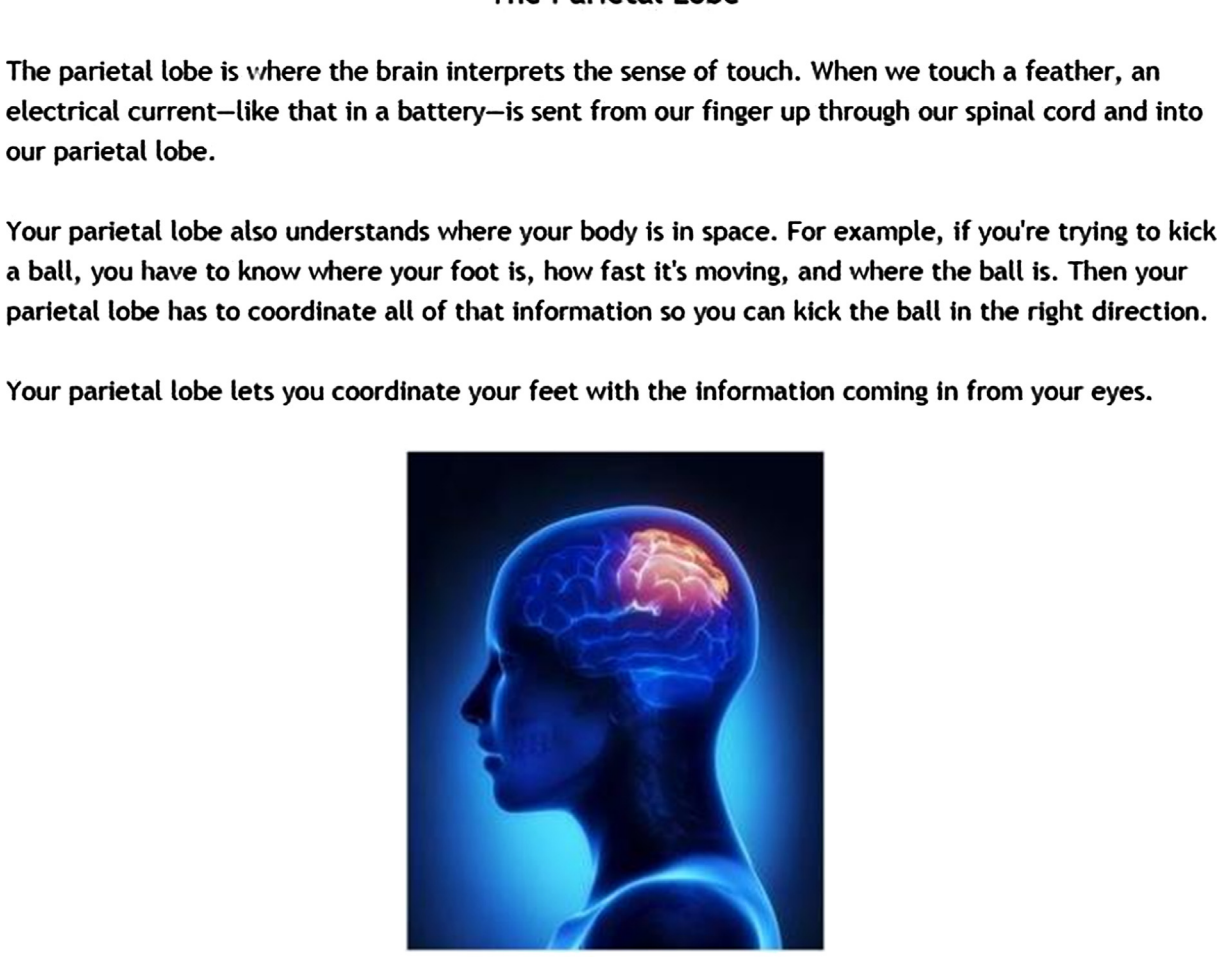

Fig. 2. Screenshot from the active control condition.

Table 1
Correlations between pre-test measures ($n = 488$).

Variable	1.	2.	3.	4.	5.
1. Vocabulary					
2. Block Design	**0.45**				
3. Mindset	0.08	**0.14**			
4. Grit	0.03	−0.07	**0.15**		
5. Locus of Control	0.06	0.01	**0.24**	**0.57**	
6. Overall Challenge Score	**−0.13**	−0.06	0.02	0.03	0.06

Note. Bolded correlations are significant at $p < .01$.

locus of control, $r = 0.24$ ($p < .01$), and grit, $r = 0.15$ ($p < .01$). However, mindset did not correlate significantly with challenge-approach motivation, as measured by participants' choices for the Make-A-Math Worksheet, $r = 0.02$ ($p > .05$). Internal locus of control was strongly correlated with grit, $r = 0.57$ ($p < .01$). Scores on the vocabulary and block design tests were also correlated, $r = 0.45$ ($p < .01$).

We performed the EFA using principal axis factoring with Promax rotation on these correlations, extracting factors with eigenvalues greater than 1.0. The EFA yielded two factors with eigenvalues greater than 1.0 (Table 2); inspection of the scree plot provided additional support for the extraction of two factors. The first factor, which we label "Self-Determination," had moderate to high loadings on locus of control, grit, and mindset. The second factor, which we label "Cognitive Ability," had high loadings on block design and vocabulary. The overall challenge score from the Make-A-Math Worksheet did not load highly on either factor. The two factors were orthogonal, $r = 0.02$.

3.2. Effects of the intervention

The second question of interest was whether the growth mindset intervention altered participants' mindset of intelligence, grit, locus of control, and challenge-approach motivation, as well as a self-determination composite variable. Pre- and post-intervention means for both groups are presented in Table 3. Random assignment was relatively successful at producing matched groups—at pre-test the two groups did not differ significantly on measures of grit, locus of control, challenge-approach motivation, or cognitive ability. They did differ significantly on mindset ($p = .002$),

Table 2
Summary of exploratory factor analysis for pre-test measures (n = 488).

Variable	Factor 1	Factor 2
Vocabulary	0.07	**0.62**
Block Design	−0.01	**0.72**
Mindset	**0.26**	0.15
Grit	**0.65**	−0.08
Locus of Control	**0.87**	−0.01
Overall Challenge Score	0.06	−0.13
Eigenvalues	1.71	1.50
% of variance	28.43	25.05

Note. Factor loadings ≥ 0.25 appear in bold.

Table 3
Pre- and post-intervention means for the dependent measures.

Measure	Condition	Pre-Test Mean (*SD*)	Post-Test Mean (*SD*)
Mindset	Control	3.91 (*1.20*)	3.87 (*1.31*)
	Growth	4.08 (*1.18*)	4.38 (*1.24*)
Grit	Control	3.25 (*0.76*)	3.29 (*0.76*)
	Growth	3.23 (*0.76*)	3.30 (*0.79*)
Locus of Control	Control	16.08 (*4.81*)	15.95 (*4.65*)
	Growth	16.13 (*4.94*)	16.51 (*4.65*)
Overall Challenge Score	Control	−6.28 (*9.13*)	−5.13 (*9.14*)
	Growth	−6.96 (*9.69*)	−3.71 (*10.08*)
Vocabulary	Control	16.33 (*2.97*)	15.79 (*3.69*)
	Growth	16.41 (*3.18*)	16.00 (*3.41*)
Block Design	Control	10.20 (*2.61*)	10.44 (*2.63*)
	Growth	10.44 (*2.81*)	10.39 (*3.02*)
Self-Determination	Control	−0.06 (*2.12*)	−0.26 (*2.15*)
	Growth	0.06 (*2.31*)	0.26 (*2.28*)

Table 4
Results of the multilevel models assessing the effects of the intervention.

Measure	p for phase	p for condition	p for phase × condition
Mindset	<.001	.002	<.001
Grit	<.001	*ns*	*ns*
Locus of Control	*ns*	*ns*	.015
Overall Challenge Score	<.001	*ns*	.001
Vocabulary	<.001	*ns*	*ns*
Block Design	*ns*	*ns*	*ns*
Self-Determination	*ns*	*ns*	<.001

Note. *ns* indicates $p > .05$.

but the use of multilevel modeling allows us to account for differences in pre-test scores across conditions when estimating the effects of the intervention. Results of the multilevel models assessing the effects of the intervention are presented in Table 4.

3.2.1. Self-determination

The self-determination composite variable was computed by taking the sum of the standardized scores for the three variables that loaded on the Self-Determination factor in the EFA: mindset, locus of control, and grit (higher values reflect a higher level of self-determination). The main effects of phase and condition on the self-determination composite variable were not significant ($ps > 0.05$). There was a significant phase × condition interaction ($p < .001$). Participants in the growth mindset condition reported greater self-determination at post-test compared to pre-test, $d = 0.09$, $t(241) = 2.687$, $p = .008$, whereas participants in the active control condition reported less self-determination at post-test compared to pre-test, $d = -0.09$, $t(245) = -4.096$, $p < .001$. Next, we shift focus from the composite measure of self-determination to individual measures, to assess the specific effects of the intervention.

3.2.2. Mindset

There was a significant main effect of phase ($p < .001$) and condition ($p = .002$) on mindset, as well as a significant phase × condition interaction ($p < .001$). Follow-up analyses using within-subjects t-tests revealed that participants in the growth mindset condition reported more of a growth mindset following the intervention, $d = 0.26$, $t(241) = 4.833$, $p < .001$, whereas participants in the active control condition reported no change in mindset following the intervention, $d = -0.03$, $t(245) = -1.008$, $p = .314$.

3.2.3. Grit

There was a significant main effect of phase ($p < .001$) on grit; participants in both groups reported more grit following the intervention, $d = 0.08$, $t(487) = 3.512$, $p < .001$. The main effect of condition and the phase × condition interaction were both non-significant.

3.2.4. Locus of control

The main effects of phase and condition on locus of control were not significant. However, the phase × condition interaction was significant ($p = .015$). Participants in the growth mindset condition reported more internal locus of control following the intervention, $d = 0.08$, $t(241) = 2.542$, $p = .012$, whereas participants in the active control condition reported no change in locus of control following the intervention, $d = -0.03$, $t(245) = -0.899$, $p = .37$.

3.2.5. Challenge-approach motivation

Challenge-approach motivation was assessed by examining participants' selection of math items during the Make-A-Math Worksheet task. There was a main effect of phase on challenge-approach motivation ($p < .001$); overall, participants tended to demonstrate more challenge-approach motivation at post-test compared to pre-test, $d = 0.23$, $t(487) = 6.71$, $p < .001$. The main effect of condition was not significant. However, there was a significant phase × condition interaction ($p < .001$). Participants in the growth mindset condition demonstrated more challenge-approach motivation at post-test compared to pre-test, $d = 0.34$, $t(241) = 6.386$, $p < .001$, relative to participants in the active control condition, $d = 0.13$, $t(245) = 2.875$, $p = .004$.

To assess how the intervention specifically affected challenge-approach motivation, we conducted follow-up tests on the number of easy and hard items selected for the Make-A-Math Worksheet. There was a main effect of phase on the number of easy items selected ($p < .001$); overall, participants tended to select fewer easy items at post-test than at pre-test, $d = 0.16$, $t(487) = 5.672$, $p < .001$. The main effect of condition was not significant. However, there was a significant phase × condition interaction ($p = .012$). Participants in the growth mindset condition tended to select fewer easy items at post-test compared to pre-test, $d = 0.23$, $t(241) = 5.287$, $p < .001$, relative to participants in the active control condition, $d = 0.09$, $t(245) = 2.546$, $p = .012$.

There was also a main effect of phase on the number of hard items selected ($p < .001$); overall, participants tended to select more hard items at post-test than at pre-test, $d = 0.18$, $t(487) = -6.060$, $p < .001$. The main effect of condition was not significant. However, there was again a significant phase × condition interaction ($p = .012$). Participants in the growth mindset condition tended to select more hard items at post-test compared to pre-test, $d = 0.29$, $t(241) = -5.744$, $p < .001$, relative to participants in the active control condition, $d = 0.09$, $t(245) = -2.508$, $p = .013$. Thus, the change in overall challenge-approach motivation reflected both an increase in the number of hard items chosen

and a decrease in the number of easy items chosen for the Make-A-Math Worksheet.

3.2.6. Vocabulary

There was a significant main effect of phase ($p < .001$) on vocabulary scores. Participants tended to perform worse on the vocabulary test at post-test compared to pre-test, $d = -0.16$, $t(487) = 4.740$, $p < .001$. The main effect of condition and the phase × condition interaction were both non-significant.

3.2.7. Block design

The main effects of phase and condition on block design scores and the phase × condition interaction were all non-significant (all $ps > 0.05$).

3.2.8. Testing time for cognitive ability measures

As an addendum to our cognitive ability results, we examined the effect of the intervention on the amount of time participants spent completing the cognitive ability measures (i.e., testing time) using multilevel modeling. As before, phase (level 1) was nested in participant (level 2). Phase, condition, and the phase × condition interaction were treated as fixed coefficients; age and income were treated as fixed covariates.

There was a significant main effect of phase ($p < .001$) on testing time for both the vocabulary test and block design (Table 5). Participants spent less time completing these measures at post-test relative to pre-test, $t(487) = 3.975$, $p < .001$ for the vocabulary test; $t(487) = 11.167$, $p < .001$ for block design. The main effects of condition and the phase × condition interactions were all non-significant (all $ps > 0.05$).

3.3. Income as a potential moderator

As a sensitivity analysis, we tested whether the growth mindset intervention had greater effects for lower-income participants, treating annual household income as a proxy measure for SES. First, we dichotomized annual income for the growth mindset intervention group (lower income ≤ $45,000, $n = 156$; higher income > $45,000, $n = 86$). Next, for the growth mindset group, we used multilevel modeling to test for main effects of phase (pre-test vs. post-test) and income category (lower income vs. higher income), as well as the interaction between phase and income category. In the models, phase (level 1) was nested in participant (level 2). Phase, income category, and the phase × income category interaction were treated as fixed coefficients. Age was treated as a fixed covariate in the models.

For all dependent measures (i.e., self-determination, mindset, grit, locus of control, overall challenge score, vocabulary, and block design), the main effect of income category and the phase × income category interaction were both non-significant. This indicates that the effects of the growth mindset intervention were similar for lower-income and higher-income participants.

4. Summary

To sum up, the growth mindset intervention significantly increased growth mindset, internal locus of control, challenge-approach motivation, and scores on a composite factor representing self-determination, relative to baseline and relative to controls. There was no effect of the mindset intervention on cognitive ability test scores or on grit. Income did not moderate the above findings.

4.1. Perceptions of the intervention

In our next analysis, we examined participants' perceptions of the intervention (Table 6). The two groups did not differ in self-reports assessing the difficulty of reading the assigned article, or in the credibility of the materials. Interestingly, the growth mindset group found the intervention more persuasive than the active control group ($p = .02$), whereas the active control group agreed with the content of the intervention more than the growth mindset group ($p = .02$).

Next, we selected participants from both groups who rated the credibility of the intervention materials favorably (i.e., responses ≥ 5 on an 8-point Likert scale), to assess whether the overall pattern of intervention effects for this subsample differed from the main results reported in Table 4. This resulted in $n = 191$ for the growth mindset intervention group and $n = 201$ for the active control group. We than ran the multilevel models using the same approach as before. Results are presented in Table 7.

Table 6
Participants' perceptions of the intervention.

Measure	Condition	Mean (*SD*)	*p* for difference
Difficult to read	Control	2.20 (*1.76*)	*ns*
	Growth	2.01 (*1.52*)	
Credible	Control	6.05 (*1.59*)	*ns*
	Growth	5.88 (*1.63*)	
Persuasive	Control	5.60 (*1.85*)	<.05
	Growth	5.95 (*1.57*)	
Agreed with content	Control	6.51 (*1.39*)	<.05
	Growth	6.21 (*1.48*)	

Note. Participants responded to each item using an 8-point Likert scale. Response options ranged from 1 ("not at all") to 8 ("very much"). *ns* indicates $p > .05$.

Table 7
Results of the multilevel models for participants who rated the intervention as credible.

Measure	*p* for phase	*p* for condition	*p* for phase × condition
Mindset	<.001	<.001	<.001
Grit	.001	*ns*	*ns*
Locus of Control	*ns*	*ns*	.003
Overall challenge score	<.001	*ns*	.002
Vocabulary	<.001	*ns*	*ns*
Block Design	*ns*	*ns*	*ns*
Self-determination	*ns*	.042	<.001

Note. *ns* indicates $p > .05$.

Table 5
Effect of mindset intervention on amount of time spent on cognitive ability tasks.

Measure	Condition	Pre-Test Mean	Post-Test Mean	*p* for phase	*p* for condition	*p* for phase × condition
Vocabulary testing time	Control	34.43	25.42	<.001	*ns*	*ns*
	Growth	30.81	21.08			
Block Design testing time	Control	32.18	17.79	<.001	*ns*	*ns*
	Growth	32.69	19.85			

Note. *ns* indicates $p > .05$.

Table 8
Exploratory factor analysis for post-test measures.

Variable	Factor 1	Factor 2
Vocabulary	0.03/−0.04	**0.61/0.44**
Block Design	−0.04/0.11	**0.69/0.94**
Mindset	0.24/**0.26**	−0.23/−**0.34**
Grit	**0.55/0.66**	0.03/−0.02
Locus of Control	**0.92/0.97**	0.04/−0.04
Overall Challenge Score	0.04/0.10	0.10/0.04
Eigenvalues	1.61/1.89	1.51/1.47
% of variance	26.84/31.53	25.21/24.46

Note. Factor loadings ≥ 0.25 appear in bold. Values for the control condition are presented before the slash. Values for the growth mindset condition are presented after the slash.

We found the same pattern of intervention effects across all dependent measures in this selected sample as in the overall sample reported in Table 4.

4.2. Post-intervention exploratory factor analysis

Given the above growth mindset induction, and the desire to examine mindset as a component of self-determination, we conducted post-hoc analyses investigating whether and how the intervention might have altered the factor structure of the dependent measures. In particular, we were curious whether the measures that loaded on the "Self-Determination" factor at pre-test (i.e., mindset, grit, and locus of control) would continue to load on the same factor following the intervention, given that the intervention altered scores on some of these measures. As before, we performed the EFA using principal axis factoring with Promax rotation to allow factors to correlate. We extracted two factors. Analyses were conducted separately for the two groups.

The results of the EFA are presented in Table 8. For the active control group, Factor 1 had high loadings on locus of control and grit, and Factor 2 had high loadings on block design and vocabulary. For the growth mindset intervention group, Factor 1 had moderate to high loadings on locus of control, grit, and mindset, and Factor 2 had moderate to high loadings on block design, vocabulary, and mindset. The overall challenge score from the Make-A-Math Worksheet did not load highly on either factor for both groups. For both groups, the two factors were relatively orthogonal (*r*s = 0.02 and −0.07).

5. Discussion

The purpose of the present experiment was to evaluate mindset as an element of self-determination, and to investigate whether a brief, online intervention could alter participants' mindset of intelligence, grit, locus of control, challenge-approach motivation, and scores on cognitive ability measures and a composite factor representing self-determination. Exploratory factor analysis indicated that two factors accounted for a majority of the variance (53%) in the pre-test measures. Mindset, grit, and locus of control defined the first factor, which we labeled Self-Determination; vocabulary and block design defined the second factor, which we labeled Cognitive Ability. Challenge scores on the Make-A-Math Worksheet did not load highly on either factor. In general, the results of the EFA affirm that mindset, grit, and locus of control are conceptually related constructs that are distinct from cognitive ability.

Multilevel modeling revealed that participants who received the growth mindset intervention reported significantly more growth mindset, internal locus of control, challenge-approach motivation, and had higher scores on a composite factor representing self-determination, relative to participants in the active control condition and relative to their own reports prior to the intervention. The growth mindset intervention did not have a significant effect on grit or performance on the cognitive ability measures.

Generally speaking, the effects of the intervention were small. For example, the mean change in mindset for the intervention group was less than half of one Likert scale point (on a 6-point scale), $d = 0.26$. By comparison, the effect of the mindset intervention in Study 2 of Yeager et al. (2016) was $d = 0.48$. In the present study, the mean change in locus of control for the intervention group was also less than half a point (on a 28-item scale), $d = 0.08$. The intervention had a slightly stronger effect on challenge-approach motivation; the mindset group demonstrated a three point mean change, $d = 0.34$, which roughly corresponds to selecting, for example, two more "very challenging" items and one fewer "not very challenging" items for the Make-A-Math Worksheet at post-test. Interestingly, however, challenge-approach motivation did not correlate with mindset ($r = 0.02$).

Paradoxically, we also found that both groups spent less time completing the cognitive ability measures at post-test compared to pre-test. However, the reduction in testing time did not differ by condition. If testing time is interpreted as a measure of effort, this suggests that the mindset intervention did not affect participants' effortful engagement on the cognitive ability measures relative to participants in the active control condition.

Multilevel modeling also revealed that the effects of the intervention did not differ for higher- and lower-SES participants. We dichotomized annual income for the growth mindset intervention group, using income as an approximate indicator of SES. Across all dependent measures, the main effect of income and the phase × income interaction were not significant. This finding is inconsistent with the results of Sisk et al. (2018), who found that mindset interventions were more effective for low SES participants.

We also performed multilevel modeling on participants who rated the intervention materials as credible to assess whether the pattern of intervention effects differed for this subsample relative to all participants. We found the same pattern of intervention effects in this selected sample across all dependent measures, suggesting that the intervention effects were similar regardless of whether participants found the materials to be credible.

Finally, comparing the results of the EFA for pre-test measures (Table 2) to the EFA for post-test measures (Table 8), the first extracted factor at post-test is very similar to the Self-Determination factor at pre-test. For the mindset intervention group, this factor had a notably high loading for locus of control (0.97), and moderate loadings for grit and mindset. At post-test a second factor with loadings on measures of cognitive ability also emerged, with mindset also loading on this factor for only the intervention group. The differences between the EFA on pre-test and post-test measures is likely due to the intervention's effects, which might have altered not only participants' responses to the post-test measures, but also the associations between these measures.

5.1. Limitations

One caveat of the present experiment is that participants were selected from the Amazon Mechanical Turk participant pool. It has been argued that possessing a growth mindset will be most helpful for individuals who are academically at-risk (Paunesku et al., 2015), low socioeconomic status (Claro, Paunesku, & Dweck, 2016), or undergoing a difficult transition such as entering high school (Yeager & Dweck, 2012). Our sample was selected with the goal of increasing the proportion of lower SES participants, using income as a rough proxy for SES (the mean average income was $37,500 per year; range: $10,000–$80,000), but

participants were not selected to be exclusively low SES, nor were they selected based on academic risk status or whether they were transitioning into a new school. Therefore, it is perhaps surprising that the online intervention had effects on a relatively non-targeted sample. This could be interpreted as a strength of the intervention.

Another limitation is that we did not conduct longitudinal analyses to determine whether the mindset intervention affected academic achievement. Doing so would allow us to determine whether changes in academic achievement, if observed, are mediated by the intervention's effects on mindset, locus of control, challenge-approach motivation, or self-determination. Based on the results of Sisk et al. (2018), we might expect any benefits of the mindset intervention to be mediated not by mindset but by changes in locus of control, challenge-approach motivation, or self-determination more generally.

5.2. Demand characteristics

A final concern is that demand characteristics influenced participants' responses to the post-test questionnaires. Demand characteristics refer to cues that allow the participant to guess the premise of the experiment and respond in ways that are favorable to the hypotheses being tested (Orne, 1962). In this experiment, the wording of the intervention content closely matched the wording of many of the post-intervention dependent measures.

For example, in one part of the mindset intervention, labeled "Getting Smarter," participants were provided with a summary of a study and told "This shows that teenagers' brains can become more intelligent." Following the intervention, participants were asked whether they agreed or disagreed with mindset items such as "Your intelligence is something about you that you can't change very much." Demand characteristics could have affected responses to this item because participants were presented with messages directly related to it during the intervention (i.e., "teaching to the test").

As another example, consider the following passage from the intervention: "building a stronger brain. . .can help you make a difference for your family, community, or the world around you." After the intervention, participants were asked if they endorsed locus of control items such as: "I feel I will someday make a real contribution to the world if I work hard at it." Once again, the close correspondence of intervention content and this post-intervention item might have had undue influence on participants' responses.

As a final example, compare this excerpt from the intervention, "When you work hard to learn something new—like a new type of *math problem*—the connections in your brain get stronger," to the measure of challenge-approach motivation: participants were asked to select *math problems* that they would like to solve later on (emphases added). Prior to the intervention, there was not a significant relationship between mindset and challenge-approach motivation ($r = 0.02$). Nevertheless, the mindset intervention somehow affected participants' responses to this challenge-approach motivation measure. It is possible that statements in the intervention that were unrelated to mindset encouraged participants to select more challenging math problems for the Make-A-Math Worksheet at post-test.

To sum up, demand characteristics could have affected participants' responses to the mindset, locus of control, and challenge-approach motivation measures following the intervention. It remains unclear which effects of Yeager et al.'s (2016) intervention were not driven by demand in the present study. Therefore, future studies must be cautious of the effects of demand characteristics on mindset interventions (for a discussion of demand characteristics in online research, see Berinsky, Huber, & Lenz, 2012; Cheung, Burns, Sinclair, & Sliter, 2017).

5.3. Conclusion

Overall, the results suggest that a brief, online intervention might be a cost-effective means of inducing growth mindset of intelligence, beliefs about self-efficacy, a willingness to approach challenges, and in turn, self-determination, all of which are potentially important precursors of academic achievement. Indeed, holding an internal locus of control has been associated with greater academic achievement, with effects in the small to medium range (see, e.g., Findley & Cooper, 1983). Challenge-approach motivation has also been shown to predict academic achievement, perhaps due in part to its association with mastery goals (Grant & Dweck, 2003). Finally, self-determination has been shown to predict persistence in high school, with students low in self-determination demonstrating a greater likelihood of dropping out (Vallerand, Fortier, & Guay, 1997). These speculations must be tempered, however, by the finding that the typical effect of mindset interventions on academic achievement is small, $d = 0.08$ (Sisk et al., 2018).

Furthermore, the mindset intervention did not alter participants' performance on the cognitive ability measures or self-reported grittiness. This result runs counter to prior arguments that mindset has profound effects on achievement (see, e.g., Dweck, 2008). With respect to grit, many of the items comprising the grit scale are worded retrospectively, such that participants reflect on their previous commitments to long-term goals (e.g., "I have achieved a goal that took years of work"). Although one could not reasonably expect the intervention to alter participants' previous commitments, it could have affected participants' overall attitude towards grittiness. The results provide no evidence that this was the case.

Future research should determine when and under which circumstances this mindset intervention will be effective. For example, would these materials be effective for adults who are returning to school? Follow-up studies must also assess the extent to which demand characteristics influence the results of mindset interventions. Studies should also examine whether the benefits of this particular mindset intervention extend beyond the context of an online survey, and lead to tangible benefits in terms of academic achievement or other real-world outcomes.

Open practices

The data are openly available at https://osf.io/atdnm/.

Author contributions

A.P. Burgoyne, D.Z. Hambrick, J.S. Moser, and S.A. Burt developed the study concept. S.A. Burt and A.P. Burgoyne performed data preparation. A.P. Burgoyne conducted the data analyses with input from D.Z. Hambrick, J.S. Moser, and S.A. Burt. A.P. Burgoyne, D.Z. Hambrick, J.S. Moser, and S.A. Burt drafted the manuscript.

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