You can't change your basic ability, but you work at things, and that's how we get hard things done

Testing the role of growth mindset on response to setbacks, educational attainment, and cognitive ability

Citation for published version:
Li, Y & Bates, TC 2019, 'You can't change your basic ability, but you work at things, and that's how we get hard things done: Testing the role of growth mindset on response to setbacks, educational attainment, and cognitive ability', *Journal of Experimental Psychology: General*, vol. 148, no. 9, pp. 1640-1655. https://doi.org/10.1037/xge0000669

Digital Object Identifier (DOI):
10.1037/xge0000669

Published In:
Journal of Experimental Psychology: General

Abstract

Mindset theory predicts that a growth mindset can substantially improve children's resilience to failure and enhance important outcomes such as school grades. We tested these predictions in a series of studies of 9-13-year-old Chinese children (n = 624). Study 1 closely replicated Mueller and Dweck (1998). Growth mindset manipulation was associated with performance on a moderate difficulty post-failure test (p = .049), but not with any of the eight motivation and attribution measures used by Mueller and Dweck (1998): mean p = 0.48. Studies 2 and 3 included an active control to distinguish effects of mindset from other aspects of the manipulation, and included a challenging test. No effect of the classic growth mindset manipulation was found for either moderate or more difficult material in either Study 2 or Study 3 (*p*s = .189 to .974). Compatible with these null results, children's mindsets were unrelated to resilience to failure for either outcome measure (*ps* = .673 to .888). The sole exception was a significant effect in the *reverse* direction to prediction found in Study 2 for resilience on more difficult material (p = .007). Finally, in two studies relating mindset to grades across a semester in school, the predicted association of growth mindset with improved grades was not supported. Neither was there any association of children's mindsets with their grades at the start of the semester. Beliefs about the malleability of basic ability may not be related to resilience to failure or progress in school.

Keywords: Mindset, educational attainment, growth mindset, post-failure performance

Introduction

Mindset theory (aka implicit theories) predicts that children's beliefs about whether basic ability is stable (fixed mindset) or can be changed substantially (growth mindset) impact causally on their cognitive performance (Mueller & Dweck, 1998) and achievement (Dweck, 2006), including educational attainment (Blackwell, Trzesniewski, & Dweck, 2007; Dweck & Molden, 2000; Gunderson et al., 2013; Paunesku et al., 2015), with the strongest effects occurring for the most challenging material (Good, Rattan, & Dweck, 2012). These findings have been widely cited, and have been recommended for adoption into "*policy at all levels (federal, state, and local) … to lift the nation's educational outcomes*" (Rattan, Savani, Chugh, & Dweck, 2015, p. 721). This call has been widely heeded in education (Yettick, Lloyd, Harwin, Riemer, & Swanson, 2016). These claims have, however, been subject to little independent replication, and there have been a number of failures to support the theory (e.g. Bahník & Vranka, 2017). Here, we tested the relationship of mindset to resilience to failure (Mueller & Dweck, 1998) and school grades Blackwell et al. (2007) in three large samples.

Background

Mueller and Dweck (1998) is a hallmark paper on mindset manipulations. Mueller and Dweck (1998) reported six studies on children aged 9-12 years old. Four of these studies tested the effects of a mindset manipulation on subsequent task performance (Studies:1, 3, 5, and 6; ns = 128, 88, 46, and 48 respectively). Mindset was manipulated by giving different forms of praise. As Dweck (2008b) explains about the Mueller and Dweck (1998) studies, "*intelligence praise instilled more of a fixed mindset, making students believe that their intelligence was a fixed trait, whereas the effort praise instilled more of a growth mindset*" (p. 57; see also, e.g., Paunesku et al. (2015); Yeager and Dweck (2012)). Mueller and Dweck (1998) manipulated mindset via these carefully crafted praise scenarios following a set of moderately difficult items (Trial 1). They praised the students for being a "hard worker," or for being "smart at these." Children in the control group received congratulations, but neither form of additional praise. All children then completed a set of more difficult items (Trial 2) and were told they performed "a lot worse" on these. This was followed by a final set of moderate difficulty items (Trial 3). The critical test was an ANOVA comparing difference-scores (Trial 3 - Trial 1) with mindset condition (growth or fixed) as a predictor. Children exposed to the growth mindset condition significantly outperformed children in the fixed mindset condition in all four experiments. Children in the growth and fixed mindset conditions differed in their scores by ~1.3 SD (~ 20 points in IQ terms). The manipulation was reported to affect all children, independent of their ability and/or ethnicity. Mueller and Dweck (1998) also reported that the fixed mindset condition impaired children's motivation for additional learning opportunities. Specifically, children who were in the fixed mindset condition had lower task enjoyment and task persistence and were more likely to attribute their failure to a lack of ability compared to those who were in the growth mindset condition (Mueller & Dweck, 1998). The method thus produced large effects, emerging reliably in each of four studies, and formed what is still acknowledged as the core "careful laboratory experiments" testing mindset theory (Paunesku et al., 2015, p. 791).

A second highly-cited report extended these findings to examine the relationship of children's mindsets to their educational learning outcomes concluding that "*Implicit theories of intelligence [mindsets] predict achievement*" (Blackwell et al., 2007, p. 246). Study 1 of this paper followed 373 children progressing into junior high school (aged around 12 years old) and observed for two years. Children were assessed at entry using a questionnaire measure of mindset (Dweck, 1999). Entry scores on mathematics were unrelated to children's mindsets, but mathematics grades at the end of the first semester of observation were correlated positively with growth mindset (r = .12) and math scores at the end of the second year of observation were positively associated with children's mindsets controlling for their entry scores on math ($\beta = 0.17$, $t(372) = 3.40$, $p < .05$).

Subsequent studies of the association between mindset and academic achievement, however, have yielded mixed results (Sisk, Burgoyne, Sun, Butler, & Macnamara, 2018). For instance, in a Chinese population, Zhao and Wang (2014) reported in 524 pupils aged 12-16 years, finding a significant association of mindsets with students' baseline achievement (r = .23). Paunesku et al. (2015) reported on 1,594 9^{th} -12^{th} grade students finding a small ($\beta = 0.06$, CI_{95} [0.03, 0.09], $t(1561) = 3.47$, $p < .001$) association of growth mindsets with pre-study GPA and finding an association of children's mindsets with final grades only when restricting analyses to the bottom $1/3^{rd}$ of participants (whereas Blackwell et al. (2007) had reported a null association with pre-study grades and a main effect in the full sample). Recently, in a large (n= 5,653) sample of university applicants, Bahník and Vranka (2017) found a small significant effect of children's mindsets on scholastic aptitude, but the direction was reversed to the prediction from mindset theory (r = - .03, CI_{95} [-0.05, -0.00], $p = 0.04$).

Goals of the present studies

The findings reported by Mueller and Dweck (1998) and by Blackwell et al. (2007) are clearly important if they are replicable. However, the claim that praising 9-12 year-old children for being smart versus for being a hard worker causes large (> 1 SD) impacts on their cognitive performance (Mueller & Dweck, 1998) has not, to our knowledge, been independently replicated. Likewise, while some studies have tested the prediction that growth mindsets are associated with improvement in school grades, the results in this field are mixed, as noted above.

In our Study 1, we therefore began with a close replication of Mueller and Dweck (1998) Study 1. We did this to establish if, with our sample, we could replicate the finding that the growth mindset manipulation is associated with better post-failure performance relative to a fixed mindset manipulation. A positive finding, even with a reduced effect size, would suggest that our population and methods are suitable to further test the theory. We therefore undertook a close replication using the manipulation, tasks and analytic approach specified in the original Mueller and Dweck (1998) study.

The similarities and differences of the present study and Mueller and Dweck (1998) Study 1 are detailed in Table 1. Briefly, we used the same mindset manipulation (priming a fixed mindset with "*you must be smart at these*" and priming a growth mindset with "*you must be a hard worker at these*"), the items from the same cognitive measures as originally used, given for the same durations. We used the same negative feedback, and the same analyses of the data. We also used the same suite of measures of achievement goal, desire to persist, enjoyment of the problems, perceptions of the quality of performance and attributions of the causes of the performance to test how these were associated with the mindset theory.

In Studies 2 and 3, we extended this work by improving the methods. Specifically, we added an active control condition and expanded the post-failure measure to include a set of more difficult items. Both these additions were designed to allow us to better understand the mechanism, if any, of the mindset manipulation. By incorporating an active control condition, we were able to isolate the predicted effect of mindset from other aspects of the growth condition, such as potential experimenter-demand effects and an effort encouragement confound (Locke & Latham, 2002). We also took the opportunity to test the effect of children's own mindset on their responses to failure. According to mindset theory, one's beliefs about intelligence should have profound effects on one's achievement (Dweck, 2006, 2008a). Because children's mindsets are deeply embodied and range from very fixed to very growth-oriented, we predicted these would have effects at least as large as those of a brief verbal manipulation.

Finally (Study 4), using children's school grades across two waves of assessment, we were able to test the claim that children's mindsets affect their educational attainment (Blackwell et al., 2007). Specifically, growth mindset theory predicts whether children believe that basic ability can be greatly changed or is fixed and hard to change causes differences in attainment and response to failure in educational setting. We therefore tested whether growth mindsets are associated with either initial grades, improvement in grades over a semester, or improved grades in children initially scoring poorly. The similarities and differences between Blackwell et al. (2007) Study 1 and our Study 4 are detailed in Table 2. We report how we determined our sample sizes, all data exclusions (if any), all manipulations, and all measures in the studies.

Study 1

We first closely replicated the report that, in 9-13-year-old children, a brief mindset manipulation induces a large change in post-failure performance, as reported by Mueller and Dweck (1998). In Study 1 of Mueller and Dweck (1998), children first completed a moderate difficulty trial of 10 cognitive ability items (which we refer to as Trial 1) from the Standard Progressive Matrices (SPM: Raven, Raven, & Court, 2000). Children were given 4 minutes for this task after which they were told that they got at least 80% correct and received one of three kinds of praise: growth ("*you must have worked hard at these problems*"), fixed ("*you must be smart at these problems*"), or control (no additional feedback). This brief laboratory manipulation of mindset using "carefully crafted scenarios" (Dweck, 2013) was followed by a second, more difficult set of SPM items (Trial 2). Children were told they did "*a lot worse*" on these, getting no more than 50% correct. Finally, children were given a further trial of 10 moderate difficulty items (Trial 3). The difference between performance on Trials 1 and 3 formed the dependent variable.

------ *Insert Table 1 about here* ------

We closely followed the methods of Mueller and Dweck (1998) Study 1, testing replicability of the reported effect of praise for being smart versus praise for hard work (see Table 1). As in Mueller and Dweck (1998) Study 1, children aged 9-13 years old were tested individually. We also implemented the full set of additional measures of learning and motivation, task-persistence, task-enjoyment, self-rated performance and failure attributions as described below and as used by Mueller and Dweck (1998). Differing from Mueller and Dweck (1998), we omitted the control group and randomly assigned children to one of the two mindset conditions to maximise power. According to mindset theory, we should see the largest difference between these two groups.

We tested four classrooms of children in the same grade and school (n = 190), yielding ~85% power to detect a small effect (d = .3). We deemed this effect size the lower limit compatible with the theoretical mechanisms proposed by mindset theory, which imply a tight dependence of performance on mindset condition.

Method

Participants

A total of 190 children participated (100% of available children). Of these 89 were male (mean age 10.56 years, SD = 0.51) and 101 were female (mean age 10.41 years, SD = 0.50). All children were recruited from a large primary school in Harbin (the capital city of Heilongjiang Province, China). The school is public and draws from a catchment area 21% below the Chinese national average income (average income 48,881 Yuan: National Bureau of Statistics of the People's Republic of China, 2017), equating to USD 7,133 (~$14,000 purchasing-power equivalent). The children are thus in relative poverty (low income relative to others in their country: OECD, 2008). Low socioeconomic status has been argued to increase the influence of mindset on performance (Claro, Paunesku, & Dweck, 2016). Thus, we expected, if anything, a larger effect in our studies. Compensation for participation consisted of a reward of sweets at the end of the study.

Materials

Individual cognitive performance was assessed using items from sets B, E, and C of the SPM (Raven et al., 2000). Following Mueller and Dweck (1998), Trial 1 (the praise cognitive test) consisted of the first 10 items from set B (moderate difficulty items). Trial 2 (the failure test) consisted of the first 10 items from set E (more difficult items). Trial 3 (the post-failure measure) consisted of the first 10 items from set C (moderate difficulty items).

Learning and motivation were assessed using the learning and motivation questionnaire (Mueller & Dweck, 1998). Preference for learning or performance goal was assessed by an item asking children which of four options they would prefer: A: "*problems that aren't too hard, so I don't get many wrong*", B: "*problems that are pretty easy, so I'll do well*", C: "*problems that I'm pretty good at, so I can show that I'm smart*" and D: "*problems that I'll learn a lot from, even if I won't look so smart*" (Mueller & Dweck, 1998), with D scored as a learning goal, and responses A, B, or C as performance goal preference. Task-persistence, task-enjoyment, and self-rated performance were assessed via a 4-item measure described in Mueller and Dweck (1998). Items were "*How much would you like to take these problems back home to work on*?", "*How much did you like working on the first/second set of problems*?", "*How much fun were the problems*?" and "*How well did you do on the problems overall*?". Children responded on a scale from 1 (not at all) to 6 (very much).

Attributional style for performance after negative feedback was assessed as in Mueller and Dweck (1998). Children were asked to explain "why they had some trouble" with the items on Trial 2. Four slotted-disks of coloured paper were pinned together so children could rotate, exposing various amounts of each disk viewed from the front. The disks each had printed on them one of four attributions: "*I didn't work hard enough.*", "*I'm not good enough at the problems*", "*I'm not smart enough.*", or "*I didn't have enough time*.", corresponding to attributions of lack of effort, lack of ability (the average of the second and third attributions) and lack of time respectively. Children were asked to rotate the disks to show how much each factor accounted for their failure. In addition, children were asked to weight the importance of ability and hardworking when solving the puzzles using a circle with marks from 1-36 around its circumference which they connected to divide the circle into two parts ("smart" and "hard work"), and colouring-in the smart proportion.

Whenever items were translated from English text into Chinese, the experimenter made an initial translation, which was then back translated by 5 bilingual (Chinese and English) speakers, checked for round-trip accuracy, and edited where necessary to ensure an accurate translation.

Design

This study used a between-group design. The independent variable was the mindset manipulation, with two levels: fixed mindset condition and growth mindset condition. The dependent variable was difference of scores between Trial 1 and 3.

Procedure

Study 1 was approved by the Psychology Research Ethics Committee at the School of Philosophy, Psychology and Language Sciences (PPLS), University of Edinburgh (reference number: 229-1415/3). After informed consent was gained from the headmaster, teachers, parents, and children themselves, children were asked to provide demographic information, and were then tested individually in a private room near their classroom. Testing began with a welcome, and an introduction to the testing procedures in which children were given an example item from the SPM items. Children were shown how to solve this problem and then were assigned to a mindset manipulation condition in a sequential ABAB order (95 in each condition).

After this introduction, children then completed the initial moderate difficulty trial (Trial 1), answering as many items as they could in 4 minutes. The experimenter (YL) then removed the children's answer sheets and scored their responses. All children received the same positive feedback "*Wow, you did very well on these problems. You got 7/8/9 right, That's a really high score*!". Children who correctly solved fewer than 5 items were told they got 7 items correct. Children solving 6–9 items correct were told they had got 8 items correct. Children who got all 10 items correct were told they got 9 items correct. Children randomized to the fixed mindset condition were then told "*You must be smart at these problems!*" while children in the growth mindset condition were told "*You must have worked hard at these problems!*". Children then completed the learning goals questionnaire.

The more difficult trial (Trial 2) was then administered. After 4 minutes, the test was scored, and, no matter what their performance, children were told "*Your performance was poor on that: You got less than half the items correct*". As in Mueller and Dweck (1998), children then completed the task persistence, task enjoyment, and overall self-rated performance quality questionnaires. Finally, children were asked to work on the post-failure items (Trial 3), again with a 4-minute time limit.

All children were then debriefed and were told that the more difficult trial on which they had received poor scores contained items that were appropriate for older and higher-grade children. Therefore, children in their grade who solved even a single item should be proud as they were especially hard working to have attempted and succeeded at these.

Results

All analyses were completed using R (R Core Team, 2019) and umx (Bates, 2018; Bates, Maes, & Neale, 2019). Standardized effect sizes are reported to aid interpretability and incorporation into subsequent meta-analyses. All data and analysis code are open-access and raw data and R analysis scripts used in all four studies are available in supplementary data at https://osf.io/u5v8f. Scores on the moderate difficulty test (Trial 1) were skewed due to ceiling effects (skew = -2.41, kurtosis = 7.66).

Does mindset manipulation affect post-failure performance?

We first tested the hypothesis that children who were in the growth mindset condition (i.e., praised for hard work) would have higher post-failure performance (Trial 3 SPM score) compared to those who were in the fixed mindset condition. We tested this hypothesis using the same one-way ANOVA approach used by Mueller and Dweck (1998), namely a difference of scores (Trial 3 - Trial 1) was used as the dependent variable (DV), and mindset condition as the independent variable (IV). As in Mueller and Dweck (1998), age or sex was not controlled. This one-way ANOVA revealed a significant difference, with children in the growth mindset condition scoring higher on Trial 3 (controlling for Trial 1) compared to those in the fixed mindset condition ($F(1,188) = 3.930$, $p = .049$; $\beta = -0.28$ CI_{95}[-0.55, 0.00]: see Figure 1 and Table 3). Following Mueller and Dweck (1998) we also tested whether children in the two groups differed in their baseline scores (Trial 1). No significant difference was found (Trial 1: $F(1,188) = 0.129$, $p = .720$; $\beta = 0.05$ CI_{95} [-0.23, 0.34]).

-------Insert Figure 1 and Table 3 about here-------

Does mindset manipulation affect motivation?

We also examined the hypotheses that growth mindset manipulation would: 1) lead children to pursue a learning goal rather than a performance goal, 2) increase task persistence, 3) increase children's enjoyment on solving the problems, 4) have higher self-rated performance quality, 5) attribute their failure on Trial 2 to effort rather than ability compared to those in the fixed mindset condition. As in Mueller and Dweck (1998), these hypotheses were tested using a Chi-square test (for hypothesis 1) and one-way ANOVAs (for hypotheses 2, 3 & 4, 5), with responses on these questions as the dependent variables, and mindset manipulation as the independent variable. Finally, Mueller and Dweck (1998) tested the attributions of the children for their failure to either hard work or lack of ability using a one-way ANOVA. Despite the significant effect of mindset manipulation on changes of cognitive scores (Trial 3 – Trial 1), the predicted effects on motivation were not supported by the results. Mindset manipulation was not associated with expression of a learning goal (χ^2 (1) = 0.192, p = .661), wishing to take the problems home (F(1,188) = 2.833, p = .094), finding working on the problems enjoyable (F(1,188) = 0.552, p = .459), or fun (F(1,188) = 0.229, p = .633). Neither was there any effect of mindset manipulation on perceived performance (F(1,188) = 0.733, p = .393). Subjects attributions regarding the role of ability and effort did not differ by condition (F(1,188) = .570, p = .451 and F(1,188) = .496, p = .482 respectively). The relative attribution of failure to ability versus effort also did not differ significantly (F(1,188)= .209, p = .648).

Study 1 Discussion

The results of Study 1 indicated that children in the growth mindset condition showed significantly higher post-failure performance compared to children in the fixed mindset condition. This close replication of Mueller and Dweck (1998) Study 1 indicated that with the same mindset manipulation, SPM items, negative feedback, and analysis plan, we could replicate the basic finding in our population, albeit substantially reduced in magnitude. This is distinct from concluding that the effect observed is driven by the mechanism proposed by mindset theory. In planning our next studies, we were guided by a desire to incorporate methodology that would allow us to better understand the mechanism behind this effect, specifically, whether the effect was due to mindset or an effort confound. To this end, we added an active control condition.

We were also cognisant that mindset theory is designed to explain how children cope with difficult material and significant challenges (Good et al., 2012). While Study 1 was a close replication of Mueller and Dweck (1998), the materials were only moderately difficult. Including more difficult material in the post-failure trials would increase the power and validity of the study.

Finally, in considering the results of Study 1, it was apparent that the design ignores an important available resource: that of the children's internalised mindsets. A design that tests the effects of children's mindsets on their post-failure performance would be valuable. These considerations of the results of Study 1 lead us to undertake a second replication, modified as described next.

Study 2

In constructing Study 2, we wished to enhance the power of the design to better investigate the predictions of mindset theory. Increased scores in the growth condition found in Study 1 provide support for mindset theory only to the extent that praise for "being a hard worker" has its effects by priming a growth mindset. However, it is also plausible that this condition primes beliefs about conscientiousness (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007) or other non-mindset motivational effects (Locke & Latham, 2002). To test this, we introduced an active control condition. This condition was designed to isolate any effect of beliefs about intelligence from potential experimenter-demand effects, goal-setting or effort (Locke & Latham, 2002). If theories about the value of hard work (rather than the malleability of intelligence) were driving the modest effect observed in Study 1 (and presumably Mueller and Dweck's large effects), then students in the growth mindset condition ought to perform no better than students in the active control condition in Study 2.

The active control we wished to construct was one which could prime the fixed mindset (which should lower performance), but which would also prime hard work as something that is needed to accomplish work (but that does not and cannot "grow the mind"). If this condition were to show effects as large or larger than the classic "you must be a hard worker" prime, that would be evidence against mindset (which predicts that priming the idea that ability is fixed should impair post-failure performance), and instead support a conscientiousness or motivational model of effortful performance. To distinguish these, we created a novel active control condition derived from the mindset questionnaire item "*You can learn new things, but you can't really change your basic intelligence*". Participants in this new active control condition were told "*Even though we cannot change our basic ability, you work hard at hard problems and that's how we get hard things done*". This condition thus confirmed the fixed mindset (we cannot change basic ability – which is predicted to be harmful), while also activating the belief that hard work is required to do hard things (which is not specific to mindset theory).

Second, we took advantage of the fact that children bring very different mindsets to the experiment. Our rationale was as follows: if beliefs about the fixed or malleable nature of intelligence change response to failure, then a child's mindset should affect their post-failure performance – indeed, this is the rationale of manipulations targeting, among other things, growth mindset (Paunesku et al., 2015). If the wide-range of naturally occurring variation in children's own beliefs (see further discussion near Figure 3 below) does not affect outcomes, this falsifies the theory. We therefore included the standard Theories of Intelligence questionnaire (Dweck, 1999), allowing us to test whether children's mindsets are associated with differences in post-failure performance. Because children's mindsets are stable and range from very fixed to very growth-oriented, we predicted these would have effects at least as large as those of the manipulation.

Third, because mindset theory predicts that a growth mindset is critically involved in responses to demanding challenges that otherwise may lead to giving up or dropping out, we wished to ensure that we tested this aspect of the theory. The classic design tests children's post-failure performance on moderate difficulty items. To extend the range of information provided by the experiment, we added an additional more difficult trial (Trial 4) containing items matched to those of Trial 2. As it is predicted that mindset most strongly affects individuals' responses to the more difficult materials (Good et al., 2012), we predicted that any effects of mindset should be most strongly reflected in responses to these more difficult items (tested as the difference in scores on Trials 2 and 4), thus maximising the opportunity to detect mindset effects on responses to failure.

Finally, to assure that the items in Trials 1 and 3 are moderately difficult for the population under test, and based on the distribution of scores in Study 1, for Study 2 we slightly increased the difficulty of items used in Trial 1 and increased the number of items used from 10 to 12 to assure difficulty more closely matched to that reported by Mueller and Dweck (1998).

Regarding our mindset manipulations, we hypothesised that the growth mindset manipulation (praise for hard work) would enhance children's post-failure performance on the moderate (Trial 3) and difficult (Trial 4) items relative to the active control condition. If mindset is responsible for effects, only the growth mindset condition should enhance post-failure performance; post-failure performance should be similar for the active control condition and the fixed mindset (praise for being smart) condition, and neither should positively predict post-failure performance. Regarding children's own mindsets, we hypothesised that growth mindsets would be positively correlated with post-failure performance on the moderate items (Trial 3) and more difficult items (Trial 4).

Method

Participants

In total, 222 pupils were recruited from a second primary school in the same city as Study 1. In total, 116 males (mean age 11.07 years, SD = .49) and 106 females participated (mean age 11 years, SD = .45). Compensation for participation consisted of sweets at the end of the study.

Materials

Children's mindsets were assessed using the 8-item Theories of Intelligence Scale (Dweck, 1999), ensuring in translation that the children understood the item language (Cain & Dweck, 1995). Example items include "*You have a certain amount of intelligence, and you can't really do much to change it*." Possible responses range from 1 (strongly agree) to 6 (strongly disagree) with high scores coded to indicate a growth mindset.

The item-sets were drawn from parallel-form versions of the SPM (Raven et al., 2000) and presented in a counterbalanced order. Trial 1 (moderate difficulty trial) included 12 (rather than 10) items from set C (rather than set B). Trial 2 (more difficult trial) consisted of the first 10 items from set E. Equivalent tests were used in the post-failure Trials 3 and 4, constructed from the parallel forms of the SPM sets C and E (Styles, Raven, & Raven, 1998). Learning and motivation measures were given as in Study 1.

Design

Study 2 used a between-group design. Two independent variables were examined: the mindset manipulation (with three levels: fixed, growth, and active control), and children's mindsets. The dependent variables were Trial 3 - Trial 1 performance, matching Mueller and Dweck (1998) dependent variable, and Trial 4 - Trial 2 performance, which should provide a larger effect of condition given the presumed association between mindset and challenge.

Procedure

Studies 2 and 3 were approved by the Psychology Research Ethics Committee at the PPLS, University of Edinburgh (reference number: 106-1516/8). The consent and welcome procedure were identical to those used in Study 1. After consent, children completed the mindset measure in their classroom. Children were allocated to one of the three conditions using a sequential-ABCABC order. Testing again took place individually in a private room near their classroom. This began with children being given an example item from the SPM items and shown how to solve this problem. They then completed Trial 1 answering as many items as they could in 4 minutes and were given the feedback appropriate to their randomized condition.

As in Study 1, the experimenter removed children's answer sheets, scored their responses, and gave the child positive feedback "*Wow, you did very well on these problems. You got 7/8/9 right, That's a really high score*!". Children randomized to the fixed mindset and growth mindset conditions received appropriate praise consisting of either "*You must be smart at these problems!*" or "*You must have worked hard at these problems!*". Children in the active control condition were told "*Even though we cannot change our basic ability, you work hard at hard problems and that's how we get hard things done*".

Children then completed the learning goals questionnaire. After this, Trial 2 (more difficult items) was administered. After 4 minutes, the items were scored, and, no matter what their performance, children were told "*Your performance was poor on that: You got less than half the puzzles correct*". Again, as in Mueller and Dweck (1998), children then completed the learning and motivation measures. Finally, children were asked to work on the items in Trials 3 and 4, again with 4-minute time limits for each trial.

All children were then debriefed with a procedure identical to that used in Study 1.

Results

As in Mueller and Dweck (1998), we first tested if children's initial ability (Trial 1 scores) differed for the three mindset manipulation conditions before testing the four stated hypotheses. No difference was found ($F(2,219) = 0.057$, $p = .944$).

Does mindset manipulation affect post-failure performance on moderately difficult items?

As in Study 1, we tested the hypothesis that the growth mindset condition would significantly improve children's post-failure performance on the moderate difficulty trial (Trial 3) compared to the fixed mindset and active control manipulation conditions. As in Mueller and Dweck (1998), we tested this hypothesis using a one-way ANOVA, with a difference of scores on the initial and final cognitive tests (Trial 3 – Trial 1) as the DV, mindset condition as the IV, and did not control for age and sex.

Contrary to prediction, there was no effect of the manipulation on the change in scores on the moderate difficulty materials ($F(2,219) = 0.440$, $p = .645$; see Figure 2). The classic contrast of the fixed mindset vs growth mindset conditions was also non-significant ($\beta = 0.00$ CI_{95} [-0.29, 0.30], $t = 0.03$, $p = .974$).

------Insert Figure 2 about here------

Does mindset manipulation affect post-failure performance on more difficult items?

Next, we tested if the growth mindset manipulation would improve children's cognitive scores on the more difficult trial (Trial 4) relative to their initial scores (Trial 2). Again, this was done by using a one-way ANOVA with a difference of cognitive scores (Trial 4 – Trial 2) as the DV and mindset condition as the IV. Again, as in Mueller and Dweck (1998), age and sex were not controlled.

On the more difficult items, where mindset was predicted to most strongly reveal its effects, there was, again, no effect of the growth mindset manipulation ($F(2,219) = 0.630$, $p = .534$). The classic fixed mindset vs growth mindset conditions contrast was similarly non-significant ($\beta = 0.13$ CI_{95} [-0.10, 0.37], $t = 1.12$, $p = .264$).

Do children's mindsets correlate with post-failure performance on moderately difficult items?

We next tested whether children's mindsets affected their responses to failure on the moderate difficulty items. This was done by using a regression model with a difference of cognitive scores (Trial 3 – Trial 1) as the DV, and children's scores on the Theories of Intelligence Scale (Dweck, 1999) as the IV. Contrary to prediction, children's mindsets were unrelated to their post-failure performance on the moderate difficulty items ($F(1, 220) = 0.074$, $p = .786$, $\beta = 0.02$ CI_{95} [-0.10, 0.14]).

Do children's mindsets correlate with post-failure performance on more difficult items?

Finally, we tested whether children's mindsets impacted their responses to failure on the more difficult items. Again, this hypothesis was tested by using a regression model with a difference of cognitive scores (Trial 4 – Trial 2) as the DV, and children's scores on the Theories of Intelligence Scale (Dweck, 1999) as the IV.

Children's mindsets were significantly linked to their post-failure performance on the more difficult items ($F(1, 220) = 7.482$, $p = .007$). However, this effect was in the **reverse** direction to that predicted by theory ($\beta = -0.13$ CI_{95} [-0.23, -0.04]). If replicated, this would suggest that holding a growth mindset *harms* response to more difficult items.

Study 2 Discussion

Summarising the results of Study 2, we found no support for any effects of the mindset manipulation on children's responses to either moderate difficulty (Trial 3) or more difficult (Trial 4) items. We also found no evidence for any effects of children's mindsets on their performance on the moderate items. Moreover, when it came to the more difficult material, we found support for a *harmful effect* of growth-oriented mindsets on scores. Thus, contrary to Mueller and Dweck (1998), we found no positive effects of growth mindset on response to failure.

We took these null outcomes seriously, and wished to run a third study, exactly replicating Study 2, in an independent sample to gather more evidence regarding whether a growth mindset manipulation can improve children's post-failure performance (or if it might even harm it), as well to further explore the role of children's mindsets on performance in this task. This is presented next, and exactly follows the analytic path used above in Study 2.

Study 3

Study 3 was executed identically to Study 2, testing the same hypotheses and under the same ethical consent.

Method

Participants

In total, 212 children participated. One male subject was removed from the analyses. This student had consistent exceptionally low grades scoring, for example, 9.2 SDs below the class average for Chinese. Their mindset was 3.75, close to the class average. Of the 211 remaining participants, 120 were male (mean age 10.78 years, SD = 0.58) and 91 were female (mean age 10.60 years, SD = 0.46).

Materials

The materials used in Study 3 were identical to those used in Study 2.

Design

The experiment design was identical to those in Study 2.

Procedure

Numbers in the fixed mindset, growth mindset and active control condition were 70, 71, and 70 respectively. All procedures were identical to those of Study 2.

Results

As before, we formulated the same four hypotheses listing in Study 2. Before testing these hypotheses, we first tested whether children's initial cognitive ability (Trial 1) differed in three mindset manipulation conditions. Again, no significant difference was found ($F(2,208) = 0.747$, $p = .475$).

Does mindset manipulation affect post-failure performance on moderately difficult items?

We tested the prediction that the growth mindset condition would improve post-failure performance, relative to the fixed mindset and active control conditions. Again, this was done using a one-way ANOVA with the difference in scores on the initial and final ability tests (i.e., Trial 3 – Trial 1) as the DV and mindset condition as the IV. As in Mueller and Dweck (1998), age and sex were not controlled.

The overall test for differences among the levels of the mindset manipulation was not significant ($F(2,208) = 2.744$, $p = .067$). As in Study 2, the contrast of fixed mindset vs growth mindset conditions was non-significant ($\beta = 0.18$ CI_{95} [-0.09, 0.46], $t = 1.32$, $p = .189$). Interestingly, performance in the active control condition was significantly improved ($\beta = 0.32$ CI_{95} [0.05, 0.60], $t = 2.34$, $p = .020$) relative to the fixed mindset condition.

Does mindset manipulation affect post-failure performance on more difficult items?

We next tested if the classic growth mindset manipulation might raise performance on more difficult items – the stated purpose of mindset manipulations. As in Study 2, a one-way ANOVA was conducted with a difference of cognitive scores (Trial 4 – Trial 2) as the DV, and mindset condition as the IV. As in Study 2, no significant effect of the manipulation was found ($F(2, 208) = 0.216$, $p = .806$). A contrast of the fixed mindset versus growth mindset conditions showed no effect ($\beta = 0.03$ CI_{95} [-0.20, 0.25], $t = 0.24$, $p = .810$).

Do children's mindsets correlate with post-failure performance on moderately difficult items?

We next tested whether children's mindsets might impact their post-failure performance on the moderate difficulty materials. As in Study 2, this hypothesis was tested using a regression model with a difference of cognitive scores (Trial 3 – Trial 1) as the DV and children's scores on the Theories of Intelligence Scale (Dweck, 1999) as the IV. Again, as in Study 2, the hypothesis was not supported ($F(1, 209) = 0.179$, $p = .673$; $\beta = -0.02$ CI_{95} [-0.14, 0.09]).

Do children's mindsets correlate with post-failure performance on more difficult items?

Finally, we tested if children's mindsets would affect their responses to the more difficult materials by using regression with a difference of initial and final score (Trial 4 – Trial 2) as the DV, and children's scores on the Theories of Intelligence Scale (Dweck, 1999) as the IV. Contrary to prediction, children's mindsets were not associated with their performance on the more difficult materials ($F(1, 209) = 0.020$, $p = .888$; $\beta = -0.01$ CI_{95} [-0.10, 0.09]).

Study 3 Discussion

The results did not support any effect of growth mindset on children's post-failure performance, either on moderate or more difficult material. The sole significant beneficial effect in the results was a higher score for children in the active control condition (relative to the fixed mindset condition). While we would not make too much of this finding, it is in the reverse direction to that predicted by the growth mindset theory – the children were primed for a fixed mindset, and this should theoretically have reduced their performance. There was no evidence found for any effects on the more difficult material. Likewise, there was no association of children's mindsets on any outcome.

Next (Study 4) we examined the association of children's mindsets with their school grades before discussing the results of all four studies.

Study 4: An analysis of links between children's mindsets and educational attainment.

Children's mindsets are predicted to enhance educational attainment and a central motivation for mindset manipulations is expected improvements in educational attainment (Blackwell et al., 2007; Dweck, 2006; Paunesku et al., 2015).

As noted in the main introduction, a seminal report supporting the role of children's mindsets on educational attainment was provided by Blackwell et al. (2007). This study reported no association between children's mindset and their mathematics grades on entry, but, controlling for these initial grades, children's mindsets correlated significantly with grades two years later. Moreover, the effect was general (rather than being restricted to students with poor initial performance). As noted above, subsequent studies of this association have yielded reversed results (e.g. r = -.03 in a study of over, 5,600 university applicants: Bahník & Vranka, 2017), through to small positive associations with initial grades, or associations only in the bottom 1/3rd of participants (e.g. Paunesku et al., 2015).

To test the relationship of mindset to grades and grade change, we used data on the grades of all children tested in Study 2 and Study 3. Our expectations for this study, were as follows. First, based on Paunesku et al. (2015) and Zhao and Wang (2014), we predicted a positive association of children's growth mindset with their initial GPA. Second, longitudinally, and following Blackwell et al. (2007), we predicted a positive association of growth mindsets with improvements in grades across a semester. Third, based on Paunesku et al. (2015), we had a subsidiary or more restricted hypothesis that this improvement might be larger for the children with lower initial grades (i.e. a mindset × initial GPA interaction). Fourth, we wished to test if having a growth mindset is associated with higher intelligence test scores. As Dweck stated about the Mueller and Dweck (1998) study, "*Since this was a kind of IQ test, you might say that praising ability lowered the student's IQs. And that praising their efforts raised them*" (Dweck, 2006, p. 73). Additionally, many mindset interventions teach students that their brain is like a muscle and can grow smarter to induce a growth mindset. Thus, we were interested in testing whether in fact the belief that ability can grow if one believes it can, is reflected in the data, i.e., if children who believe they can grow their basic cognitive ability have done so.

We tested these four predicted associations using the children from Studies 2 and 3. Across our two studies, we have a comparable number (433 compared to 373) of children, or a comparable age (around 11 years old in both studies). We observed the children for one semester, rather than two years, but Blackwell et al. (2007) reported a significant effect after just one semester (r = .12). As in Blackwell et al. (2007), children's mindsets were assessed at entry using a questionnaire measure (Dweck, 1999). We recorded not only initial scores on mathematics but also English and Chinese grades.

------Insert Table 2 about here------

Methods

Participants

Participants were all 433 pupils from Studies 2 (n= 222) and 3 (n= 211) as described above.

Materials

All children in the sample are formally assessed by their school twice each semester. With permission, we obtained children's grades in their three core classes (English, Chinese, and mathematics) for the semesters preceding and following our mindset measures. This allowed us to test both the association of mindset with initial GPA, and change in performance across time. Children's mindsets were assessed using scores on the 8-item Theories of Intelligence Scale (Dweck, 1999) as described in Study 2 and 3. Cognitive ability was assessed using scores on the Trial 3 (set-E SPM) items ascertained in the first phases of Studies 2 and 3.

Analyses

To maximise power, and because children's grades in the three subjects correlated highly, we formed a GPA measure for each child for each semester, based on the factor scores on a 1-factor model of grades. For both studies, this 1-factor CFA model of grades fit well (e.g. for Study 2 CFI = 1; TLI = 1; RMSEA = 0). Subject loadings on this factor were also high (e.g. 0.80, 0.79, and 0.87 and 0.70, 0.86, and 0.90 for Math, Chinese, and English in semesters 1 and 2 respectively for Study 2). Similar results obtained for the children in Study 3. Factor-score GPAs were used to test predicted associations of children's mindsets with grades within and across semesters.

Do our participants show typical variation and means of mindset scores?

As shown in Figure 3, children in Studies 2 and 3 displayed the full range of mindset scores, which appeared normally-distributed. Mean scores were in keeping with previous reports: compared to the children studied in Blackwell et al. (2007), our children had slightly more fixed mindset, e.g. the mean mindset score in our Study 3 was 4.16 (CI_{95} [4.04, 4.29]), compared to 4.43

(*CI* not reported) reported in the 12-year-olds studied by Blackwell et al. (2007). The standard deviation in Study 4 suggests little if any restriction of range to suppress associations of differences in children's mindsets with attainment or change in attainment.

------Insert Figure 3 about here------

Do children's mindsets predict grades?

Regression was used to test the hypothesis that school grades would be associated with children's mindsets. As in Blackwell et al. (2007), we did not control for age and sex in this analysis. For children in Study 2, mindset was unrelated to initial GPA ($\beta = 0.03$ CI_{95} [-0.10, 0.16], $t = 0.42$, $p = .671$). Nor were children's mindsets associated with GPA in semester 2 ($\beta = 0.05$ CI_{95} [-0.11, 0.21], $t = 0.63$, $p = .530$). Thus, our first hypothesis was not supported. Adding cognitive ability to the model left these associations unchanged (e.g. controlling for Trial 1 scores: $\beta = -0.01$ CI_{95} [-0.14, 0.11], $t = -0.21$, $p = .834$ and $\beta = 0.01$ CI_{95} [-0.14, 0.17], $t = 0.18$, $p = .855$ for semester 1 and 2 respectively). Cognitive ability was a highly significant predictor of GPA in both semesters (e.g. controlling for Trial 1 scores, semester 1 $\beta = 0.35$ CI_{95} [0.22, 0.47], $t = 5.4$, $p < .001$; semester 2 $\beta = 0.25$ CI_{95} [0.09, 0.41], $t = 3.16$, $p = .002$). In addition, because Blackwell et al. (2007) found a positive association between children's mindsets and math ability in specific, we therefore tested our first hypothesis in single school subject levels instead of averaged as GPA. Again, children's mindsets yielded only null effects on attainment (p-values 0.883 for English, 0.872 for Chinese, and 0.356 for mathematics). Furthermore, a cognitive ability × mindset interaction (testing the hypothesis that growth mindset would translate cognitive performance into greater GPA outcomes in children with lower ability scores), was non-significant for GPA in semester 1 and 2 ($\beta = 0.04$ CI_{95} [-0.09, 0.16], $t = 0.58$, $p = .560$ and $\beta = 0.05$ CI_{95} [-0.13, 0.24], $t = 0.60$, $p = .553$ respectively).

Similar null results obtained in the children tested in Study 3: children's mindsets failed to predict initial GPA ($\beta = 0.04$ CI_{95} [-0.10, 0.17], $t = 0.52$, $p = .601$). Nor were they associated with GPA in semester 2 ($\beta = 0.06$ CI_{95} [-0.08, 0.20], $t = 0.88$, $p = .382$). Adding a control for cognitive ability level did not change these results (e.g. controlling for Trial 1 scores, $\beta = 0.00$ CI_{95} [-0.13, 0.13], $t = -0.06$, $p = .955$ and $\beta = 0.01$ CI_{95} [-0.12, 0.13], $t = 0.14$, $p = .888$ for semester 1 and 2 respectively). Once again, cognitive ability scores were strong predictors of GPA in both semesters (e.g. controlling for Trial 1 scores, $\beta = 0.36$ CI_{95} [0.23, 0.49], $t = 5.38$, $p < .001$ in semester 1). In models substituting single school subjects for GPA, children's mindsets were unrelated to attainment (*p* values 0.876, 0.552, and 0.504 for English, Chinese, and mathematics respectively). Again, as in Study 2, we tested the effect of the cognitive ability × mindset interaction on GPA outcomes. No significant result was found for GPA in either semester 1 (β = - 0.06 CI_{95} [-0.21, 0.10], t = -0.74, p = .458) or semester 2 (β = -0.02 CI_{95} [-0.17, 0.13], t = -0.23, p = .816).

Do children's mindsets enhance learning across time?

We next tested the prediction that children with a growth mindset would show GPA improvement (final GPA, controlling for initial GPA), either as a main effect, or, if only children gaining lower scores in semester 1 showing any benefit of their mindsets (Paunesku et al., 2015), as an interaction with initial GPA. This prediction was tested in a regression predicting GPA in semester 2 from children's mindsets and initial GPA × children's mindsets. Age and sex were not controlled.

For children in Study 2, neither hypothesis was supported: There was no significant effect of mindset on GPA change (β = 0.03 CI_{95} [-0.06, 0.12], t = 0.63, p = .532). In addition, there was no interaction of children's mindsets (β = -0.06 CI_{95} [-0.19, 0.07], t = -0.87, p = .387). Similarly, in Study 3, there was no main effect of children's mindsets on GPA change (β = 0.04 CI_{95} [-0.04, 0.11], t = 1.00, p = .319) and no initial GPA × children's mindsets interaction (β = -0.05 CI_{95} [-0.13, 0.03], t = -1.18, p = .238).

Might children's mindsets have highly restricted across-time effects, specific to single school subjects?

We next examined the possibility that children's mindsets may have a highly-specific effect, interacting on a course-by-course basis with low semester 1 grades such that while, in most children, their mindsets would be unrelated to grades. For the lowest-performing children in each subject, growth mindsets would trigger the predicted effort and hard work response which would improve grades in that subject by the end of the semester. For the children in Study 2, this predicted interaction failed to emerge. In all cases these subject × children's mindsets interaction effects were non-significant (β = 0.03 CI_{95} [-0.09, 0.14], t = 0.47, p = .640; β = 0.01 CI_{95} [-0.08, 0.10], t = 0.25, p = .803; β = 0.06 CI_{95} [-0.06, 0.19], t = 0.99, p = .323 for English, Chinese, and mathematics, respectively). Similarly, for the children in Study 3, course-by-course tests for initial grade × children's mindsets effects on final grades also were not supported for any subjects: β = 0.02 CI_{95} [-0.05, 0.10], t = 0.56, p = .578; β = 0.02 CI_{95} [-0.07, 0.12], t = 0.50, p = .620; β = 0.05 CI_{95} [-0.04, 0.14], t = 1.04, p = .297 for English, Chinese, and mathematics respectively.

Do children's mindsets predict baseline reasoning ability?

We tested the hypothesis that growth mindset would be associated with higher cognitive ability using regression models, again not controlling for age and sex. Contrary to prediction, children's mindsets were not significant associated with cognitive ability as measured by either the moderate difficulty (β = 0.12 CI_{95} [-0.01, 0.25], t = 1.76, p = .080) or more difficult (β = 0.12 CI_{95} [-0.02, 0.25], t = 1.72, p = .086) baseline tests. Similar results were obtained for the children in Study 3: children's mindsets were unrelated to scores on either the moderate difficulty (β = 0.12 CI_{95} [-0.02, 0.25], t = 1.68, p = .094) or more difficult (β = 0.07 CI_{95} [-0.07, 0.20], t = 0.99, p = .322) baseline tests.

Discussion of Study 4

We found no evidence for growth mindset promoting higher grades or higher cognitive ability scores. Children's mindsets were unrelated to their initial grades and were unrelated to their change in GPA. Likewise, the possibility that children's mindsets effects could appear, but only in children doing less well at the beginning of the semester (Paunesku et al., 2015), was not supported. We were surprised also to find no association of children's mindsets with cognitive ability scores, as these are stable (Deary, 2012) and we expected the chronic developmental influence of children's belief in the malleability of intelligence to have some association with their manifested ability. The mean ability scores of children with a growth mindset did not differ from those with mixed or fixed mindsets.

To interpret the full set of findings in an integrated fashion, we next synthesise the findings from Studies 1-4 in a brief general discussion.

General Discussion

Mindset was predicted to have a major influence on determining children's resilience to failure as well as influencing real-world outcomes in the form of school grades. Mindsets and mindset manipulation effects on both grades and ability, however, were largely non-significant, or even reversed from the theorised direction. In Study 1 we found a significant effect of the growth mindset condition on post-failure performance. This was not replicated in Studies 2 or 3. In no study did we find any effects on post-failure performance on the more challenging materials (contrary to the prediction from mindset theory). The only significant effect of mindset manipulation across Studies 2 and 3 was that in Study 3, children in the active control condition showed improved scores on the moderate difficulty material relative to the growth mindset and fixed mindset conditions. As these subjects were primed for an implicit fixed-mindset, this effect contradicts the idea that beliefs about ability being fixed are harmful. At best, this supports a role for explicit exhortations to exert effort as potentially improving performance on moderate difficulty (but not more difficult) tasks. This effect, however, is predicted by both personality (Roberts et al., 2007) and motivation theory (Locke & Latham, 2002).

Turning to the effects of children's internalised mindsets, we found only one significant outcome, but this was in the reverse direction, with a growth mindset appearing to harm post-failure performance in Study 2 (but not in Study 3). Finally, in Study 4, which examined predicted linkages between children's mindsets and grades and progress in school, we failed to find any support for growth mindsets promoting higher grades, either as a main effect, or in interaction with initial scores, or in subjects in which children were struggling.

In summary, we studied relationships of mindset manipulations as well as children's internalised mindsets on their responses to failure and their school performance. We found little or no support for the idea that growth mindsets are beneficial for children's responses to failure or school attainment. Our findings across multiple substantial studies with active controls as well as real-life outcomes across time suggests mindset has no impact on school grades, response to challenge, or goal orientation. Namely, that implicit mindsets about the nature of intelligence have near-zero effects on grades and no effect on general cognitive ability. In the specific case of responses to failure, neither children's internalised mindset nor activated beliefs about whether intelligence is or is not fixed impacted on performance. The data collected are compatible with an effect of praising hard work on increased effort, but not with any increase in performance on difficult tasks, again, in line with data on incentive effects (Gignac, 2018).

Limitations

One limitation suggested by reviewers regards the ethnicity of our subjects, contrasting the discovery samples which were US-based, while our subjects were Chinese. Relatedly, a reviewer at another journal hypothesised that our Chinese subjects likely had uniformly growth-oriented mindsets due to living in a collectivist culture. They suggested that this would account for the higher PISA (Programme for International Student Assessment) scores in China. As shown in Figure 3, however, our subjects were not clustered around a growth orientation and were normally-distributed across a wide range of scores with a mean in keeping with previous US-based reports. Moreover, ethnic differences have previously been examined and reported as being unrelated to mindset effects in the original mindset studies (Mueller & Dweck, 1998) and mindset theory has also been used for two decades in Asian samples, including seminal papers such as Hong, Chiu, Dweck, and Sacks (1997), and continuing in current reports (Zeng, Hou, & Peng, 2016). This suggests an expectation among mindset experts that the theory should work in Chinese participants, and we were unable to find any statement to the contrary. Additionally, the effects of mindset are not couched in terms of ethnicity but in terms of universal developmental processes linking mindsets to realised cognitive and educational attainment. As such they should hold in all children. Related to this question of sample composition, a reviewer hypothesised that our Chinese participants were too wealthy to show the effects. As noted in the participants description in Study 1, our participants were not wealthy and, in fact, were significantly impoverished, even relative to the Chinese median income. Low socioeconomic status is predicted to increase, not nullify the influence of mindset on performance (Claro et al., 2016). Finally, a reviewer suggested that the experience of failure may have been insufficiently severe to elicit effects of mindset. As perception of failure is largely a matter of feedback, we disagree: Subjects in the study were often distressed to receive such negative feedback.

Our samples, then, appear suitable for revealing mindset effects if they exist: our participants were children near-identical in age to those reported in Mueller and Dweck (1998), they lacked material resources – argued to magnify mindset effects (Claro et al., 2016) – and showed a range of mindset scores and attainment scores. Rather than being uniformly growth-oriented, the sample showed a full normal range of mindsets and was slightly more fixed-minded on average than in previous samples. This, again, should have increased our power to create group-differences in the mindset manipulation studies, and the wide variation in mindset should have revealed similarly large effects of mindset on responses to failure and in educational attainment. The failure to show significant growth versus fixed mindset condition effects in the lab or effects of mindset on grades appears to be strong evidence against mindset theory.

Future directions

As the purpose of mindset manipulations in school is to impact how children are taught (Paunesku et al., 2015), given these null outcomes, additional independent studies testing the theory are needed. Other outcomes attributed to mindset should also be tested for replicability, e.g. the role of mindset on willpower (Job, Walton, Bernecker, & Dweck, 2013), as well as claims about the general applicability of the theory to domains broad as personal relationships and sporting success (Dweck, 2006). Future work on mindset should remove the confound of encouraging hard work and conscientiousness - which is a known influence on attainment (Rosander & Backstrom, 2014). Additionally, since experimenter expectations can significantly alter experimental results (e.g. Doyen, Klein, Pichon, & Cleeremans, 2012), a double-blind experimental design could be considered in further studies. Finally, given widespread and costly policy and real-world educational implications, we encourage an 'emptying of the file drawer' to account for non-reported studies.

For the majority of teachers who report believing mindset matters, 80% of whom say they have been unable to make effective changes in their own classes (Yettick et al., 2016), the present results may provide a simple answer to this apparent disparity: learning does not require (Finn et al., 2014) or cause (Ritchie, Bates, & Deary, 2015) changes in basic ability, but does require prosaic teaching practices such as systematic practice and feedback via appropriate testing (Lindsey, Shroyer, Pashler, & Mozer, 2014).

Context of the Research

Across over 600 children we found no evidence to support mindset theory. The children were 9-13 years old, living in poverty, and had a normal distribution of mindsets, all of which should have increased the chances of observing impacts of mindsets if they existed. Instead, we found that the children's naturally held mindsets did not predict performance on cognitive tests, grades, or improvement in academic achievement. This lack of a relationship persisted for low-achieving children. Further, we found no evidence that a growth mindset condition improved children's performance on cognitive tests following failure. In all cases, including examinations of low-achieving sub-groups, we found that growth mindset either had no effect on performance or appeared to be explained by motivation to work hard rather than beliefs about the malleability of intelligence (i.e., mindset). We encourage further independent studies to test mindset theory and suggest controlling for confounding variables such as experimenter demands and effort encouragement.

References

Bahník, Š., & Vranka, M. A. (2017). Growth mindset is not associated with scholastic aptitude in a large sample of university applicants. *Personality and Individual Differences, 117*, 139-143.

Bates, T. C. (2018). umx: A package for SEM in R (Version 1.9.0) [R package]. Edinburgh, UK: github.com.

Bates, T. C., Maes, H., & Neale, M. C. (2019). umx: Twin and path-based structural equation modeling in R. *Twin Research and Human Genetics, 22*(1), 27-41.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: A longitudinal study and an intervention. *Child Development, 78*(1), 246-263.

Cain, K. M., & Dweck, C. S. (1995). The relation between motivational patterns and achievement cognitions through the elementary school years. *Merrill-Palmer Quarterly, 41*, 25-52.

Claro, S., Paunesku, D., & Dweck, C. S. (2016). Growth mindset tempers the effects of poverty on academic achievement. *Proceedings of the National Academy of Science USA, 113*(31), 8664-8668.

Deary, I. J. (2012). Intelligence. *Annual Review of Psychology, 63*, 453-482.

Doyen, S., Klein, O., Pichon, C. L., & Cleeremans, A. (2012). Behavioral priming: It's all in the mind, but whose mind? *PLoS One, 7*(1), e29081.

Dweck, C. S. (1999). *Self-theories: Their Role in Motivation, Personality, and Development*. New York: Psychology Press.

Dweck, C. S. (2006). *Mindset: The New Psychology of Success*. New York: Random House.

Dweck, C. S. (2008a). Brainology: Transforming students' motivation to learn. *Independent School, 67*(2), 110-119.

Dweck, C. S. (2008b). Mindsets: How praise is harming youth and what can be done about it. *School Library Media Activities Monthly, Volume XXIV*(5), 55-58.

Dweck, C. S. (2013). QnAs with Carol S. Dweck. Interview by Sujata Gupta. *Proceedings of the National Academy of Science USA, 110*(37), 14818.

Dweck, C. S., & Molden, D. C. (2000). Self-theories: Their impact on competence motivation, and aquisition. In C. S. Dweck & A. J. Elliot (Eds.), *Handbook of competence and motivation* (pp. 122-140). New York: The Guilford Press.

Finn, A. S., Kraft, M. A., West, M. R., Leonard, J. A., Bish, C. E., Martin, R. E., et al. (2014). Cognitive skills, student achievement tests, and schools. *Psychological Science, 25*(3), 736-744.

Gignac, G. E. (2018). A moderate financial incentive can increase effort, but not intelligence test performance in adult volunteers. *British Journal of Psychology, 109*(3), 500-516.

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology, 102*(4), 700-717.

Gunderson, E. A., Gripshover, S. J., Romero, C., Dweck, C. S., Goldin-Meadow, S., & Levine, S. C. (2013). Parent praise to 1- to 3-year-olds predicts children's motivational frameworks 5 years later. *Child Development, 84*(5), 1526-1541.

Hong, Y.-y., Chiu, C.-y., Dweck, C. S., & Sacks, R. (1997). Implicit theories and evaluative processes in person cognition. *Journal of Experimental Social Psychology, 33*(3), 296-323.

Job, V., Walton, G. M., Bernecker, K., & Dweck, C. S. (2013). Beliefs about willpower determine the impact of glucose on self-control. *Proceedings of the National Academy of Science USA, 110*(37), 14837-14842.

Lindsey, R. V., Shroyer, J. D., Pashler, H., & Mozer, M. C. (2014). Improving students' long-term knowledge retention through personalized review. *Psychological Science, 25*(3), 639-647.

Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist, 57*(9), 705-717.

Mueller, C. M., & Dweck, C. S. (1998). Praise for intelligence can undermine children's motivation and performance. *Journal of Personality and Social Psychology, 75*(1), 33-52.

National Bureau of Statistics of the People's Republic of China. (2017). China statistical year book. Retrieved 18/01/2017, 2017, from http://www.stats.gov.cn/tjsj/ndsj/2016/html/0411EN.jpg

OECD. (2008). *Growing unequal? Income distribution and poverty in OECD countries*. Paris, France.: Organisation for Economic Co-operation and Development.

Paunesku, D., Walton, G. M., Romero, C., Smith, E. N., Yeager, D. S., & Dweck, C. S. (2015). Mind-set interventions are a scalable treatment for academic underachievement. *Psychological Science, 26*(6), 784-793.

R Core Team. (2019). R: A language and environment for statistical computing (Version 3.5.2). Vienna, Austria: R Foundation for Statistical Computing.

Rattan, A., Savani, K., Chugh, D., & Dweck, C. S. (2015). Leveraging mindsets to promote academic achievement: Policy recommendations. *Perspectives on Psychological Science, 10*(6), 721-726.

Raven, J., Raven, J. C., & Court, J. H. (2000). *Raven manual: Standard progressive matrices, including the parallel and plus versions* (2000 edition ed.). Oxford, UK: Oxford Psychologists Press.

Ritchie, S. J., Bates, T. C., & Deary, I. J. (2015). Is education associated with improvements in general cognitive ability, or in specific skills? *Developmental Psychology, 51*(5), 573-582.

Roberts, B. W., Kuncel, N. R., Shiner, R., Caspi, A., & Goldberg, L. R. (2007). The power of personality: The comparative validity of personality traits, socioeconomic status, and cognitive ability for predicting important life outcomes. *Perspectives on Psychological Science, 2*(4), 313-345.

Rosander, P., & Backstrom, M. (2014). Personality traits measured at baseline can predict academic performance in upper secondary school three years late. *Scandinavian Journal of Psychology, 55*(6), 611-618.

Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., & Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychological Science, 29*(4), 549-571.

Styles, I., Raven, M., & Raven, J. C. (1998). *Raven's Standard Progressive Matrices: SPM Parallel sets A-E*.

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist, 47*(4), 302-314.

Yettick, H., Lloyd, S., Harwin, A., Riemer, A., & Swanson, C. B. (2016). Mindset in the classroom: A national survey of K-12 teachers.: Education Week Research Center.

Zeng, G., Hou, H., & Peng, K. (2016). Effect of growth mindset on school engagement and psychological well-being of Chinese primary and middle school students: The mediating role of resilience. *Frontiers in Psychology, 7*, 1873.

Zhao, J., & Wang, M. (2014). Mothers' academic involvement and children's achievement: Children's theory of intelligence as a mediator. *Learning and Individual Differences, 35*, 130-136.

Table 1 The similarities and differences between Mueller & Dweck (1998) Study 1 and the present Studies 1, 2 and 3

	Mueller & Dweck (1998)	**The present paper**		
	Study 1	**Study 1**	**Study 2**	**Study 3**
Participants	N= 128 (70 girls and 58 boys)	N= 190 (101 girls, 89 boys)	N= 222 (106 girls, 116 boys)	N= 211 (91 girls, 120 boys)
Age	Mean age = 10.7, SD = 0.60	Mean age = 10.48, SD = 0.51	Mean age = 11.03, SD = 0.47	Mean age = 10.70, SD = 0.54
Ethnicity	50% Caucasian, 19% African American, 31% Hispanic	100 % Chinese	100 % Chinese	100 % Chinese
Source	One public elementary school in a small midwestern town and two public elementary schools in a large north-eastern town in the U.S.	One public primary school in a north-eastern city in China.	Another public primary school in the same city as Study 1.	Another public primary school in the same city as Study 1.
SES	Not reported	City 21% below the Chinese national average income	City 21% below the Chinese national average income	City 21% below the Chinese national average income

Ravens tests	All trials were from Raven's Standard Progressive Matrices (SPM: Ravens, 1976).	All trials were from the SPM (Raven et al., 2000).	All trials were from the SPM (Raven et al., 2000) and SPM Parallel trials (Styles et al., 1998)	All trials were from the SPM (Raven et al., 2000) and SPM Parallel trials (Styles et al., 1998)
Tests	Three tests 1) moderate difficulty (Trial 1)* 2) more difficult (Trial 2)* 3) equal to Trial1 (Trial 3)* (* exact items were not given)	Three tests: 1) moderate difficulty (Trial 1) 2) more difficult (Trial 2) 3) equal to Trial1 (Trial 3)	Four tests: 1) moderate difficulty (Trial 1) 2) more difficult (Trial 2) 3) equal to Trial1 (Trial 3) 4) equal to Trial2 (Trial 4)	Four tests: 1) moderate difficulty (Trial 1) 2) more difficult (Trial 2) 3) equal to Trial1 (Trial 3) 4) equal to Trial2 (Trial 4)
Test lengths	Trial 1 & 3 = 10 items Trial 2 = 10 items	Trial 1 & 3 = 10 items Trial 2 = 10 items	Trial 1 & 3 = 12 items Trial 2 & 4 = 10 items	Trial 1 & 3 = 12 items Trial 2 & 4 = 10 items
Average score on Trial 1	5.2/10 (52%) (7.9 attempted)	8.94/10 (89%) (attempts not scored)	7.64/12 (63%) (10.9 attempted)	7.61/12 (63%) (10.8 attempted)
Average score on Trial 2	1.6/10	4.4/10	5.1/10	4.5/10

Feedback rule	All participants were told that they had solved at least 80% of the problems that they answered, no matter what their actual scores were.	All participants were told that they had solved at least 80% of the problems that they answered, no matter what their actual scores were.	All participants were told that they had solved at least 80% of the problems that they answered, no matter what their actual scores were.	All participants were told that they had solved at least 80% of the problems that they answered, no matter what their actual scores were.
General praise	"Wow, you did very well on these problems. You got [numbers of problems] right. That's a really high score."	"Wow, you did very well on these problems. You got [numbers of problems] right. That's a really high score."	"Wow, you did very well on these problems. You got [numbers of problems] right. That's a really high score."	"Wow, you did very well on these problems. You got [numbers of problems] right. That's a really high score."
Fixed mindset condition	"You must be smart at these problems"	"You must be smart at these problems"	"You must be smart at these problems"	"You must be smart at these problems"
Growth mindset condition	"You must have worked hard at these problems"	"You must have worked hard at these problems"	"You must have worked hard at these problems"	"You must have worked hard at these problems"
Control condition praise	Control group received general praise only, with no additional feedback given.	No controls. To maximise effective n, all subjects were allocated to either the fixed mindset	Active control group were told "Even though we cannot change our basic ability, you work hard at hard problems and that's	Active control group were told "Even though we cannot change our basic ability, you work hard at hard problems and that's

		or growth mindset conditions	how we get hard things done!”	how we get hard things done!”
Negative feedback (after Trial 2)	Participants were told they had performed “a lot worse” on the second trial of problems and had solved no more than 50% of the problems that they answered.	Participants were told they had performed “a lot worse” on the second trial of problems and had solved no more than 50% of the problems that they answered.	Participants were told that they had performed “a lot worse” on the second trial of problems and had solved no more than 50% of the problems that they answered.	Participants were told that they had performed “a lot worse” on the second trial of problems and had solved no more than 50% of the problems that they answered.
Additional tests	None	None	Theories of Intelligence Scale (Dweck 1999)	Theories of Intelligence Scale (Dweck 1999)
Time allowed	4 minutes	4 minutes	4 minutes	4 minutes
Analysis	One-way ANOVA comparing change in performance (Trial 3 – Trial 1).	One-way ANOVA comparing change in performance (Trial 3 – Trial 1).	One-way ANOVA comparing change in performance (Trial 3 – Trial 1).	One-way ANOVA comparing change in performance (Trial 3 – Trial 1).

Table 2 The similarities and differences between Blackwell, Trzesniewski & Dweck (2007) Study 1 and the present Studies 2 and 3

	Blackwell, Trzesniewski & Dweck (2007)	**The present paper**	
	Study 1	**Study 2**	**Study 3**
Participants	N= 373 (198 girls and 175 boys)	N= 222 (106 girls, 116 boys)	N= 211 (91 girls, 120 boys)
Age	7th grade	5th grade (Mean age =11.03, SD=0.47)	5th grade (Mean age=10.70, SD=0.54)
Ethnicity	55% African American, 27% South Asian, 15% Hispanic, 3% East Asian and European American.	100 % Chinese	100 % Chinese
Source	One public secondary school in New York city.	One public primary school in a north-eastern city in China.	One public primary school in a north-eastern city in China.
SES	53% children were eligible for free lunch	City 21% below the Chinese national average income	City 21% below the Chinese national average income
Academic outcomes measurement	Math grades	GPA (Math, Chinese and English grades)	GPA (Math, Chinese and English grades)

Theory of Intelligence measurement	Implicit Theories of Intelligence Scale for Children (Dweck, 1999, p.177)	Theories of Intelligence Scale (Dweck, 1999, p.178)	Theories of Intelligence Scale (Dweck, 1999, p.178)
Scale properties	6 items, each scored 1-6	6 items from the Implicit Theories of Intelligence Scale for Children plus 2 extra items, each scored 1-6	6 items from the Implicit Theories of Intelligence Scale for Children plus 2 extra items, each scored 1-6
Extra items	NA	"To be honest, you can't really change how intelligent you are"; "You can change even your basic intelligence level considerably."	"To be honest, you can't really change how intelligent you are"; "You can change even your basic intelligence level considerably."
Average mindset score	4.43	4.25	4.16

Table 3 Summary of key hypotheses across the present Studies 1, 2 and 3 with key stats for each prediction

	Study 1	**Study 2**	**Study 3**
Does a growth mindset manipulation enhance post-failure performance on the moderate difficulty items?	Yes	No	No
Statistical results	F (1,188) = 3.930, p = .049*	F(2,219) = 0.440, p = .645	F(2,208) = 2.744, p = .067 (active control did best) β = 0.32 CI_{95} [0.05, 0.60], t = 2.34, p = .020*
Does a growth mindset manipulation enhance post-failure performance on the more difficult items?	NA	No	No
Statistical results	NA	F(2,219) = 0.630, p = .534	F(2, 208) = 0.216, p = .806
Do children's mindsets predict response to failure	NA	No	No

on moderate difficulty items?			
Statistical results	NA	$F(1, 220) = 0.074$, $p = .786$	$F(1, 209) = 0.179$, $p = .673$
Do children's mindsets predict response to failure on more difficulty items?	NA	No (in a reversed direction)	No
Statistical results	NA	$F(1, 220) = 7.482$, $p = .007$**; $\beta = -0.13$ CI_{95} [-0.23, -0.04]	$F(1, 209) = 0.020$, $p = 0.888$
Do children's mindsets relate to grades?	NA	No	No
Statistical results	NA	Semester 1: $\beta = 0.03$ CI_{95} [-0.10, 0.16], $t = 0.42$, $p = .671$ Semester 2: $\beta = 0.05$ CI_{95} [-0.11, 0.21], $t = 0.63$, $p = .530$	Semester 1: $\beta = 0.04$ CI_{95} [-0.10, 0.17], $t = 0.52$, $p = .601$ Semester 2: $\beta = 0.06$ CI_{95} [-0.08, 0.20], $t = 0.88$, $p = .382$
Do children's mindsets relate to changes of grades?	NA	No	No

Statistical results	NA	$\beta = 0.03$ CI_{95} [-0.06, 0.12], $t = 0.63$, $p = .532$	$\beta = 0.04$ CI_{95} [-0.04, 0.11], $t = 1.00$, $p = .319$
Do children's mindsets relate to cognitive ability?	NA	No	No
Statistical results	NA	Trial 1: $\beta = 0.12$ CI_{95} [-0.01, 0.25], $t = 1.76$, $p = .080$ Trial 2: $\beta = 0.12$ CI_{95} [-0.02, 0.25], $t = 1.72$, $p = .086$	Trial 1: $\beta = 0.12$ CI_{95} [-0.02, 0.25], $t = 1.68$, $p = .094$ Trial 2: $\beta = 0.07$ CI_{95} [-0.07, 0.20], $t = 0.99$, $p = .322$

Note: *p < 0.05, ** p < 0.01, ***p < 0.001.

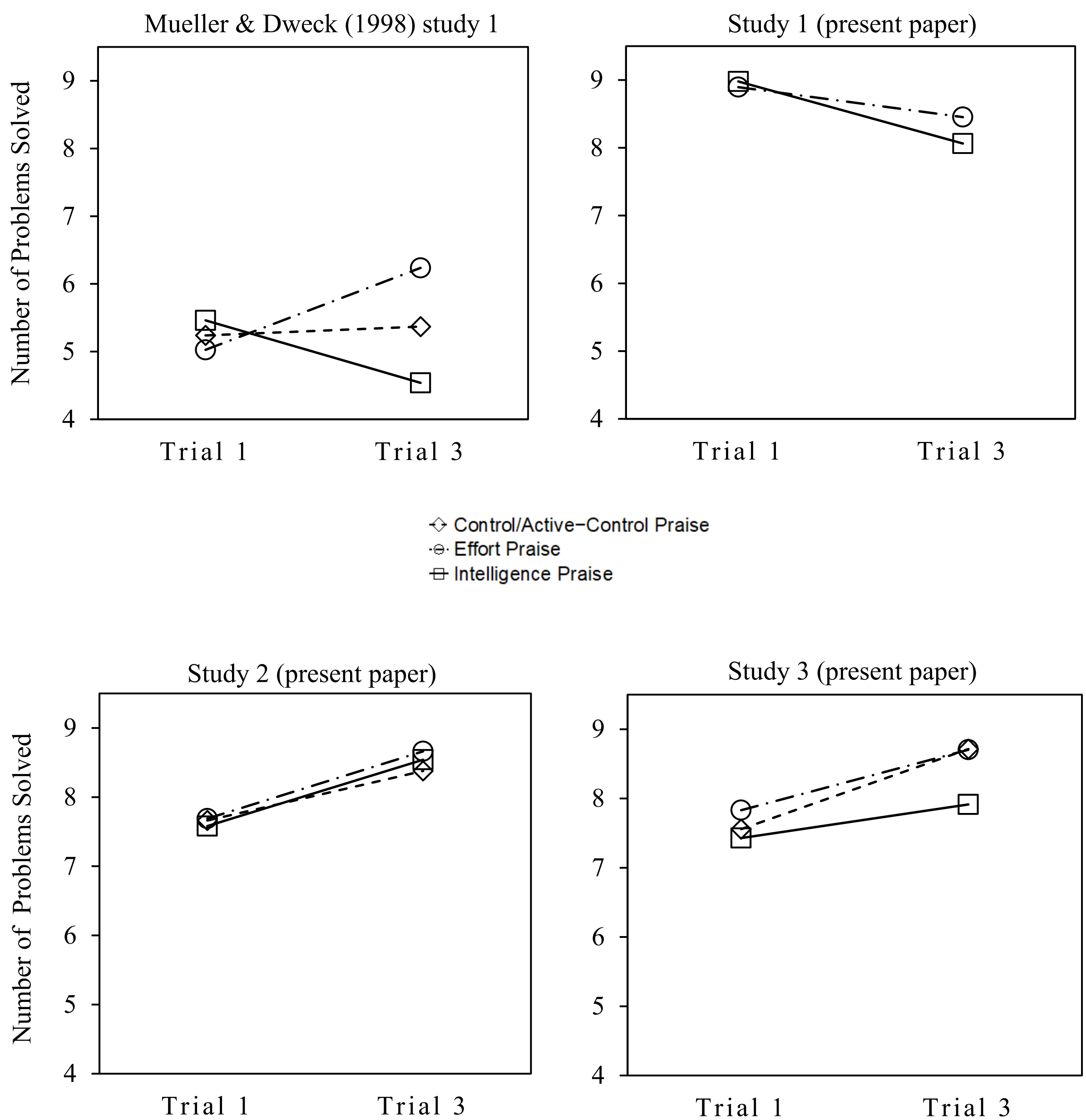

Figure 1: Number of problems children solved before (Trial 1) and after (Trial 3) the failure SPM test in Mueller and Dweck (1998) Study 1 and the present Studies 1, 2 & 3.

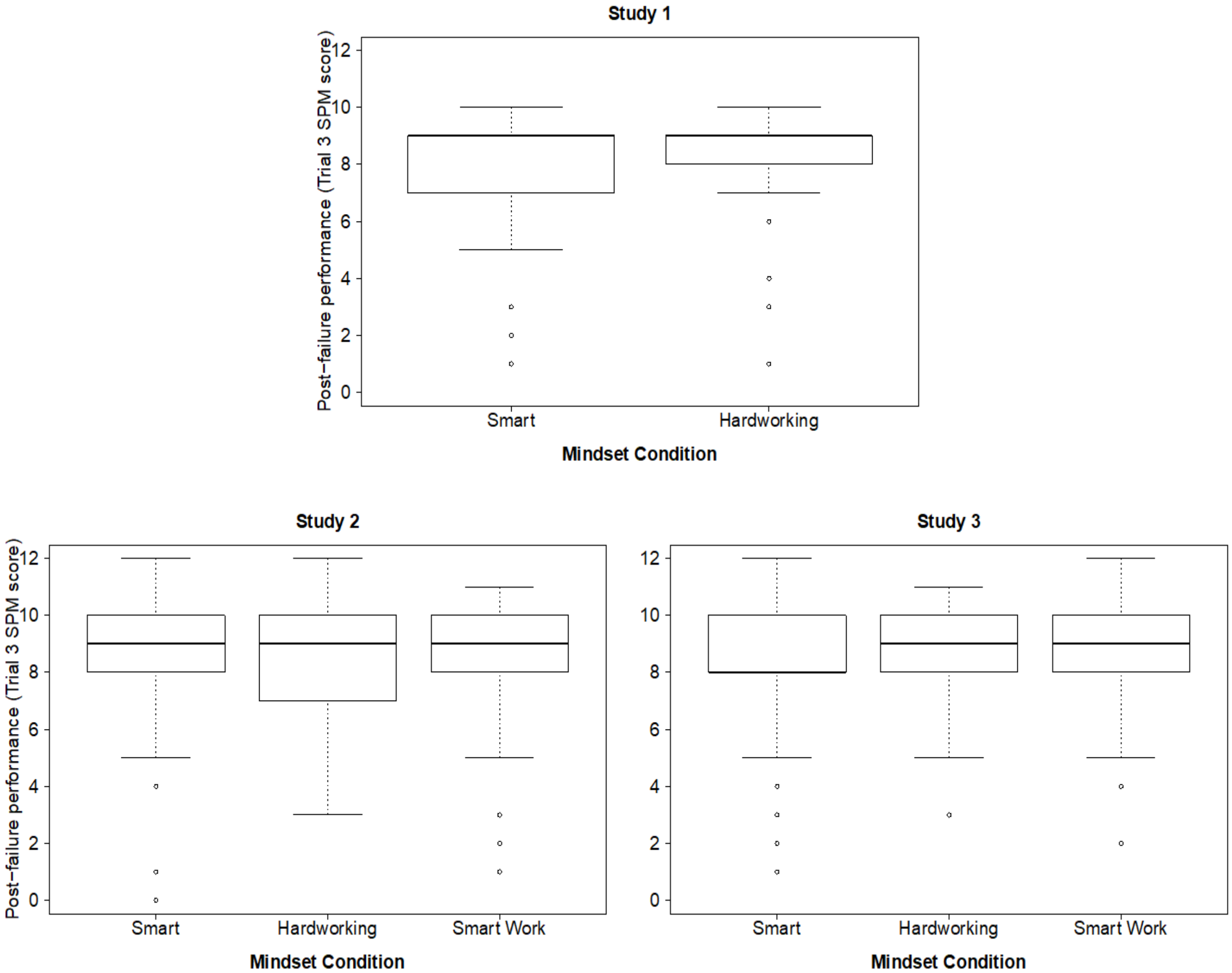

Figure 2: Post-failure performance (Trial 3 SPM score) for each mindset condition (shown on the x-axis), plotted separately for Study 1 (top), Study 2 (bottom left) & Study 3 (bottom right) panes.

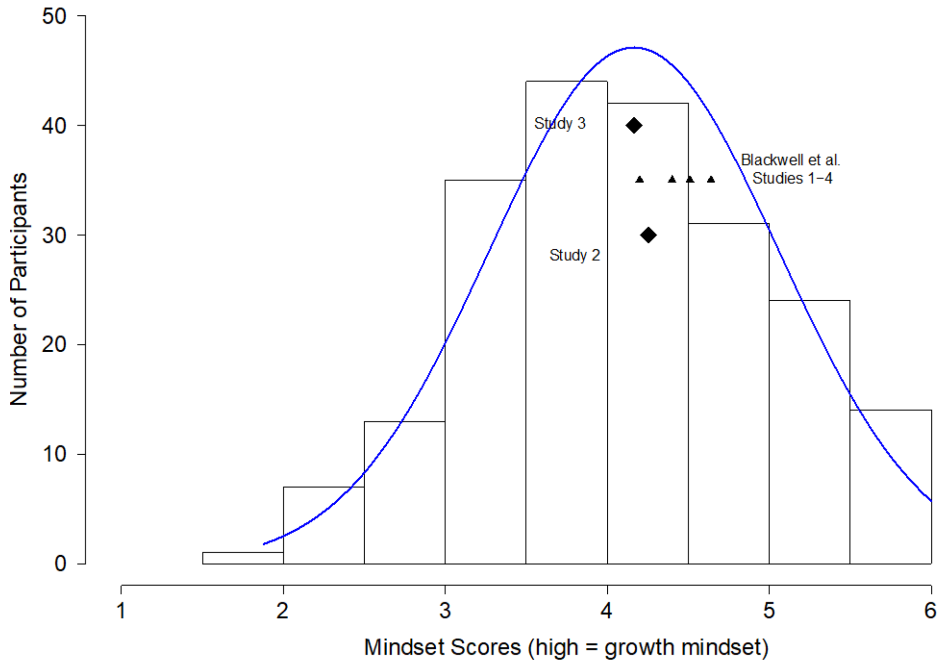

Figure 3: Mean mindset (Dweck, 1999) scores for children tested in Study 2 and Study 3 in the present report, as well as mean scores from Blackwell et al. (2007) Studies 1 through 4 for comparison. A histogram of all scores from the present report, along with a corresponding superimposed normal curve are also presented.