Does growth mindset improve children's IQ, educational attainment or response to setbacks?

Active-control interventions and data on children's own mindsets

Authors

Yue Li & Timothy C. Bates*

Address

Department of Psychology

University of Edinburgh,

EH8 9JZ Edinburgh, UK

Corresponding author

e-mail tim.bates@ed.ac.uk

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Abstract

      Mindset theory predicts that children's IQ and school grades are positively linked to their belief that basic ability is malleable rather than fixed. We test this prediction in three experimental studies (total n = 624 individually-tested 10-12-year-olds). Two studies included active-control conditions to test effects of fixed-ability beliefs independent of motivation. In addition, we tested whether children's own mindsets relate to real-life IQ, educational attainment in longitudinal analyses of school grades. Praise for intelligence had no significant effect on cognitive performance. Nor were any effects of mindset were found for challenging material. Active-control data showed that occasional apparent effects of praise for hard work on easy outcome measures reflected motivational confounds rather than effects of implicit beliefs about the malleability of intelligence (study 3, active control condition). Children's own mindsets showed no relationship to IQ, school grades, or change in grades across the school year, with the only significant result being in the reverse direction to prediction (better performance in children holding a fixed mindset). Fixed beliefs about basic ability appear to be unrelated to ability, and we found no support for mindset-effects on cognitive ability, response to challenge, or educational progress.

Introduction

Mindset theories of cognitive ability and educational attainment predict that children's beliefs about whether basic ability is stable (fixed mindset) or can be changed substantially (growth mindset) impact causally on IQ (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 on 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 (Bahník & Vranka, 2017). In particular, the claim that mindset intervention in children (10-12 year olds) causes large (> 1 SD) impacts on post-challenge IQ (Mueller & Dweck, 1998) has not been replicated, and no studies have included graded outcome measures (easy and difficult ability items), or active-control conditions, against which intervention effects may be benchmarked, as well as objective measures of external benefits (school grades across time). Here, we report a large (total n = 624) test of both intervention and longitudinal predictions in a sample population consisting of entire classes of children aged between 9 and 12 years, closely matching those studied by Mueller and Dweck (1998) and (Blackwell et al., 2007). We begin by briefly summarising the background to this research and the two papers on which the present tests were based.

Background to reported mindset effects on children's IQ and grades

Some of the most impactful experimental evidence for mindset theory was provided by a study of a mindset manipulation in 10-12-year-old children (Mueller & Dweck, 1998), These authors reported that praise for intelligence versus praise for hard work *"undermined children's motivation and performance"* (Mueller & Dweck, 1998, p. 33). In study 1 of this report, children first completed an easy set of 10 Standard Progressive Matrices (SPM: Raven, Raven, & Court, 2000) cognitive ability puzzles. Children were given 3-minutes for this task after which they

were told 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 is reported as being carefully selected to strongly manipulate mindset. This manipulation was followed by second, much more challenging set of SPM items. Children were told they did "*a lot worse*", getting no more than 50% correct. Finally, children were given a further set of 10 moderately easy items, and performance on this set formed the core dependent variable. Children in the growth and fixed conditions differed on this outcome by ~1.3 SD (~ 20 points in IQ terms). The intervention was reported to affect all children independent of their ability and/or ethnicity. Significant effects were shown in each of six small-to-moderately-sized studies (Ns = 128, 51, 88, 51, 46, 48) reported in the same paper.

A second, widely-cited, report that "*Implicit theories of intelligence predict achievement*" (Blackwell et al., 2007, p. 246) further supported the idea that children's own mindsets affect real-life outcomes such as educational attainment. In this study, seventh grade children (aged around 12-years old) were assessed on the standard mindset questionnaire (Dweck, 1999) and a number of additional attitudinal variables. Follow-up measures of school grades were obtained in the next year. Controlling for entry scores, mindset predicted final mathematics grades (β =0.17, t(372) = 3.40, p < .001) (Blackwell et al., 2007). Interestingly, mindset was unrelated to children's baseline grades. Others have sought to replicate and extend such claims, but with much smaller, and often non-significant results. For instance, Paunesku et al. (2015) found that a mindset intervention in 9th-12th grade students failed to significantly raise grades, finding instead a marginally significant effect only after excluding students whose performance was adequate and merging children in the mindset intervention group with a non-specific "sense-of-purpose" group. Unlike Blackwell et al. (2007), these authors reported a significant but small (β = 0.06, CI95= [0.03, 0.09]) association of growth mindset with pre-study GPA (t(1561) = 3.47, *p* < .001). Recently in in a large sample of university applicants, Bahník and Vranka (2017) found no association of mindset with scholastic aptitude in university entrants.

Goals of the present studies

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These findings highlight a research gap: the need for replication of the core findings of a significant causal association of mindset with cognition and response to challenge in young children, and of positive relationships of children's own beliefs that intelligence is greatly malleable to key outcomes of developed ability and attained school grades. Despite these experimental and longitudinal outcome-linked findings being reported more than a decade ago and being cited over 2,000 times each, to our knowledge no independent studies testing these effects have been published.

In addition to a lack of independent replication, the classic praise intervention lacks an active control. The critical test of mindset theory requires contrasting activated beliefs that intelligence is fixed versus that intelligence is malleable. The classic manipulation, however, contrasts praise for intelligence (designed to activate beliefs that intelligence is fixed), with praise for hard work. Praise for ability is not incompatible with an active belief that hard work plays a role in achievement. Likewise, praise for "hard work" does not exclude activated beliefs that intelligence is fixed. Apparent effects of the manipulation, then, may result not from activation of fixed-intelligence beliefs, but from well-known performance enhancing effects of setting more challenging goals (Locke & Latham, 2002) and/or activating conscientiousness schemas (Moffitt et al., 2011), activated by praise for hard work. To isolate specific effects of beliefs about ability, therefore, an active control condition is required: one which motivates work while still activating the implicit belief that one's basic ability cannot be changed (fixed mindset) to allow a test of whether this belief is debilitating.

The nature of outcome ability measures used is also important. As an outcome-variable, Mueller and Dweck (1998) used performance on a relatively easy set of items. Mindset is predicted not only to aid execution on tasks well within a subject's ability, but to grow that ability by precisely by improving processing-investment in tasks which are currently challenging (Blackwell et al., 2007; Dweck & Molden, 2000; Gunderson et al., 2013; Paunesku et al., 2015). Because mindset is predicted to be especially important on challenging work (Good et al., 2012), it is important, to measure post-challenge performance not only on easy items, but also on challenging items, where mindset is predicted to be especially important on challenging work (Good et al., 2012).

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For these reasons, we set out (study 1) to replicate and extend the original study of Mueller and Dweck (1998) using the same mindset manipulation (priming limited mindset with "*you must be smart at these*" and priming a growth mindset with "*you must be a hard worker at these*"), the same SPM-based cognitive ability tests, given for the same durations, along with accompanying negative feedback to challenging material, and the same final outcome measure (score on a moderate set of SPM items).

In studies 2 and 3, we extend this work by incorporating an active-control condition to isolate the predicted effect of beliefs about intelligence from experimenter-demand effects on goal-setting (Locke & Latham, 2002), and to allow a test of the (presumably much more robust and larger) effect of the children's *own* mindsets (Dweck, 1999) on response to negative feedback.

Finally (study 4), using the individual grades across two waves of assessment of all children taking part in studies 2 and 3, we tested the claim that mindsets affect children's educational attainment (Blackwell et al., 2007) and cognitive ability (Dweck, 2006). We were therefore able to test for the presence of both main effects of growth mindset on higher grades and for a possible (Paunesku et al., 2015) effect restricted to children with initially low grades (an initial grade × mindset interaction). 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 tested replication of the report that, in 10-year-old children, a brief praise intervention induces a large difference in ability scores reported by Mueller and Dweck (1998). We closely followed the methods of this study, testing replicability of the reported effect of praise-for-ability versus praise-for-effort intervention in whole classes of individually tested 10-12 year olds randomly allocated to one of two praise conditions, and with praise administered following an easy set of Raven-IQ items, followed by a more difficult set and negative feedback, and with performance on a final moderate-difficulty set of items as the main DV of interest. We also implemented the series of additional measures of learning and motivation, task-persistence,

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task-enjoyment, self-rated performance, and attributional style for performance motives as described by Mueller and Dweck (1998).

We tested one complete grade of children in school (n = 190), yielding ~85% power to detect a d = .3 size effect, which we deemed the lower limit compatible with the theoretical mechanisms proposed by mindset which imply a tight dependence of performance on implicit theory in this experimental scenario.

Method

Participants. A total of 190 children participated (100% of children in grade 5). 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 subjects were recruited from a large primary school in Harbin (the capital city of Heilongjiang Province, China). Schools are public and draw 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 both relative and absolute poverty. This is predicted to significantly amplify effects of mindset on performance (Claro, Paunesku, & Dweck, 2016), increasing the power of our studies. Compensation for participation consisted of a reward of sweets at the end of the study.

Materials. Individual IQ was assessed by using items from sets B, E, and C of the SPM (Raven et al., 2000). Following Mueller and Dweck (1998), the praise IQ test consisted of the first 10 items from set B (easy). The challenging test consisted of the first 10 puzzles from set E (challenging). The post-challenge measure consisted of the first 10-items from set C (moderate-difficulty).

Learning and motivation were assessed using the learning and motivation questionnaire (Mueller & Dweck, 1998). Preference for learning or performance goals was assessed by an item asking participant's 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-

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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*?". Participants 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). Four slotted-disks of colored paper were pinned together so they 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 skill, lack of intelligence, and lack of time respectively. Participants were asked to rotate the disks to show how much each factor accounted for their failure. In addition, subjects were asked to weight the importance of ability and effort 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 "effort"), and coloring-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.

Procedure

After informed consent was gained from the headmaster, teachers, parents, and participants themselves, participants were asked to provide demographic information, and were then tested individually in a private room near the students' classroom. Testing began with a welcome, and an introduction to the testing procedures in which subjects were given an example item from the Raven puzzles, and shown how to solve this puzzle, prior to beginning the experimental tasks. Participants were assigned to a mindset intervention condition in a sequential ABAB order (95 in each condition).

Children then completed the initial easy puzzle-set, answering as many items as they could in 4 minutes. The experimenter (YL) then removed the subject's answer sheet 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*!". Subjects who correctly solved fewer than 5 items were told they got 7 items correct. Subjects solving 6–9 items correct were told they had got 8 items correct. Subjects who got all 10-items correct were told they got 9 items correct. Subjects randomized to the praise-for-intelligence condition were then told "*You must be smart at these problems!*" while children in the praise-for-effort condition were told "*You must have worked hard at these problems!*". Children then completed the learning goals questionnaire.

The challenge test (set E difficult items) was then administered. After 4-minutes, the test was scored, and, no matter what their performance, subjects were told "*Your performance was poor on that: You got less than half the puzzles correct*". As in Mueller and Dweck (1998) subjects then completed the task persistence and task enjoyment, overall self-rated performance quality, and failure attribution questionnaires, and the smart vs hard working attribution for their task performance. Finally, participants were asked to work on the post-challenge puzzles (set C, moderate-difficulty), again with a 4-minute time limit. This formed our critical DV.

All participants were then debriefed, and were told that the hard ability test on which they had received poor scores contained problems that were appropriate for older and higher-grade students. Therefore, in fact, students in their grade who solved even a single puzzle 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, 2016) and umx (Bates, 2014; Bates, Neale, & Maes, 2017). 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 three studies are available in supplementary data at https://osf.io/uethh. As expected scores on the easiest test were skewed due to ceiling effects (skew = -2.41, kurtosis = 7.66).

The main hypothesis was that praise for effort would be associated with higher final cognitive-ability scores, compared to praise for ability. This hypothesis was tested in a regression

model with post-challenge ability scores as the DV, mindset condition as the IV, and sex, age entered as covariates.

Contrary to prediction, mindset-condition was not significantly associated with post-challenge ability scores ($\beta = -0.24$ [-0.53, 0.05], $t = -1.64$, $p = 0.102$). Adding a control for initial ability (score on the challenge IQ test: which was a highly significant predictor of post-challenge scores: $\beta = 0.48$ [0.35, 0.61], $t = 7.44$, $p < 0.001$) left mindset non-significant by conventional standards ($\beta = -0.24$ [-0.48, 0.02], $t = -1.87$, $p = 0.064$: see Figure 1). No effect was found of sex or age, but removing these covariates did not meaningfully alter results.

While Mueller and Dweck (1998) reported their mindset intervention was equally effective for all children (i.e., no interaction of initial ability × mindset-condition), we also examined this interaction as, recently, this interaction outcome has been reported as a significant outcome where no main effect was found (Paunesku et al., 2015). No evidence was found for such an interaction ($\beta = 0.01$ [-0.25, 0.27], $t = 0.07$, $p = 0.943$).
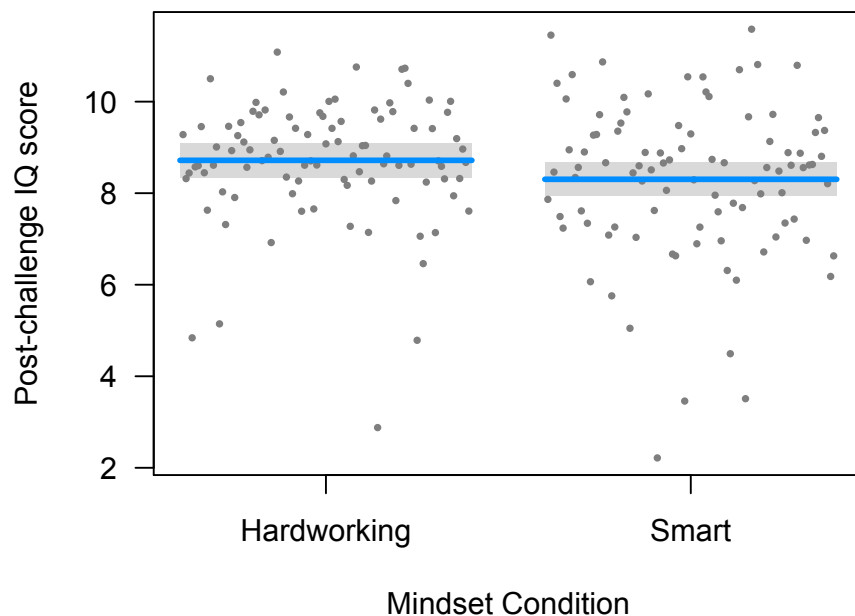

Figure 1: Study-1 final ability scores, comparing praise for intelligence and praise for effort.

Our primary interest was the post-challenge hypothesis. However, we also examined the hypotheses that praise-for-effort would increase enjoyment solving the puzzles, persistence, and self-rated performance compared to praise for intelligence. This was done via regressions, with responses on these questions as the dependent variables, and mindset condition as the independent variable. Sex and age were entered as covariates. The predicted effects were not supported by the results. Condition was not associated with expression of a learning goal (β = -0.07 [-0.36, 0.22], t = -0.49, p = 0.626), wishing to take the problems home (β = 0.25 [-0.03, 0.54], t = 1.75, p = 0.082), finding working on the problems enjoyable (β = -0.08 [-0.37, 0.2], t = -0.58, p = 0.565), or fun (β = 0.10 [-0.18, 0.39], t = 0.72, p = 0.474). Neither was there any effect of condition on perceived performance (smart higher than work: β = 0.10 [-0.18, 0.39], t = 0.72, p = 0.474).

Discussion

Contrary to expectation, the mindset intervention did not significantly impact post-challenge scores. This result lead us to undertake a second replication, modified to enhance the chance of success and to shed additional light on mindset.

Study 2

Three modifications were made which did not alter the direct replication design, but improved power and reduced the ambiguity of outcomes. To improve the distribution of outcomes on the initial set of easy puzzles, we slightly increased their difficult and increased the number of items available (increased from 10 to 12 items). In the first change material change, we added a more difficult post-challenge test consisting of a matched-items from the set-E SPM scale. As it is predicted that mindset should most strongly effect more challenging material (Good et al., 2012), this should maximise the opportunity to detect mindset effects on response to challenge.

Second, if mindset is important for response to challenge, then children's own mindset should show much larger effects than the intervention. We therefore included the standard

mindset questionnaire (Dweck, 1999), allowing us to test whether children's limited vs growth mindsets caused differences in post-challenge performance. The addition of a measure of mindset also allowed us to test whether mindset impacts educational attainment and cognitive ability (see study 4 below).

Third, and perhaps most importantly, we wished to test specificity of the praise intervention. Both trait personality (Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007) and motivation theory (Locke & Latham, 2002) predict that hard work improves outcomes on challenging tasks. What is specific to the mindset theory account of attainment compared to these accounts is the prediction that believing basic ability is malleable causes increases in basic ability and grades. As noted in the introduction, the standard intelligence vs hard-work praise intervention confounds support for hard work with beliefs about intelligence. To distinguish these effects, we created a novel active-control condition based on 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 conformed to the limited mindset (we can't change basic ability), while also activating the belief that hard work is required to do hard things.

Method

Participants

In total, 222 pupils were recruited from a second primary school in the same city as Study 1 drew upon: 116 males (mean age 11.07, SD = 0.49) and 106 female subjects (mean age 11, SD = 0.45). Compensation for participation consisted of sweets at the end of the study.

Materials

Mindset was assessed using the 8-item Theories of Intelligence scale (Dweck, 1999). 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 8-item Theory of Talent scale was also administered but is not analysed here.

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The puzzle-sets were drawn from the original and parallel-form versions of the SPM (Raven et al., 2000), presented in a counterbalanced order. Test one included 12 (rather than 10) items from set C (rather than set B). The second (challenge test) consisted of the first 10-items from set E. Equivalent easier and more difficult tests were used in the post-feedback test. Learning and motivation measures were given as in Study 1.

Procedure

The procedure was identical to that used in study 1, with children again tested individually in a private room near their classroom. Seventy-four subjects were allocated to each condition at sequential-random. Participants in the praise-for-intelligence-and-effort 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*". At the end of experimental session, all participants were debriefed as in study 1.

Results

Does mindset enhance post-challenge reasoning ability?

We first tested if fixed mindset treatment impacted negatively on post-feedback performance using regression, testing if scores on the third set of ability puzzles were predicted by praise intervention, controlling for age, sex, and baseline ability scores.

On the easier post-challenge ability measure (comparable to that used in Mueller & Dweck, 1998), there was no effect of condition (F(2, 215) = .475, p = 0.623). The more powerful contrast of the limited vs. non-limited conditions was also near zero (β = 0.06 [-0.21, 0.32], t = 0.41, p = 0.682). In line with these null results, and contrary to prediction, children's own mindsets were unrelated to their response post-challenge ability scores (β = 0.07 [-0.04, 0.18], t = 1.22, p = 0.223).

On the more challenging puzzles, where mindset was predicted to most strongly reveal its effect, there was, again, no effect of mindset intervention (F(2, 215) = 0.23, p-value = 0.796). The focussed limited vs non-limited contrast was similarly non-significant (β = 0.06 [-0.16, 0.28], t = 0.56, p = 0.578: See Figure 2 left panel).

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Contrary to the prediction of mindset theory, response to this challenging material was related to mindset in the *reverse* direction to the growth-mindset prediction ($\beta = -0.10$ [-0.19, -0.01], t = -2.26, p = 0.025). This may be a false-positive, but the direction of response suggests that a growth mindset *harms* response to more difficult challenges (See Figure 2 right panel).
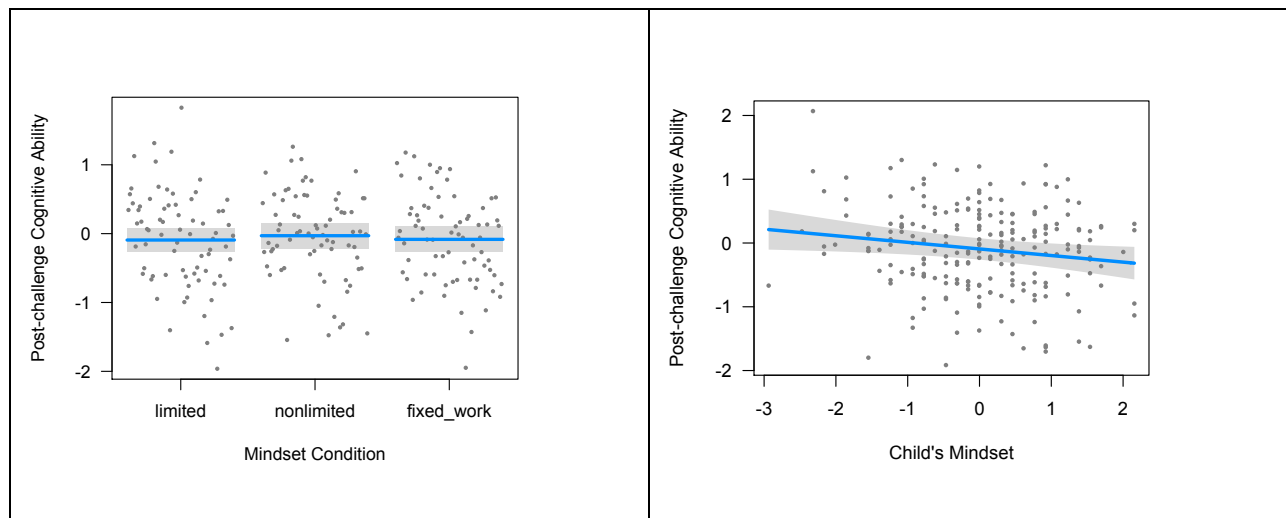

Figure 2: Growth-mindset intervention is unrelated to performance (left panel) while children's own growth-mindsets *harmed* post-challenge performance (right panel). Data from Study 2 challenging item-set.

Discussion

Contrary to Mueller and Dweck (1998), we found no effect of mindset manipulation on response to challenge. Moreover, children's own growth mindset showed a small, but significant, *negative* effect on response to challenge (i.e., the opposite effect to that predicted: see Figure 2). 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 mindsets performed as predicted by mindset theory.

Study 3

Study 3 was executed identically to Study 2, testing the same hypotheses.

Method

Subjects

Subjects. 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 10.6, SD = 0.46).

Procedure

Numbers in the limited, non-limited, and working despite limits condition were 70, 71, and 70 respectively. All procedures were identical to those of study 2.

Results

Does a mindset intervention enhance post-challenge reasoning ability?

As before, we tested the prediction that the growth-mindset intervention would improve post-feedback performance, relative to the fixed- and active-control conditions. Again, for each level of difficulty this was done using regression models to predict scores on the final ability tests as DVs with mindset condition, children's own mindset, pre-test ability, and the interaction of mindset and baseline ability as predictors, controlling for age and sex.

Does mindset or praise alter response to negative feedback on easier puzzles?

We first tested differences in solving the easier puzzle set following negative feedback. As in study 2, there was no effect of children's own mindset on their response to the challenge (β = 0.01 [-0.09, 0.12], t = 0.28, p = 0.777). There was, however a significant effect of mindset condition ($F_{(2, 204)}$ = 4.161, p = 0.017). Relative to the limited condition, scores in the non-limited condition were improved (β = 0.26 [0.01, 0.51], t = 2.03, p = 0.044).

This result would seem to be compatible with mindset theory were it not for the fact that our active-control condition, in which children were told that their basic ability cannot be changed (while still reinforcing the fact that doing puzzles requires work) failed to show the harmful effect predicted from activation of a fixed mindset, and instead yielded a *positive* effect ($\beta = 0.36$ [0.1, 0.61], $t = 2.8$, $p = 0.006$), with the active-control fixed-mindset yielding an approximately 35% larger effect compared to the growth mindset condition (see Figure 3).
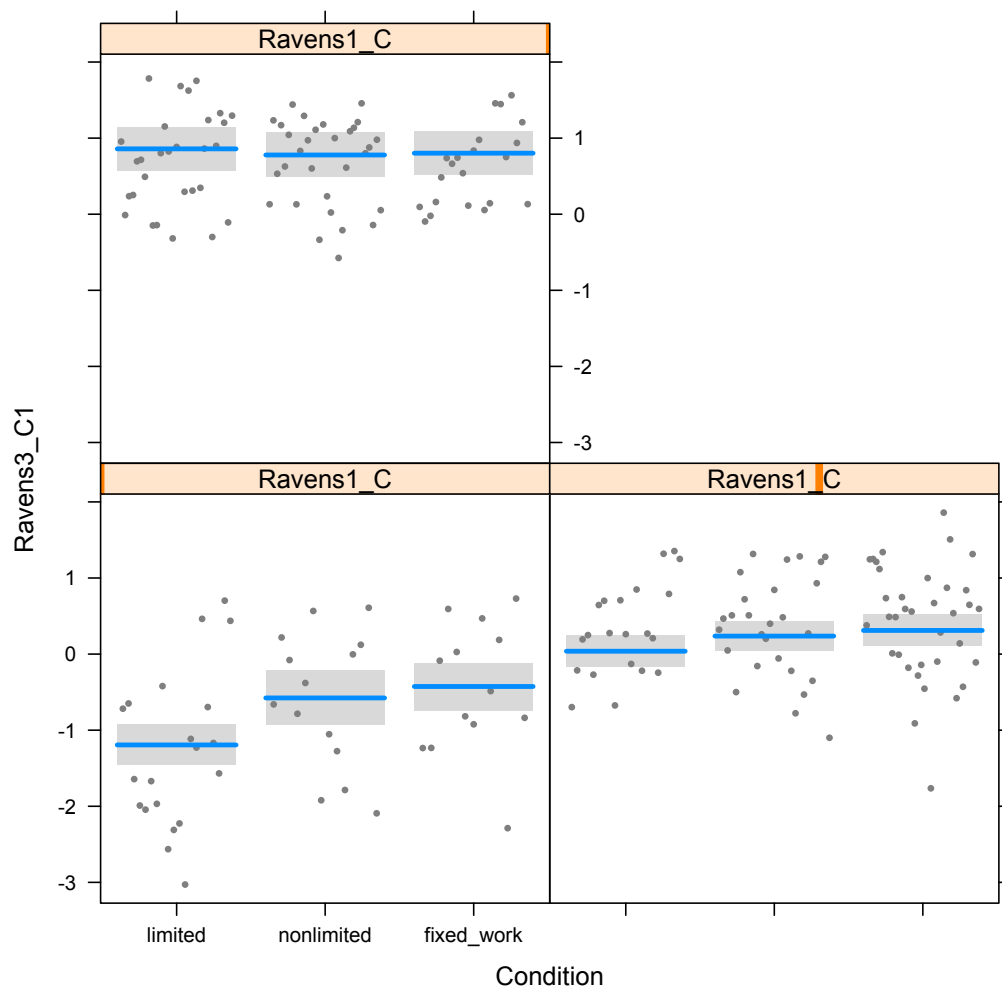

Figure 3: Interaction plot from Study 3 breaking out scores on the (easy) post-challenge Raven score across the three mindset conditions × pre-test Raven score. Panels show results for, at bottom left, the children with the lowest scores on the initial ability test, bottom right shows

children with average ability scores, and the upper panel shows the results for the most able children.

Does mindset affect response to negative feedback on challenging material?

We next tested if mindset raised performance on material which children found challenging – the stated purpose of mindset interventions. Contrary to prediction, no differences were found among the mindset conditions ($F(2, 202) = 0.306$, p= 0.737). The focussed contrast for this prediction (performance in the fixed versus growth praise groups) also showed no effect ($\beta = 0.06$ [-0.16, 0.27], $t = 0.51$, $p = 0.612$). Consistent with these null results, the predicted positive effect of children's own mindsets on post-challenge performance failed to materialise ($\beta = 0.01$ [-0.08, 0.10], $t = 0.16$, $p = 0.870$). Finally, we tested if the growth mindset intervention was effective but only in children with lower initial scores. The relevant initial-ability × condition, interaction, however, was non-significant ($F(2, 202) = 0.187$, $p = 0.830$) as was the focal "ability × non-limited condition" contrast (β (relative to the limited condition) = 0.03 [-0.17, 0.24], $t = 0.32$, $p = 0.749$). As no effect of mindset on outcomes was found, we did not analyse the attitude measures predicted to mediate these effects.

Prior to discussing these experimental randomized intervention outcomes, we next examine the effects of mindset outside the laboratory, turning to real-life grades for the children studied in studies two and three.

Study 4: An analysis of links between mindset and educational attainment.

Mindset is predicted to impact the development of intellectual ability and educational attainment (Blackwell et al., 2007; Paunesku et al., 2015). We next tested these predicted associations using the mindset scores collected in studies 2 and 3, along with the student's own grades in math, English, and Chinese classes, taken mid-term and at the end of the year. Main effects of mindset should emerge as associations between growth mindset and higher cognitive ability and higher initial grades, reflecting the impact of mindset on attainment (Dweck, 2006). Even if mindset affects only those children who are struggling (Paunesku et al., 2015), then the lower range of GPA scores should become increasingly enriched with fixed-mindset children

over the course of education. Longitudinally, mindset is predicted to be associated with relative improvements in grades across the year (Blackwell et al., 2007), possibly focussed on children with low initial grades (Blackwell et al., 2007; Good et al., 2012; Paunesku et al., 2015). Mindset is thus predicted to show both main-effect and interactive associations with students' grades and grade-trajectories across a school year. Because mindset is predicted to raise cognitive ability (Dweck, 2006), we also tested the prediction that students' mindsets are associated with their cognitive ability using cognitive ability scores taken during studies 2 and 3.

Methods

Participants

Participants were all 222 pupils from study 2, and 211 pupils from study 3, as described above.

Materials

All children in the sample are formally assessed twice a year. We obtained children's grades in their three core classes – English, Mathematics, and Chinese – for the semesters preceding and following our mindset measures, allowing a test of both absolute level, and of change in performance across a year. Children's mindsets were assessed as score on the 8-item Theories of Intelligence scale (Dweck, 1999) as described in study 2 and 3. Likewise, cognitive ability was assessed using scores on the set-E SPM items ascertained in the first phrases 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 0.86 and 0.69, 0.86, and 0.90 for Math, Chinese, and English in semesters 1 and 2 respectively in study 2 class). Similar results obtained for the children in study 3. Factor-score GPAs were used to test predicted associations of mindset with grades within and across semesters.

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Do our subjects show typical variation and means of mindset?

As a first step, we examined the mean and variance of mindset in our sample. As shown in Figure 4, subjects in studies 2 and 3 displayed the full range of mindset, normally-distributed, and with an average in keeping with previous reports. They differed from the subjects studied in Blackwell et al. (2007) very little, being slightly more oriented toward an entity mindset (e.g. mean in present Study 3 was 4.16 CI96[4.04, 4.29], significantly more fixed compared to the mean of 4.43 reported in 12-year-olds studied by Blackwell et al. (t(210) = -4.43, p <.001)). Thus the intervention studies (Study 2 and 3) had significant room to manipulate mindset, and, in the present Study 4 analyses, there is ample range to reveal mindset–attainment associations.
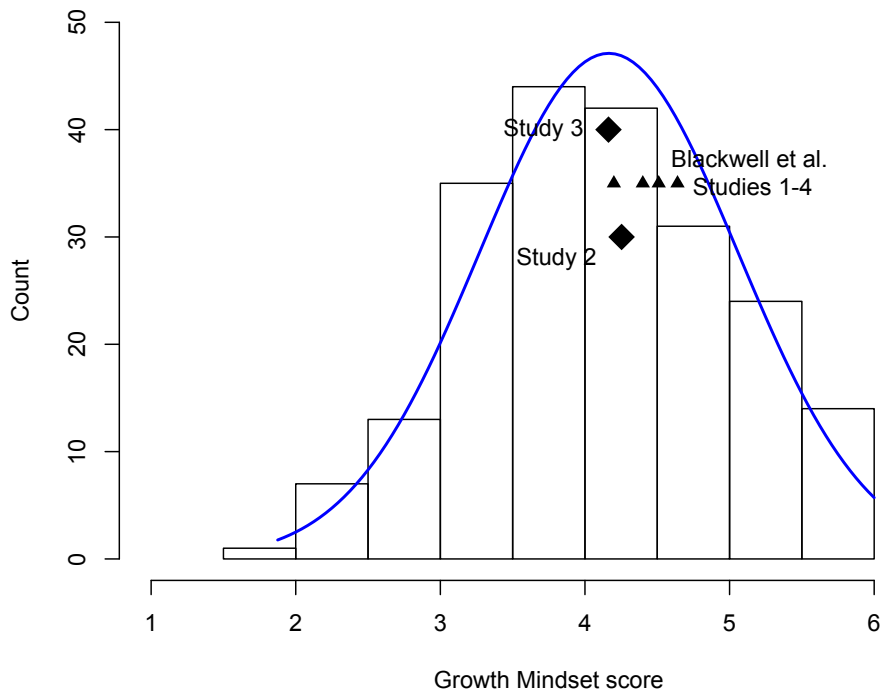

Figure 4: Mindset scores for all children in studies 2 and 3, together with a corresponding normal curve, together with plots of the mean mindset in each study reported by Blackwell et al. (2007) showing full range of scores in the present study and a small difference favouring fixed mindset in the present samples.

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Does mindset predict grades?

We used regression modelling to test for a positive association of school grades with growth mindset, controlling for age, sex and scores on the challenge test (Ravens E).

In the class recruited for Study 2, mindset was unrelated to GPA in either semester 1 or 2 (β = -0.01 [-0.14, 0.11], t = -0.22, p = 0.829; β = 0.03 [-0.12, 0.18], t = 0.35, p = 0.723 respectively). By contrast, ability (Set E SPM scores) was a highly significant predictor of GPA in both semesters (Semester 1 β = 0.34 [0.22, 0.47], t = 5.38, p < 0.001; semester 2 β = 0.25 [0.1, 0.4], t = 3.22, p = 0.002). Because cognitive ability is itself predicted to be impacted strongly by mindset (Dweck, 2006), potentially masking a mindset effect on GPA, we removed this control variable from the model. Mindset remained a non-significant predictor, with no effect on either initial or final GPA (β = 0.03 [-0.11, 0.16], t = 0.39, p = 0.700 and β = 0.05 [-0.11, 0.2], t = 0.61, p = 0.540 respectively). Models of change in each subject on their own (instead of averaged as GPA), also yielded only null effects of mindset on attainment (p values .692 for English, .812 for Chinese, and .855 for mathematics).

Similar null results obtained in the children tested in study 3. As in study 2, regression models predicting GPA from mindset, controlling for age, sex, and ability scores showed mindset was unrelated to GPA in either the first (β = 0.03 [-0.09, 0.16], t = 0.52, p = 0.606) or the second semester (β = 0.05 [-0.07, 0.18], t = 0.86, p = 0.391).

Once again, and further validating the importance of cognitive ability for school attainment, scores on the Raven Set E was a very strong predictor of GPA in both semesters (e.g., β = 0.32 [0.19, 0.45], t = 4.97, p < 0.001 in semester 1). Therefore, again as in handling the study 2 data, we examined the effect of mindset with ability removed from the model to unmask any suppression effect: Mindset still failed to predict either initial or final GPA: β = 0.04 [-0.09, 0.18], t = 0.65, p = 0.516; β = 0.08 [-0.06, 0.21], t = 1.13, p = 0.262 respectively. In models substituting single school subjects for GPA, mindset was unrelated to attainment (p-values 0.748, 0.607, and 0.630 for English, Chinese, and mathematics respectively). In addition, a cognitive ability × mindset interaction (testing the hypothesis that growth mindset would translate IQ into greater GPA outcomes in children with lower ability scores), was non-significant for GPA in

semester 1 (β = -0.08 [-0.21, 0.06], t = -1.12, p = 0.266) and 2 (β = -0.01 [-0.14, 0.12], t = -0.13, p = 0.898).

Does mindset enhance learning across time, at least following initial poor attainment?

We next tested the prediction (Paunesku et al., 2015) that attainment growth (final GPA, controlling for initial GPA) would be associated with mindset, either as a main effect, or as an interaction, with only children gaining lower scores in semester 1 showing any benefit of mindset (i.e., a significant GPA1 × mindset interaction). This was tested in a regression predicting GPA2 from mindset and GPA1 × mindset (controlling for age and sex).

For children in study 2, neither hypothesis was supported: There was no significant effect of mindset on GPA change across the year (β = 0.03 [-0.06, 0.12], t = 0.65, p = 0.514). In addition, there was no special impact of mindset at low levels of initial GPA (gpa1 × mindset interaction β = -0.07 [-0.20, 0.06], t = -1.09, p = 0.276). GPA2 was, however, strongly linked to GPA1 (β = 0.9 [0.80, 0.99], t = 18.74, p < 0.001). In the study 3 children, once more, neither hypothesis was supported. There was no main effect of mindset on GPA change across the year (β = 0.04 [-0.03, 0.12], t = 1.21, p = 0.228) and no initial GPA × mindset interaction (β = -0.05 [-0.13, 0.03], t = -1.2, p = 0.230).

Might mindset have highly restricted across-time effects, specific to single school subjects?

We next examined the possibility that mindset may have a highly-specific effect, interacting on a course-by-course basis with low semester-1 grades such that while, in most students, mindset would be unrelated to grades, for the lowest-performing students in each subject, growth-mindset 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 n study 2, this predicted interaction failed to emerge. In all cases these subject × mindset interaction effects were non-significant (β = 0.01 [-0.08, 0.1], t = 0.27, p = 0.790); β = 0.02 [-0.09, 0.14], t = 0.43, p = 0.671; β = 0.06 [-0.06, 0.19], t = 1.01, p = 0.315 for Chinese, English, and mathematics, respectively). Similarly, for the children in study 3, course-by-course tests for initial-grade × mindset effects on final grades also were not supported for any subject: β = 0.03 [-0.06, 0.13], t = 0.69, p = 0.489; β = 0.03 [-0.05, 0.1], t = 0.68, p = 0.500; β = 0.06 [-0.03, 0.15], t = 1.25, p = 0.212 for Chinese, mathematics, and English respectively.

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Does mindset predict baseline reasoning ability?

Mindset is predicted to be the major mechanism by which differences in ability and grades are created (Dweck, 2006). It is therefore critical that students' mindsets are associated with their cognitive ability. While the presence of an association would be ambiguous (higher ability might cause a feeling that growth is possible), a null or negative correlation can falsify the theory. This hypothesis was tested in regressions, controlling for age and sex. Children's mindsets were not significant predictors of ability as measured by either the easier ($\beta = 0.12$ [-0.02, 0.25], t = 1.73, p = 0.085) or more difficult ($\beta = 0.12$ [-0.01, 0.25], t = 1.75, p = 0.082) baseline tests. Similar results were obtained for the children in study 3. The hypothesised effect of mindset on IQ development failed to emerge in regression models with ability as a DV (either the easy or more difficult test) and mindset as a predictor, controlling for age and sex. Replicating the null effect in study 2, children's own mindsets were unrelated to scores on either the difficult ($\beta = 0.06$ [-0.08, 0.2], t = 0.88, p = 0.381) or easier ($\beta = 0.11$ [-0.03, 0.25], t = 1.61, p = 0.110) cognitive tests.

Discussion of study 4

We found no evidence for growth mindset promoting higher grades: Even in the lowest-performing children, children's own growth-mindset failed to trigger the predicted improvements over the year. While mindset was predicted to have a main effect, with growth mindset increasing developed intellectual ability and school grades, we found no empirical support for these main effects, nor any effects at the level of individual subjects. In particular, we were surprised to find no association of mindset with cognitive ability scores, as these are highly stable (Deary, 2012) and should reflect the chronic developmental influence of children's own mindsets (Dweck, 2006).

We also expected to find mindset effects on performance in children who were struggling at the beginning of semester (Paunesku et al., 2015), with mindset predicted to be associated with relative improvements in grades across the year, focussed on children with low initial grades (Blackwell et al., 2007). These predicted links with grade-trajectories across the school year did not, however, emerge in either dataset set. To interpret the full set of findings in an integrated fashion, we next collect these findings in a brief general discussion.

General Discussion

Mindset was predicted to be a major influence determining not only student learning, but also ability and, in randomized experimental manipulations, children's response to negative feedback. Mindsets and mindset-intervention effects on both grades and ability, however, were null, or even reversed from the theorised direction. In study 2, we found one nominally significant effect of mindset on post-challenge cognitive ability, but in the opposite direction to that predicted. Other effects, bar one, were non-significant. This single significant effect of the mindset intervention in study 3 appeared only on easier material, and contrary to prediction, in this case the active-control subjects, primed for fixed mindset, but also primed for hard work scored best. This contradicts the idea that beliefs about ability being fixed are harmful. At best, it supports a role of effort on easy tasks, predicted by both personality (Roberts et al., 2007) and motivation theory (Locke & Latham, 2002).

Limitations?

How do we account for our results? Differing ethnicity is unlikely to account for the difference as seminal papers such as Hong, Chiu, Dweck, and Sacks (1997) have used Chinese subjects, and this continues in current, complex mediational reports (Zeng, Hou, & Peng, 2016). Moreover, ethnic differences have previously been reported as being unrelated to mindset effects in the original mindset studies (Mueller & Dweck, 1998). Critically, effects of mindset are not couched in terms of ethnicity but in terms of universal developmental processes linking implicit theories to realised cognitive and educational attainment, and we are unaware of ethnicity ever being proposed in print as a theoretically motivated moderator.

A reviewer at another journal hypothesised that our Chinese subjects were too wealthy, and/or already had strongly growth-oriented mindsets due to their collectivist culture. They argued, moreover that these advantages were what accounted for higher scholastic scores in China in samples such as PISA. In fact, subjects were not clustered around a high-growth orientation, and as shown in Figure 4 displayed a full range of mindset, normally-distributed, and with an average in keeping with previous reports. As noted in the subject description in Study 1, our subjects are not wealthy and, in fact, are significantly impoverished, even relative to the Chinese median income.

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Our samples, then, appear ideal for revealing mindset effects if they were present: Our subjects 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 have a range of attainment, allowing us to examine effects restricted to children with initial low scores. Rather than being uniformly growth-oriented, the sample was showed a full normal range of mindsets, and was slightly more fixed-minded by default. This, again, should have increased our power to create group-differences in the intervention studies, and the wide variation in mindset should have revealed similarly large effects of mindset on response to challenge and in educational attainment. The failure to show significant growth vs versus active-control intervention effects or real-life effects, then, is strong evidence against beliefs about whether IQ can be markedly changed as relevant for cognitive performance or development.

We conclude that our findings across three substantial studies with active-controls as well as real-life outcomes across time support the null: that implicit mindsets about the nature of intelligence are unrelated to attainment.

Future directions

As the purpose of mindset interventions in school is to impact how children are taught (Paunesku et al., 2015), given these null outcomes, additional studies testing replicability 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), and peace, along with personal relationships, business and sporting success (Dweck, 2006). Future work on praise should remove the confound of implicit theory with reinforcing hard work and conscientiousness – which is a known cause of higher attainment. Finally, given widespread and costly policy and real-world educational implications, we encourage an emptying of the file drawer to account for non-reported null 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

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require prosaic teaching practices such as working on practice and feedback via appropriate testing (Lindsey, Shroyer, Pashler, & Mozer, 2014).

Context paragraph

Our research has focused on cognitive ability, typically in genetically informative samples, able to identify both genetic, family level, and unique environmental influences on development, along with moderation of heritability, for instance by parental social status. Alongside this, we have worked on positive psychology traits, such as optimism, which promote positive development and resilience. We were therefore very interested in models of intellectual development such as mindset theory, based on interventions targeting potentially highly modifiable substrates, and strongly impacting cognitive ability and educational attainment. We were both excited to explore this area, and cognizant of the great value that replication and use of innovations such as active controls and multiple measures and outcomes, and open data can bring to social science. Users of the data we have collected, we hope, will include not only cognitive psychologists and individual differences researchers, but developmental psychologists, education researchers. In terms of ongoing research, we hope others will include active-control conditions to test for effects of fixed-ability beliefs independent of motivation. The lack of association of performance with mindset for educational and response to challenge outcomes mindset reinforces the value of replication adequate controls.

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. (2014). umx: A package for SEM in R (Version.9) [R package]. Edinburgh, UK: github.com.

Bates, T. C., Neale, M. C., & Maes, H. H. (2017). umx: A library for Structural Equation and Twin Modelling in R. *Journal of Statistical Software*.

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.

Claro, S., Paunesku, D., & Dweck, C. S. (2016). Growth mindset tempers the effects of poverty on academic achievement. *Proc Natl Acad Sci U S A, 113*(31), 8664-8668.

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

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., & 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. *Psychol Sci, 25*(3), 736-744.

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *J Pers Soc Psychol, 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 Dev, 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. *Proc Natl Acad Sci U S A, 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. *Psychol Sci, 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.

Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., et al. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences of the United States of America, 108*(7), 2693-2698.

Mueller, C. M., & Dweck, C. S. (1998). Praise for intelligence can undermine children's motivation and performance. *J Pers Soc Psychol, 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

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. (2016). R: A language and environment for statistical computing (Version 3.3.0). 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. *Perspect Psychol Sci, 10*(6), 721-726.

Raven, J., Raven, J. C., & Court, J. H. (2000). *Raven manual: Sstandard 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? *Dev Psychol, 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.

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. *Front Psychol, 7*, 1873.