Expanding minds: Growth mindsets of self-regulation and the influences on effort and perseverance☆

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ABSTRACT

Given that countless studies have documented the wide-ranging benefits of self-regulation, determining if and how self-regulation can be improved is an important scientific and societal priority. Existing theories suggest that the deterioration of self-regulation is partially shaped by perceptions of effort. Therefore, one promising way to sustain self-regulation may be to cultivate a growth mindset, which has been shown to affect behavior in part by altering effort attributions. Although growth mindsets—the belief that a given trait can be improved through practice—have been studied extensively, particularly in the domain of intelligence, little research has examined the effects of promoting a growth mindset specifically about self-regulation. Here five studies test how promoting a growth mindset of self-regulation impacts actual self-regulation in daily life and the laboratory. In Study 1, relative to an active control that received relationship training, an intensive self-regulation training program emphasizing a growth mindset led participants to persevere longer on impossible anagrams, which was partially mediated by altering attributions of mental fatigue. Relatively, the self-regulation training also led participants to notice more opportunities for self-control in daily life and more successfully resist everyday temptations. The subsequent four studies isolated and abbreviated the growth mindset manipulation, demonstrated improved persistence and decreased effort avoidance, and attempted to further examine the critical mediators. Collectively, results indicate that a growth mindset of self-regulation can change attributions and allocation of effort in meaningful ways that may affect the willingness to attempt challenging tasks and the perseverance required to complete them.

Extensive research indicates that self-regulation—the ability to direct one's attention, thoughts, moods, and behavior in line with one's personal goals— is among the most critical skills in life. High levels of self-regulation predict better academic achievement, greater professional success and income, stronger interpersonal relationships, more fulfillment, and better health (Baumeister, Heatherton, & Tice, 1994; Duckworth, 2011; Duckworth & Seligman, 2005; Mischel, Shoda, & Peake, 1988; Moffitt et al., 2011; Ridder, Ouwehand, Stok, & Aarts, 2011; Ryan & Deci, 2000; Shoda, Mischel, & Peake, 1990). Given that self-regulation underlies such a diversity of highly valued outcomes, it would be of great value to identify successful interventions that can allow individuals to effectively develop and exert such control.

An emerging consensus is forming that one powerful determinant of self-regulation is how an individual *experiences and interprets effort*

(Brehm & Self, 1989; Brehm, Wright, Solomon, Silka, & Greenberg, 1983; Eisenberger, 1992; Hockey, 2011; Inzlicht, Schmeichel, & Macrae, 2014; Kurzban, Duckworth, Kable, & Myers, 2013; Molden, Hui, & Scholer, 2016). Recent theories suggest that negative interpretations of accumulated effort can shift motivational priorities and lead individuals to withdraw effort even at the risk of self-regulatory failure (Boksem & Tops, 2008; Hockey, 2011; Robert & Hockey, 1997). As an illustration, one primary reason why autonomously chosen goals are often achieved appears to be because individuals interpret the exertion of effort toward those goals as natural and "having a sense of ease" (Deci & Ryan, 2012; Werner, Milyavskaya, Foxen-Craft, & Koestner, 2016).

Collectively, this research suggests that a promising approach for enhancing self-regulation might be to alter how effort is interpreted. We

hypothesize that altering growth mindsets—in which people view their traits and abilities as malleable and capable of development rather than as stable and fixed—may serve as a promising approach for altering perceptions of effort and enhancing self-regulation. If mindsets of self-regulation can alter the meaning people attribute to experiences of effort, then perhaps cultivating a growth mindset of self-regulation can prevent the withdrawal of effort that so often leads to self-regulatory failure.

1. Effort in self-regulatory pursuits

Despite the benefits of exerting cognitive effort, people typically avoid effort when it is not absolutely necessary. This tendency has been termed the "law of least mental effort" (Balle, 2002) and has a long history in a variety of characterizations of humans as "lazy organisms" (McGuire, 1969) and "cognitive misers" (Taylor, 1981) dominated by a "drive for cognitive economy" (Baroody & Ginsburg, 1986). An example of direct empirical support for the law of least mental effort comes from Kool, McGuire, Rosen, and Botvinick (2010). Their paradigm, the demand selection task (DST), allows participants to repeatedly choose to complete one of two different subtraction problems, one of which imposes a greater demand on working memory capacity because it requires a carrying operation (Fürst & Hitch, 2000). Kool and colleagues showed that whether or not participants consciously noticed the difference in difficulty between the problems, they chose the easy problems at a rate significantly higher than chance, demonstrating an overall tendency to avoid effort (see also Kool & Botvinick, 2013).

Research has recently begun to illustrate the importance of *responses to effort* in people's self-regulatory pursuits. For example, people show reduced self-regulation on tasks where they perceive that such regulation produces increased experiences of effort, even when these experiences are manipulated independent of the task itself (Clarkson, Hirt, Austin Chapman, & Jia, 2011; Clarkson, Hirt, Jia, & Alexander, 2010), occur outside of conscious awareness, (Bijleveld, Custers, & Aarts, 2012; Marien, Custers, Hassin, & Aarts, 2012), or are merely imagined as occurring in the near future (Macrae et al., 2014). In addition, people are more likely to sustain self-regulation when these experiences of effort are either ameliorated or reinterpreted. That is, circumstances that enhance relaxation or boost tolerance for effort before or during goal pursuit—such as watching a humorous video clip or favorite television program (Derrick, 2013; Tice, Baumeister, Shmueli Blumberg, & Muraven, 2012), or meditating (Friese, Messner, & Schaffner, 2012), to name just a few examples—can also bolster self-regulation. Similarly, if people misattribute their experiences of effort during goal-pursuit to sources unrelated to this pursuit (Clarkson et al., 2010), reconstrue this effort as enjoyable (Laran & Janiszewski, 2011), or simply do not believe that these experiences are related to any limits in their capacity for self-regulation (Job, Dweck, & Walton, 2010; Job, Walton, Bernecker, & Dweck, 2015), this too bolsters such regulation. In sum, a growing number of empirical findings are demonstrating the importance of experiences of effort for self-regulation.

In addition, experiences of effort have also begun to take a focal role in recent attempts to understand the processes of self-regulation success and failure. For example, the *shifting priorities* model of self-regulation (Inzlicht et al., 2014) proposes that the aversiveness and decreased value people perceive in experiences of effort directly motivates them to cease self-regulation and focus on less effortful pursuits that are more immediately rewarding or pleasurable. Furthermore, the *opportunity costs* model of self-regulation (Kurzban et al., 2013) proposes that people use their experiences of effort and fatigue to decide whether the costs of maintaining self-regulation toward one particular goal would too greatly interfere with benefits that might be realized by pursuing alternative goals; thus, experiences of increased effort during self-regulation toward some objective are presumed to decrease the overall perceived value of sustaining regulation and increase the likelihood it will cease (Hockey, 2011). Similarly, the *motivated effort-allocation*

model of self-regulation (Molden et al., 2016) proposes that people weigh their experiences of effort against their experiences of progress when self-regulating toward a particular goal to determine whether they still feel it is currently worth dedicating their efforts toward this goal; as experiences of effort increase without sufficient increases in perceived progress the judged worth of self-regulation, and its likelihood of continuing, is presumed to diminish.

In short, on the whole, there appears to be a growing theoretical consensus for the central importance of experiences of effort for determining continued self-regulation and an increasing number of empirical demonstrations supporting this consensus. Any attempts to design an intervention to improve self-regulation would thus likely be well-served by focusing on methods for reliably altering people's experiences of effort in a way that could help them sustain such regulation. The primary objective of the present research is to develop one such method that draws upon the decades of experimental and longitudinal research suggesting that instilling a *growth mindset* could have just such an effect on these types of experiences.

1.1. Growth mindsets

Mindsets are constellations of beliefs regarding the fixedness or malleability of personal qualities, such as intelligence or extraversion. Some people believe a particular quality is an immutable trait ("you've got what you've got") while others believe it is a malleable trait that can be cultivated through learning. Although fixed and growth mindsets tend to reflect fairly stable beliefs (Robins & Pals, 2002), they can also be situationally induced. For example, previous research has manipulated mindsets in a wide variety of domains across physical, intellectual, managerial, and personality dimensions (Aronson, Fried, & Good, 2002; Martocchio, 1994; Yeager et al., 2016; Jourden, Bandura, & Banfield, 1991; Mukhopadhyay & Johar, 2005; Burnette, Pollack, & Hoyt, 2010; Wood & Bandura, 1989; Paunesku et al., 2015; for a review see Dweck & Molden, 2005). These manipulations have ranged from brief inductions in the laboratory (e.g., Miele & Molden, 2010; Niiya, Crocker, & Bartmess, 2005; Nussbaum & Dweck, 2008), to targeted training programs (Paunesku et al., 2015; Yeager et al., 2014; Aronson et al., 2002), and even intensive multi-week interventions (e.g. Blackwell, Trzesniewski, & Dweck, 2007).

Altering mindsets, either through brief manipulations or intensive interventions, holds the potential for dramatic shifts in cognition, affect, and behavior. Considerable evidence from meta-analyses (Burnette, O'Boyle, VanEpps, Pollack, & Finkel, 2013) suggests that fixed and growth mindsets are each associated with a unique constellation of motivations, attributions, and response patterns that primarily arise in the face of challenge (for a review see Dweck & Molden, 2005). There are two well-established features of a growth mindset that are particularly relevant to the present research: attributions of effort and exertion of effort.

First, growth mindsets are associated with perceiving effort as useful rather than futile (Hong, Chiu, Dweck, Lin, & Wan, 1999; Miele, Finn, & Molden, 2011; Miele & Molden, 2010). This has been largely shown in the domain of intelligence. For example, in studies examining the effect of mindsets on individuals' judgments of their own learning, those with a growth mindset of intelligence interpreted high levels of effort as an indication that they were working hard to improve their ability to remember the information (Miele et al., 2011; Miele & Molden, 2010). In contrast, those with a fixed mindset of intelligence interpreted effort as an indication that they were reaching the limits of their ability to remember new information. Similarly, in an assessment and intervention conducted in a middle school math course, students with a growth mindset were more likely to believe that experiences of working hard are related to improvement, which in turn predicted higher math achievement (Blackwell et al., 2007). That is, students with a growth mindset endorsed statements like "The harder you work at something the better you'll be at it", whereas students with a fixed mindset

endorsed statements like "When I work hard at my schoolwork it makes me feel like I'm not very smart", and this endorsement predicted improved math grades throughout middle school. In sum, mindsets can distinctly shape the appraisals people make of effort and often lead an individual to believe they are either developing or hitting the limits of their capacity.

The second promising feature of a growth mindset is that in addition to influencing the appraisals of effort, it can also influence one's willingness to exert effort. Substantial evidence suggests that a growth mindset tends to lead to increased effort—rather than the withdrawal of effort—in the face of setbacks (Henderson & Dweck, 1990; Hong et al., 1999; Robins & Pals, 2002). For example, in one set of studies examining mindset and attributions of effort, correlational and causal evidence suggested that individuals with a growth mindset of intelligence were more likely to attribute their failure to a lack of effort rather than a lack of ability (Hong et al., 1999). This attribution explained why those with a growth mindset were more likely to opt in for extra training after receiving feedback of the failure. In a separate study tracking undergraduates throughout college, students with a growth mindset of intelligence responded to setbacks by escalating their effort while those with a fixed mindset de-escalated their effort (Robins & Pals, 2002). These types of isolated findings were confirmed by a large-scale meta-analysis of over 100 studies spanning multiple achievement domains, which showed that growth mindsets produce *mastery-oriented* attributions that lead to sustained effort, particularly following challenges and the threat of failure (Burnette et al., 2013).

1.2. Developing a growth mindset of self-regulation

Cumulatively, this research suggests that growth mindsets may be a promising tool for enhancing self-regulation, particularly in contexts that require sustained effort. However, surprisingly little research has examined the effect of promoting growth mindsets specifically about one's ability to exert self-regulation. Although there are certainly areas where a growth mindset of intelligence and a growth mindset of self-regulation may overlap (e.g. completing one's math homework), there are countless areas that are relevant to self-regulation but not intelligence (e.g. maintaining a healthy diet, reducing impulse spending, staying faithful to one's partner, sticking with a New Year's Resolution). Believing that your intelligence can improve with effort would likely not influence your dedication to running a faster mile; however, believing that your self-regulation could improve with practice just might. Unlike a growth mindset of intelligence, a growth mindset of self-regulation may inspire individuals to appraise effortful self-control as a useful process for developing their underlying ability to persevere. Given that self-regulation underlies such a variety of cherished goals, it could be of great value to examine a mindset intervention that directly targeted individuals' beliefs about their ability to develop and exert such self-regulatory control. We propose that individuals' mindsets regarding their ability to exert self-regulation—as an ability that is either fixed or malleable with practice—may play an important role in the success or failure of their self-regulation attempts.

Although they may at times have similar effects, it is important at the outset to distinguish a growth mindset of self-regulation as described in the present research from a non-limited theory of willpower (Job et al., 2010a). A non-limited theory of willpower involves the belief that exerting self-regulation is self-sustaining rather than depleting, and thus also may have implications for how people interpret and respond to experiences of effort, as multiple studies have demonstrated (see Job et al., 2010; Job, Bernecker, Miketta, & Friese, 2015; Job, Walton, et al., 2015; Job, Walton, Bernecker, & Dweck, 2013; Martijn, Tenbült, Merckelbach, Dreezens, & de Vries, 2002). However, this theory does not revolve around beliefs about whether the capacity for self-regulation can grow over time with effort. That is, a non-limited theory of willpower concerns whether self-regulation produces feelings of "momentum" that facilitate goal-pursuit once it has begun. In

contrast, a growth mindset focuses on the malleability and expansion of overall abilities for self-regulation as a function of practice and effort over time. Therefore, a non-limited theory of willpower operates on a shorter timescale than a growth mindset, and a growth mindset places a stronger emphasis on the value—and necessity—of effort for achieving growth. In the present research, we focused solely on the implications of cultivating and manipulating people's growth mindsets independent of their non-limited theories of willpower, but we further consider the potential relationship and interaction between the two in the General Discussion.

In summary, we suggest that inducing a growth mindset of self-regulation may change the way individuals perceive and allocate effort, facilitating perseverance and continued engagement with valued goals. As mentioned, an emerging consensus is forming that the experience of effort plays a key role in the waning of continued goal pursuit over time (Hockey, 2011; Inzlicht et al., 2014; Kurzban et al., 2013; Molden et al., 2016). We suggest that the meaning that individuals attribute to effort may shape whether that sensation signals an individual to continue or discontinue pursuing the task at hand. This notion is supported by metacognitive accounts of effort that suggest that sometimes the *perception* of difficulty and necessary effort can play a more influential role in behavior than actual difficulty and necessary effort (Dunn et al., 2010; Marcora, Staiano, & Manning, 2009; Miele et al., 2011; Miele & Molden, 2010; Werner et al., 2016).

1.3. Overview of experiments

Across five studies, the present research examined the impact of a growth mindset of self-regulation on actual self-regulation. Study 1 tested whether an intensive intervention—designed to promote a growth mindset of self-regulation and teach empirically supported goal-pursuit strategies—would lead to: (a) mastery-oriented beliefs regarding self-control, including a growth mindset and positive appraisals of fatigue, as well as (b) improved self-regulatory behavior with regards to persistence, inhibition, and self-control in daily life. This intervention was multifaceted and had the primary goal of measuring if—and to what extent—it was possible to significantly improve individuals' mindsets and behavior regarding self-regulation. Building upon the foundation of Study 1, Studies 2–5 then investigated the potential effects of a growth mindset of self-regulation more precisely as well as the possible mediating role of appraising fatigue as something beneficial rather than taxing. Study 2 investigated whether a brief manipulation of self-regulation mindsets would reveal analogous results to the multifaceted intervention from Study 1 with regard to persistence and appraisal of fatigue. Study 3 examined whether this growth mindset effect would extend beyond persistence to attention regulation. Study 4 investigated whether the growth mindset would reduce the natural tendency for effort avoidance compared to not only a fixed mindset but also a neutral condition. Study 5 sought to replicate the results from Study 4 and explore whether changes in appraisal of fatigue underlie changes in effort aversion. Collectively, these studies explored how a growth mindset of self-regulation affects attributions and allocation of effort in various self-regulatory domains.

2. Study 1

2.1. Participants

87 volunteers (52 female) from a Midwestern university and local community participated in a quasi-randomized active controlled intervention in exchange for $90 (mean age = 23.2, range = 18–45). For this and all subsequent studies, data from the full sample was collected before any analysis began.

2.2. Procedure

The study was described as an investigation of personal development and well-being in which participants would take a six-week course on either self-regulation or relationships. Quasi-random assignment was used to assign eligible participants into the two conditions of the study. Without knowing which condition would be presented when, participants noted their availability and were assigned to the condition that was most feasible with their schedule while balancing across conditions for age, GPA, and gender. Both the treatment condition (self-regulation training) and the active control (relationships training) consisted of 12 ninety-minute sessions administered twice a week for six weeks. To ensure that the class size was small enough for active participation and personal feedback from the instructors, each condition of the intervention was divided into three classes consisting of roughly 12 participants. Workshops in both conditions were held in the same classroom on campus and taught by the same instructors. The two conditions were designed to be nearly identical in structure (e.g. time of day, time spent with instructors, sense of community with other participants, opportunity to share ideas and frustrations) but divergent in content.

During the first day of the self-regulation training, the topic of growth mindsets was taught using a mix of slides, descriptions of scientific studies, and discussion about how to develop a growth mindset of self-regulation. The growth mindset topic was reiterated at all of the remaining self-regulation workshops. Participants in this condition also learned concrete strategies relevant to executing self-regulation, all of which were derived from the empirical literature on self-regulation. For instance, participants were taught: (a) ways of reinterpreting their setbacks and failures through cognitive reappraisal (McRae, Ciesielski, & Gross, 2012), (b) motivational strategies such as evaluative conditioning to mentally link goal pursuit with desired affective experiences (De Houwer, Thomas, & Baeyens, 2001; Levey & Martin, 1975), and, (c) approaches to automatize behavior such as implementation intentions (Gollwitzer, 1999).

In the relationship training condition, participants learned about concrete strategies to improve their communication, broaden their social network, and deepen existing relationships, all of which were also evidence-based. For instance, participants were taught: (a) capitalization strategies to celebrate the joys of those around them (Gable & Reis, 2010), (b) self-expansion strategies through shared experiences with others (Aron, Aron, & Norman, 2003), and (c) how to deepen their existing relationships through empathy and vulnerability (Batson et al., 1991; Brown, 2013). Meticulously designing a well-matched relationship curriculum was a conservative choice for a control group, because it involved an active intervention designed to be beneficial across many criteria of participants' daily lives. This approach, in contrast to using a "life as usual" control, helps mitigate therapeutic alliance effects, exposure effects, and expectancy effects (Boot, Simons, Stothart, & Stutts, 2013). An overview of each curriculum is included in Supplemental Materials.

Before and after the intervention, participants completed a series of measures assessing their self-regulation and interpersonal relationships. Measures pertinent to this report include: (a) self-report questions assessing growth mindset and beliefs about mental fatigue, (b) persistence as measured by time dedicated to an impossible anagram task, (c) inhibition as measured by an anti-saccade task, as well as (d) self-control experiences in daily life as measured by experience sampling methods. All additional measures are listed in Supplemental Materials.

2.3. Materials

2.3.1. Evaluation of instructors/intervention quality

Because the instructors knew about the study hypotheses, it was crucial to measure participants' experiences in the study to examine whether there may have been systematic differences in treatment (e.g. the instructors were particularly helpful to the participants in the experimental condition). Risks of experimental demand may be especially high if the instructors gave different levels of helpfulness and expressed expectations across the two conditions. To assess whether participants across the two conditions had similar or divergent experiences during the training, the following measures were included at post-testing: (a) overall impressions of the instructor, (b) perceptions of the instructors' effectiveness, and (c) the quality of the curriculum used in the intervention. In total, 22 items were asked (e.g. *The instructors were friendly; I found the program valuable*) on a 1(*strongly disagree)* to 7(*strongly agree*) scale.

2.3.2. Manipulation check

Participants completed an adapted version of the eight-item scale on lay theories of intelligence (Dweck, 1999). Participants saw the same questions as the original version but with the words "self-regulation" and "self-control" instead of "intelligence". Sample items include, "Your self-regulation is something about you that you can't change very much" and "You have a certain amount of self-control, and you can't really do much to change it". Participants rated their agreement with each item on a 1(*strongly disagree)* to 6(*strongly agree*) scale. The items were averaged to create an index of lay theories of self-regulation ($\alpha = 0.91$ at pre-testing; $\alpha = 0.94$ at post-testing). Higher scores reflect a stronger growth mindset and beliefs that self-regulation is malleable and can be developed.

2.3.3. Attributions of fatigue

At both testing sessions, participants completed four questions regarding their beliefs about mental fatigue (Chronbach's alpha of $\alpha = 0.85$). We opted to use the word "fatigue" as we thought it would be intuitive to participants, and it aligns with the widely accepted definition of fatigue as, "the feeling that people may experience after or during prolonged periods of cognitive activity. These feelings […] generally involve tiredness or even exhaustion, an aversion to continue with the present activity, and a decrease in the level of commitment to the task at hand" (Boksem & Tops, 2008; Robert & Hockey, 1997). Items were designed for a non-scientific audience that may not be familiar with the term "self-regulation", therefore we opted to frame the items with regard to "mental control" skills. The specific items were: *Feelings of mental fatigue are a sign that I'm expanding the limits of my mental control; Feelings of mental fatigue are a sign that I'm developing my mental control skills; Feelings of mental fatigue are a sign that I should scale back my effort so I don't get too exhausted* (reverse scored)*; and Feelings of mental fatigue are a sign that I'm reaching the limits of my mental capacity* (reverse scored). Participants responded using a 1(*strongly disagree)* to 7(*strongly agree*) scale. Higher scores reflect greater endorsement of mental fatigue being a sign of developing one's capacity for self-regulation.

2.3.4. Persistence

In the impossible anagram task, participants unscrambled strings of five letters to form English words (Baumeister, Bratslavsky, Muraven, & Tice, 1998). Participants were given unlimited time to try to solve ten anagrams. Three of the anagrams, unbeknownst to the participants, were impossible to solve at the post-testing session (e.g. RODNI). In efforts to prevent suspicion of the impossibility of the task, only one impossible item was provided at pre-testing. Possible items at pre-testing and post-testing were matched for difficulty. Persistence was measured as the average time spent on the impossible items.

2.3.5. Inhibition

The anti-saccade task is a widely-used measure of inhibition that requires individuals to inhibit eye movements to a salient distractor and to look in the opposite direction for a target stimulus (Reineberg, Andrews-Hanna, Depue, Friedman, & Banich, 2015). Participants were instructed to focus on a fixation cross (lasting 1.5–3.5 s) in the center of the computer screen. When this cross disappeared, a distractor cue—a

small, black square—flashed 10 cm either to the right or to the left of the cross. The distractor disappeared after a fixed interval (233 ms for easy, 200 ms for moderate, or 183 ms for difficult trials), after which a target digit (1 through 9) appeared for 150 ms on the opposite side on the screen before being masked with gray cross-hatching. Participants' primary task was to identify the target digit (time-sensitive) and type their response (not time-sensitive). Looking toward the distractor is costly to performance, because there is insufficient time to revert one's gaze toward the other side of the screen to identify the target digit. Successfully inhibiting the initial eye movement toward the distractor therefore allows participants to shift their gaze in time to identify the target digit. After 18 practice trials, participants completed three blocks each with 36 anti-saccade trials. Inhibition was operationalized as the average accuracy across the three blocks of anti-saccade trials regardless of trial difficulty (Reineberg et al., 2015).

2.3.6. Experience sampling

To assess daily self-regulation, we utilized a mobile app called MetricWire to collect experience sampling method (ESM) data during the week of pre-testing, the fourth week of the intervention, and the week of post-testing. During each of these weeks, participants received alerts five times per day Monday through Friday between 10 am and 8 pm. Following best practices in ESM delivery, one alert was sent randomly within each of five time windows: 10:00–11:30, 12:30–1:30, 2:30–3:30, 4:30–5:30, and 6:30–7:30 (Hektner, Schmidt, & Csikszentmihalyi, 2006). Each survey stayed active for 25 min. If the survey was not completed after 20 min, a reminder alert was sent. If no response was provided within the 25-min window, then no data were recorded.

Adapted from Hofmann's procedures, each ESM survey included the following seven questions on self-control (Hofmann, Baumeister, Förster, & Vohs, 2012): (1) Within the last 30 min, did you at any point feel like you needed to exert some kind of self-control? [*yes/no*], (2) If yes, how strong was the desire or impulse that provoked the need for self-control? [on a scale from 1 (*I hardly felt it at all*) to 10 (*it was irresistible*)], (3) How motivated were you to control the desire or impulse? [on a scale from 1 (*not at all motivated*) to 10 (*extremely motivated*)], (4) How effortful did you expect it would be to control the desire or impulse? [on a scale from 1 (*not at all effortful*) to 10 (*extremely effortful*)], (5) Did you attempt to control the desire or impulse? [*yes/no*], (6) Did you successfully control the desire or impulse? [*yes/no*], and (7) If yes, how much effort did it actually take to control the desire or impulse? [on a scale from 1 (*none*) to 10 (*very much*)]. To avoid the impression that the study was primarily about self-regulation as opposed to relationships or well-being more broadly, seven additional questions were included (see the Supplemental Materials); however, for the purposes of this report, only the questions pertaining to self-control are reported.

Five different surveys were created that varied the presentation order of the questions using Latin squares counterbalancing. However, questions with display logic were always blocked together. If a participant answered "no" to question one (needing to exert some kind of self-control), then the remainder of self-control questions were not presented.

In compliance with standard guidelines, all measures, manipulations and exclusions in the study are reported either here in the manuscript or in Supplemental Materials in both this and all subsequent studies.

2.4. Results

Two participants withdrew from the study before the intervention began, and 10 participants withdrew before completing the entire intervention. There was no difference in the withdrawal rate by condition, with six participants leaving from the self-regulation condition and six from the relationships condition. This left a total of 75

participants (46 female, mean age = 22.8, range = 18–43) with complete data for analysis. Participants attended an average of 10.6 of the 12 sessions, and attendance did not differ between the self-regulation and relationship conditions. A one-way analysis of variance (ANOVA) comparing attendance across conditions indicated that the "dosage" of treatment was similar across conditions, $F(1, 73) = 0.06$, p = 0.81. This sample of 75 participants provided a statistical power of 0.80 to detect effect sizes equivalent to d = 0.66 for mean differences between the conditions. Before testing our hypotheses, we used a series of one-way ANOVAs to check for any baseline differences between conditions on dependent measures. For the most part, the quasi random assignment was effective (all Fs < 3.2, ps > 0.08; Table 1 Supplemental Materials); however, there were two notable exceptions. Compared to those in the relationship training condition, participants in the self-regulation training condition reported feeling more motivated to reach their long-term goals, $t = -2.97$, p = 0.004, and across the 2930 ESM prompts responded to during baseline, they reported more positive mood, $t = -4.73$, p < 0.001. Therefore, to be conservative, all analyses controlled for these two baseline differences by including pre-test scores for these variables as covariates.[1]

2.4.1. Evaluation of instructors/intervention quality

The two conditions were well-matched with regard to participant experience; a series of one-way ANOVAs showed no differences between conditions on participants' perceptions of instructor competence, friendliness, enthusiasm for the material, the encouragement received, or the desire for the students to succeed (all F's < 1.19, p's > 0.28, Table 2 Supplemental Materials). Similarly, there were no differences between conditions on participants' perceptions of the challenge, utility, or their enjoyment of the curriculum (all F's < 0.90, p's > 0.34).

2.4.2. Manipulation check

There was no difference in participants' mindsets regarding self-regulation at baseline ($t = 0.13$, p = 0.90; Table 1 Supplemental Materials). Verifying that participants were internalizing the key growth mindset concept taught in the self-regulation condition, there was a significant main effect of condition on post-testing lay theories of self-regulation controlling for pre-testing, $F(1, 72) = 9.46$, p = 0.003, d = 0.75. As predicted, compared to those in the relationship training condition (M = 4.72, SD = 0.77), participants in the self-regulation training condition (M = 5.18, SD = 0.63) viewed self-regulation as significantly more malleable by the end of the program.

2.4.3. Persistence and appraisal of fatigue

Persistence was assessed using one-way analysis of covariance (ANCOVA) comparing time spent on the impossible anagrams at post-testing, controlling for time spent on the impossible item at pre-testing. As predicted, there was a significant main effect of condition on anagram persistence at post-testing, $F(1, 68) = 7.03$, p = 0.01, d = 0.63. Participants in the self-regulation training condition persisted significantly longer (M = 92.16 s, SD = 66.24 s) than those in the relationship training condition (M = 74.45 s, SD = 46.51 s).

Compared to those in the relationship training condition, those in the self-regulation condition were also more likely to appraise their fatigue as a signal of expansion at post-testing controlling for appraisal at pre-testing, $F(1, 72) = 12.33$, p = 0.001, d = 0.93; (Self-Regulation: M = 4.56, SD = 0.67; Relationships: M = 3.98, SD = 0.57). Furthermore, change in appraisal of fatigue from pre-testing to post-testing was correlated with change in persistence ($r = 0.37$, p = 0.002). When both mindset and change in appraisal of fatigue were

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[1] All of the effects hold when these two variables are not included as covariates. The most substantial change when removing the covariates from the analyses is that the effect of condition on post-test persistence when controlling for only pre-test persistence becomes even stronger, $F = 10.13$ p = .002.
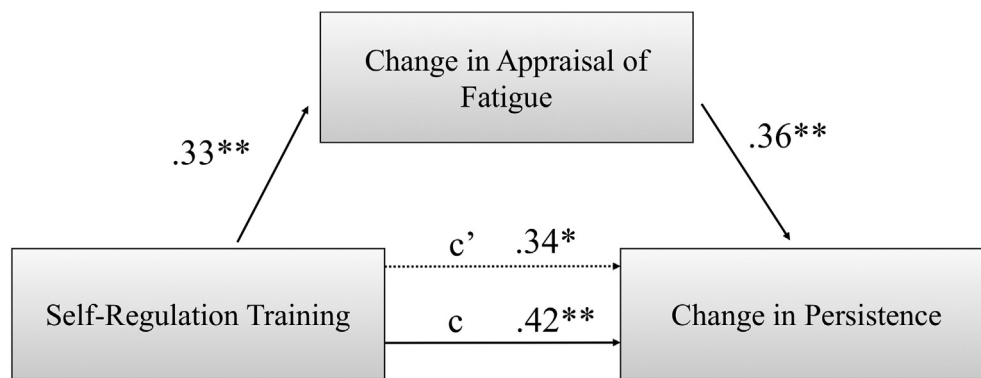
Fig. 1. Mediation model of intensive intervention.

Partial mediation on change in persistence via change in appraisal of fatigue CI: [1.81, 24.22]. Standardized betas reported. Change scores represent responses from pre-testing subtracted from the scores at post-testing. Bootstrapping with 5000 re-samples was used to calculate a 95% confidence interval around the indirect effects. * < 0.05, ** < 0.01.

simultaneously included in a regression predicting change in persistence, change in appraisal of fatigue predicted change in persistence, $B = 0.27$, $t = 2.33$, p = 0.02, as well as mindset, $B = 0.34$, $t = 2.86$, p = 0.01.

To test whether improvements in persistence were partially mediated by changes in appraisal of fatigue, we used the PROCESS macro, which utilizes an ordinary least squares analytic framework, to estimate significant indirect effects (Hayes, 2013). A mediational analysis revealed that appraisal of mental fatigue as a signal of expansion partially explained the effect of self-regulation training on increased persistence, $B = 0.17$ SE = 0.10, CI [0.02, 0.42] (Fig. 1). Specifically, those in the self-regulation training condition developed a stronger appraisal of fatigue as a signal of expansion by post-testing, and this change in appraisal may have contributed to the increase in persistence at post-testing.

2.4.4. Inhibition

The second dependent measure was average accuracy for the three blocks of anti-saccade trials at post-testing controlling for average accuracy at pre-testing. There was no effect of condition on inhibition as measured by the anti-saccade task, $F(1, 72) = 0.03$, p = 0.86. This finding provides preliminary evidence that the improvement in persistence was not a consequence of enhanced inhibition.

2.4.5. Experience sampling

Multilevel modeling was used to analyze the ESM data, because observations were nested within individuals. Overall, there was a 50.3% response rate to a total of 5825 ESM surveys sent. This sample of 75 participants with 2930 ESM responses provided a statistical power of 0.80 to detect effect sizes equivalent to $d = 0.35$ for mean differences between the conditions (Faul, Erdfelder, Lang, & Buchner, 2007). There was no significant difference in response rates across conditions, $F(1,75) = 0.04$, p = 0.84. There were also no significant differences in response rates across conditions at any of the three time points (all Fs < 2.51, $p's$ > 0.12). We were primarily interested in examining the Condition × Time interactions regarding the degree to which participants: (i) recognized the opportunity to use self-control (categorical *yes/no* variable), (ii) attempted to use self-control (categorical *yes/no* variable), (iii) succeeded in using self-control (categorical *yes/no* variable), and (iv) experienced effort in exerting self-control (continuous Likert variable; Table 1). For the categorical variables, multilevel logistic regressions were run, and the log odds values were computed into odds ratios and probabilities for greater interpretability. These ESM variables were first analyzed in terms of their *incidence rate*—the *frequency* of an event out of the total number of experience sampling prompts to which participants responded. Provided that an ESM prompt was answered, the categorical questions in that survey answered as *yes* were coded as 1, as *no* were coded as 0, and as *NA* were coded as 0. This approach allows for the detection of changes in the overall frequency of events. A complementary approach is to examine the *efficiency*

rate—the frequency of attempts or successes in self-control relative to the total number of surveys in which participants noticed a need to exert self-control. Incidence and efficiency analyses are reported below. For all ESM analyses, there were no differences between conditions at baseline.

A significant Condition × Time interaction emerged for the incidence rate of feeling the need to exert self-control (Tables 1 and 2). Whereas participants in the self-regulation training condition did not change in noticing the need for self-control (baseline: 33%; post-test: 29%), participants in the relationship training condition dropped markedly (baseline: 26%; post-test: 13%).

A significant Condition × Time interaction also emerged for the incidence rate of attempting to resist desires (Tables 1 and 2). Participants in the self-regulation training condition did not change in their frequency of attempts (baseline: 20%; post-testing: 21%), but participants in the relationship training condition dropped significantly (baseline: 18%; post-test: 9%).

A significant Condition × Time interaction also emerged for the incidence rate of successfully resisting desires (Tables 1 and 2). Whereas participants in the self-regulation training condition did not change in their frequency of success (baseline: 17%; post-testing: 18%), participants in the relationship training condition dropped markedly (baseline: 14%; post-testing: 7%).

We next examined efficiency rates–the proportion of times that participants engaged in self-control out of the total number of times they perceived an opportunity. There was a marginal Condition × Time interaction on attempts to resist the desire (Tables 1 and 2). Over time, those in the self-regulation training condition attempted marginally more often to resist the desires that they noticed (pre-test = 67%; post-test = 77%) compared to the relationship training condition (pre-test = 74; post-test = 70%).

No Condition × Time interaction emerged for the efficiency rate of how successfully participants exerted self-control when they perceived an opportunity to do so (Table 1). Those in the self-regulation training condition successfully resisted a desire when perceiving the opportunity similarly across time (pre-test = 57%; post-test = 67%), as did those in the relationship training condition (pre-test = 60%; post-test = 58%).

A significant Time × Condition interaction emerged for experiences of effort when attempting to resist desires (Tables 1 and 2). Participants in the relationship training condition reported using significantly more effort at post-testing compared to pre-testing, whereas those in the self-regulation training condition reported exerting similar degrees of effort across time. Therefore, these data suggest that the training helped participants sustain their self-regulatory pursuits over time with similar degrees of effort, while the tendency for those in the relationship training condition was to experience more effort and less self-regulatory success.

Finally, as noted in Table 1, there were no significant interactions or main effects of condition or time on either strength of impulse or motivation to resist the impulse (all Bs < 0.08, ps > 0.54). These results

Table 1

Main effects and Condition × Time interactions for experience sampling measures.

	Main effect of time			Main effect of condition			Condition × Time		
Categorical dependent variables	$e\hat{b}$	z	d	$e\hat{b}$	z	d	$e\hat{b}$	z	d
I: Did you feel the need to exert control in the last 30 min?	0.92	−4.59***	1.25	1.92	3.02**	0.74	1.12	2.99**	0.74
I: Did you attempt to resist the desire?	0.94	−2.84**	0.69	1.79	2.69**	0.65	1.16	3.71***	0.95
I: Did you attempt to resist the desire and succeed?	0.96	−2.08*	0.49	1.86	2.80**	0.68	1.16	3.32***	0.83
E: Did you attempt to resist the desire?	1.03	0.87	0.20	0.98	−0.09	0.02	1.13	1.76†	0.42
E: Did you attempt to resist the desire and succeed?	1.04	1.11	0.26	1.11	0.41	0.09	1.09	1.32	0.31

Continuous dependent variables	B	t	d	B	t	d	B	t	d
How much effort did you expect to exert?	0.03	2.29*	0.55	−0.12	−0.83	0.19	0.02	0.90	0.21
How much effort did you actually exert?	0.04	2.22*	0.53	0.01	0.03	0.01	−0.07	−1.94*	0.46
How strong was the impulse or desire?	0.03	1.52	0.36	0.08	0.55	0.13	−0.03	−0.79	0.18
How motivated were you to resist the desire?	0.01	0.47	0.11	0.08	0.61	0.14	0.02	0.52	0.12

Note: All main effects and interactions controlled for baseline failures of random assignment (motivation and mood). "I" reflects incidence rate; "E" reflects efficiency rate. For the categorical measures, an odds ratio is reported ($e\hat{b}$).

† p < 0.10.
* p < 0.05.
** p < 0.01.
*** p < 0.001.

add important context to the effects of noticing more opportunities for self-control and making more frequent attempts. The null interaction effects regarding strength of impulse and motivation, along with the finding that experienced effort remained stable within the self-regulation training condition, suggest that participants in the experimental group were not merely reporting less intense self-control dilemmas over time as a product of greater sensitivity to or willingness to report these dilemmas.

Across these ESM measures, the relationship training condition showed a decline in self-control over the course of the academic term, whereas the self-regulation training led to no such decline. Although participants in the self-regulation training condition did not show *increased* self-control over time, we have reason to believe that their consistency over the academic term was a sign that the self-regulation training was helpful. Results revealed a main effect of time on

anticipation of necessary effort; over the course of the eight weeks, regardless of condition, participants reported expecting that it would take more effort to control the impulses they faced, b = 0.03, t = 2.29, p = 0.02, d = 0.55. This result suggests that participants, regardless of condition, were anticipating self-control to be more challenging as the academic quarter progressed. This interpretation is supported by research demonstrating that self-control tends to worsen over the course of the academic term (Oaten & Cheng, 2005; Oaten & Cheng, 2007). Even though participants across conditions were anticipating greater challenge over time, only those in the relationship training condition experienced a deterioration of self-control.

2.5. Discussion

The primary goal of Study 1 was to examine whether a six-week

Table 2

Post hoc analyses for time and condition within the experience sampling measures.

	Difference between conditions at pre-test		Difference between conditions at post-test		Difference across Time: Self-regulation		Difference across Time: Relationships	
Categorical dependent variables	$e\hat{b}$	z	$e\hat{b}$	z	$e\hat{b}$	z	$e\hat{b}$	z
I: Did you feel the need to exert control in the last 30 min?	1.12	0.22**	2.94	3.6***	0.97	−1.20	0.87	−5.32***
I: Did you attempt to resist the desire?	1.15	0.61	3.22	3.69***	1.01	0.49	0.87	−4.63***
I: Did you attempt to resist the desire and succeed?	1.16	0.63	3.38	3.77***	1.02	0.70	0.88	−3.86***
E: Did you attempt to resist the desire?	0.69	−1.05	1.69	1.38	1.09†	1.82	0.96	−0.72
E: Did you attempt to resist the desire and succeed?	0.95	−0.12	1.54	1.12	1.05	1.11	0.99	−0.72

Continuous dependent variables	B	t	B	t	B	t	B	t
How much effort did you expect to exert?	−0.33	−0.87	0.06	0.13	0.09	2.29*	0.04	0.97
How much effort did you actually exert?	0.42	0.90	0.03	0.05	0.02	0.38	0.16	2.87**
How strong was the impulse or desire?	0.29	0.76	0.11	0.25	0.01	0.38	0.07	1.63
How motivated were you to resist the desire?	0.06	0.15	0.7	1.58	0.04	1.03	−0.01	−0.29

Note: Difference between conditions at pre-test; Difference between conditions at post-test; Difference from pre-test to post-test among the treatment group receiving self-regulation training; Difference from pre-test to post-test among the waitlist control group receiving relationship training. "I" reflects incidence rate; "E" reflects efficiency rate. For the categorical measures, an odds ratio is reported ($e\hat{b}$).

† p < 0.10.
* p < 0.05.
** p < 0.01.
*** p < 0.001.

multifaceted intervention could change individuals' mindsets and behavior regarding self-regulation. These findings suggest that the self-regulation training indeed enhanced participants' growth mindsets and appraisals of fatigue, as well as their self-regulation in both the lab and in daily life. The intervention improved persistence on challenging puzzles in part by changing underlying beliefs about what mental fatigue signifies. This partial mediation supports the hypotheses described earlier, suggesting that attributions of effort—a well cited element of a growth mindset—may play a greater role in self-regulatory pursuits than previously credited. However other mediation models may exist as well, particularly because unmeasured mediators may be at play.

Compared to the relationship training condition, participants in the self-regulation training condition showed no improvements on the inhibition task, which is consistent with the possibility that improvements in self-regulation as a momentary guide toward long-term goals likely depends on a broader form of self-regulation training beyond executive function (Berkman, 2016). Given the broad focus of the present intervention—promoting a growth mindset and general goal pursuit strategies rather than deliberate practice of inhibition—the null effect on inhibition are perhaps unsurprising.

Additionally, relative to those who received relationship training, participants who received self-regulation training displayed beneficial patterns over time regarding their self-control. Those in the self-regulation training condition noticed more opportunities to exert self-control, attempted to resist desires more often, successfully resisted desires more often, and contrary to their expectations, experienced less effort while doing so. It is important to note when interpreting these Condition × Time interactions that the effects were driven by those in the relationship training condition showing marked declines in the self-control measures over the course of the academic term. Prior research suggests that self-control tends to weaken over the course of an academic term (Oaten & Cheng, 2007), therefore the present results suggest that the self-regulation training may have buffered against this normative decline. Although participants in the self-regulation condition did not show *increased* self-control over time, this buffering effect is a common consequence of growth mindset training and has been demonstrated in other studies (Blackwell et al., 2007; Yeager et al., 2014). Additionally, in our sample, participants across conditions anticipated their self-control dilemmas would be more effortful over time. This anticipation of challenge seems to have translated into worse daily self-control for those in the relationship training condition, but not for those equipped with a growth mindset and goal pursuit strategies.

Interestingly, the strength of the perceived impulses people experienced challenging their self-control remained similar for both conditions across time; yet, results showed that participants in the self-regulation training condition learned to successfully face these challenges more frequently while using less effort. This suggests that participants in the self-regulation training condition were not simply reporting less intense self-control dilemmas over time as a product of being enrolled in a self-regulation training program. Instead, they appeared to more frequently notice the need to exert self-control in dilemmas that were equivalently challenging as in the self-regulation training condition. We posit that noticing opportunities to use self-regulation may be an important part of overall self-regulation. If an individual does not notice the need for self-regulation, that does not necessarily mean that there was no need for self-regulation. As Duckworth, Gendler, and Gross (2017) describe, self-regulation entails more than momentary willpower. It also entails forecasting potential future dilemmas and proactively changing one's situational circumstance to avoid the temptation.

Although promising, this study has limitations. First, it is possible that some demand characteristics were present, because participants were aware of their condition. In an effort to mitigate these demand effects, this study featured: (a) an active control condition in which participants also expected some kind of improvement, (b) a cover story

that focused on improving overall well-being in both conditions so that participants were not solely focused on self-regulation in the experimental condition, and (c) a post-intervention questionnaire regarding perceptions of the experimenters' behaviors and expectations, in which no evidence for demand characteristics was observed. Nonetheless, these efforts do not fully eliminate the risk that the responses of participants in the self-regulation training condition were due in part to their desire to please the experimenters.

Second, the goal of the study was to assess the overall extent to which self-regulatory beliefs and behavior could be improved in six-weeks; therefore, we took a multifaceted approach to see whether combining helpful features (e.g. a growth mindset and self-regulatory strategies from the field) would lead to such improvement. However, inherent in this multifaceted approach is an uncertainty as to whether the growth mindset was the driving factor in the observed changes. The intervention did indeed improve participants' growth mindsets, yet it is still unclear the extent to which this improvement directly led to the other benefits observed. Finally, the intervention was time intensive for both the participants and the instructors, placing limits on the feasibility of delivering the intervention to large audiences across multiple contexts.

Despite these limitations, Study 1 suggested the potential importance of a growth mindset of self-regulation and laid the foundation for a more precise laboratory study examining this mindset. Study 1 demonstrated that (a) it is indeed possible to teach individuals to adopt a growth mindset of self-regulation, (b) as one would predict from the broader literature on growth mindsets, this led to a shift in appraisals of fatigue, (c) a positive appraisal of fatigue partially mediated the improvement in persistence on an anagram task. Therefore, Study 2 attempted to build upon these results while addressing the limitations of Study 1.

3. Study 2

The goals of Study 2 were to (a) more directly examine whether appraisals of fatigue are directly affected by a more narrowly focused growth mindset intervention, and (b) replicate the indirect effect of these appraisals on increased persistence. Most research that has demonstrated the waning of self-regulation over time has utilized the sequential task paradigm, which has shown that task performance declines following previous exertion of effort (Baumeister et al., 1998; Baumeister, Dale, & Sommer, 1998; Muraven, Tice, & Baumeister, 1998).[2] Utilizing this framework, we examined the effect of a growth versus fixed mindset on persistence after participants had completed either a relatively easy or effortful math task (Lisjak, Molden, & Lee, 2012). Previous research has shown that people's performance on this math task requires cognitive effort (DeStefano & LeFevre, 2004; Vohs et al., 2008). Based on the results from Study 1, the primary hypothesis was that a growth mindset of self-regulation would improve persistence on the anagram task regardless of which version of the math task they completed. A secondary hypothesis was that if completing the more effortful math task led to worse performance on the anagram task—as would be predicted by the limited resource model of self-control (Baumeister et al., 1998; Hagger, Wood, Stiff, & Chatzisarantis, 2010)—then the growth mindset might be particularly effective at improving anagram persistence after exerting mental effort. Lastly, in addition to measuring appraisal of fatigue (i.e. what fatigue represents),

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[2] However, a more recent meta-analysis has suggested that the depletion effect might not be as robust as originally believed (Carter et al., 2015). Additionally, a recently conducted a series of replication studies came to the same conclusions that the depletion effect may not be as strong as once thought (Hagger et al., 2016). These findings further argue for investigating alternative approaches to understanding self-control failure that do not rely on the idea of reaching one's capacity

participants also reported the degree of experienced effort and fatigue during the anagram task. These were included to examine whether the growth mindset affects how much fatigue is experienced in addition to how fatigue is appraised.

3.1. Participants

126 undergraduate students (51 female) participated in exchange for course credit (mean age = 18.9, range = 18–22).

3.2. Procedure and materials

Participants were randomly assigned to read an article either describing self-regulation as an innate skill that was largely immutable (fixed mindset) or as a developable skill that strengthens with practice (growth mindset). The articles were created by our research team but were presented as having been drawn from the popular magazine *Scientific American* to increase their persuasiveness. The articles were matched for length, complexity, interest, and references to scientific research. Both articles used the term "mental control" in place of "self-regulation" to be more colloquial for lay audiences, and mental control was defined in the article as "the capacity to control one's attention, thoughts, emotions, and actions". In the fixed condition, the article included statements such as "*A person's capacity for mental control is surprisingly stable, and attempts to 'train' mental control have little to no effect*" and "*There is considerable evidence and scientific consensus that people's capacity for mental control is a stable trait, which is restricted by the biology of our brains*". Whereas the growth condition included statements such as, "*You can increase your mental control dramatically simply by exerting mental control more often*" and "*People's capacity for mental control can be improved through practice in ways that change the biology of our brains*". The full text of the articles is presented in the Supplemental Materials.

To ensure that participants read the article in full and to reinforce the manipulation, participants were asked to summarize the findings and describe how their life experiences aligned with the premise of whichever article they had read. Next, participants were asked two questions intended to serve as the mindset manipulation check: (1) *The amount of mental control I have can improve with practice; (2) Mental control is a fixed quality. However much I have now is all I will ever have* (reverse scored).

Next participants were randomly assigned to complete either relatively easy (e.g. 7 + 6 + 4) or relatively effortful (e.g. 11 + 96 + 77) numerical equations (Lisjak et al., 2012). Participants were asked to complete as many problems as possible in 5 min. Afterwards, all participants completed the same impossible anagram task as in Study 1 and answered the same questions assessing appraisal of mental fatigue.

Participants also reported the degree of perceived effort and fatigue they experienced during the anagram task. Using a scale from 1(*strongly disagree*) to 7(*strongly agree*), perceived effort was measured with two items (*I tried my hardest on the task; I exerted a lot of effort on the task; a* = 0.71) and perceived fatigue was measured with five items (*The task made me feel tired; The task was exhausting; I felt the urge to quit while doing the task; The task challenged my mental control; The task used up my mental energy; a* = 0.89). Furthermore, participants answered questionnaires regarding their experience in the study and additional beliefs regarding self-regulation (reported in the Supplementary Materials). An attention check (e.g. *Because I am paying attention, I will select disagree*) was embedded into the questionnaires to identify participants not paying adequate attention to the study details.

3.3. Results

Three participants were dropped due to incomplete data as a result of losing internet connection during the tasks, eight participants were dropped for failing the attention check (five in the growth condition,

three in the fixed condition), and three participants (one in the growth condition and two in the fixed condition) were dropped for having response times more than three standard deviations away from the mean on the persistence task (M = 61.5, SD = 42.5). Data from the remaining 112 participants were included. This sample size of 112 provided a statistical power of 0.80 to detect main effects and interactions equivalent to $d = 0.53$ (Faul et al., 2007).

The manipulation check results revealed that mindsets of self-regulation can be at least temporarily changed from a brief intervention. Those in the growth condition reported viewing self-regulation as more malleable than those in the fixed condition, $F(1, 110) = 179.94$, p < 0.001, $d = 2.51$; Growth M = 6.37, SD = 0.65; Fixed M = 4.66, SD = 0.70. Because the skew coefficient (1.01) in the anagram data was beyond the acceptable critical value for skew in this sample size, persistence was log transformed for analysis (Doane & Seward, 2011), but raw means are reported for greater interpretability.

As in Study 1, results revealed a significant main effect of mindset condition on persistence, $F(1, 110) = 5.52$, $p = 0.02$, $d = 0.45$.[3] In support of our hypothesis, those in the growth mindset condition persisted, on average, for 12.62 s longer on impossible anagrams than those in the fixed mindset condition (Growth: $M = 65.30$ s, $SD = 34.07$ s; Fixed: $M = 52.68$ s, $SD = 31.26$ s).[4] There was no effect of math condition on anagram persistence, $F(1,110) = 0.87$ $p = .35$, and no significant interaction, $F(1, 108) = 0.05$ $p = .82$. Therefore, the growth mindset increased persistence regardless of whether the participant had previously completed an easy or effortful math task.

Compared to those in the fixed condition, those in the growth condition were more likely to appraise their fatigue as a signal that their self-regulation was expanding, $F(1, 110) = 12.18$, $p < .001$, $d = 0.65$; Growth M = 4.74, SD = 0.86; Fixed M = 4.22, SD = 0.70. Furthermore, individuals who appraised their fatigue as a signal of expansion persisted longer on the impossible anagrams ($r = 0.31$, $p < .001$). When both mindset and appraisal of fatigue were simultaneously included in a regression predicting persistence, appraisal of fatigue predicted persistence, $B = 0.28$, $t = 2.93$, $p = .004$, but mindset did not, $B = 0.10$, $t = 1.08$, $p = .28$.

We next examined a mediational model in which the growth mindset changed appraisal of fatigue and thereby improved persistence. A mediational analysis using bootstrapping through the PROCESS macro (Hayes, 2013) confirmed a significant indirect effect of the growth mindset manipulation on anagram persistence through appraisal of fatigue as a signal of expansion, $B = 0.12$, $SE = 0.09$, 95% CI [0.05–0.41]. This analysis replicates the partial mediation observed in Study 1 and provides converging evidence that a growth mindset is influential in part because it changes how fatigue is appraised (Fig. 2).

Consistent with the findings of Study 1, there was no effect of mindset condition on degree of experienced effort $F(1, 110) = 1.12$, $p = .29$ nor degree of experienced fatigue $F(1, 110) = 0.02$, $p = .89$. This implies that a growth mindset may not affect the degree to which challenges feel effortful and tiring, but rather how the experienced fatigue is construed.

3.4. Discussion

The results of Study 2 indicate that a growth mindset of self-regulation can be meaningfully elicited by even a brief intervention. They further indicate that such a brief and targeted intervention can indeed alter people's appraisals of effort, which then partially and indirectly improves their persistence, replicating Study 1. As noted in Study 1, in

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[3] When including the three outliers, this effect becomes null, $F(1, 113) = 2.17$, $p = .14$.

[4] There was no effect of mindset condition on math performance, $F(1, 110) = 0.01$, $p = .93$ nor math condition on anagram persistence, $F(1, 110) = 0.87$, $p = .35$.
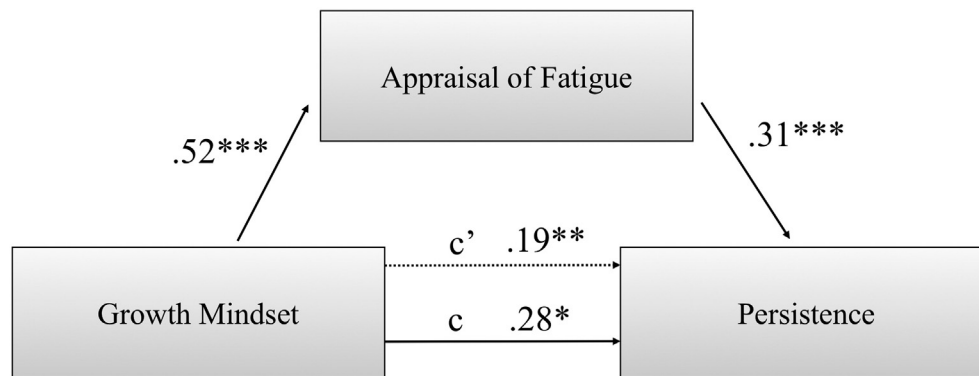
Fig. 2. Mediation model of brief intervention.
Partial mediation on persistence via appraisal of fatigue CI: [1.03, 13.48]. Standardized betas reported. Bootstrapping with 5000 resamples was used to calculate a 95% confidence interval around the indirect effect. * < 0.05, ** < 0.01, *** < 0.001.

addition to appraisals of effort, there are likely other unmeasured mediators that help explain this effect of a growth mindset of self-regulation on persistence.

Importantly, in Study 2, experimenters were unaware of the condition to which participants were assigned, and both the experimental and control condition focused on mental control. Therefore, this study did not suffer from the risk of potential demand effects like Study 1. The results of this study did not replicate the ego depletion effect, which is consistent with other recent replication failures (Carter, Kofler, Forster, & McCullough, 2015; Hagger et al., 2016). However, it is possible that this null effect is partially due to insufficient power to detect a small effect size.

Cumulatively, Studies 1 and 2 showed that being exposed to a growth mindset of self-regulation changes the way that people appraise fatigue, which in turn increases persistence on an impossible anagram task. This effect remained even when participants first completed a separate effortful task. Nonetheless, it remains unclear whether a growth mindset of self-regulation would affect performance on tasks other than persistence that still require effort. Study 3 sought to investigate this further by examining the effect of the growth mindset of self-regulation on attention regulation.

4. Study 3

Studies 1 and 2 suggested that a growth mindset of self-regulation increases persistence on an impossible anagram task, yet it remains unclear whether this mindset extends to other types of tasks. This study examined whether the growth mindset and appraisal of fatigue would influence performance on an attention regulation task. To measure attention regulation, we chose a mindful breathing task because (1) it is intuitively perceived as a task requiring self-regulation, (2) it is widely practiced by millions of people, giving it broad practical relevance, yet (3) it assesses and requires skills other than persistence. As in Studies 1 and 2, we hypothesized that the growth mindset would lead participants to appraise fatigue as a signal of expansion rather than a signal of reaching one's capacity. We also predicted that the growth mindset would improve performance on the mindful breathing task, extending the results from Studies 1 and 2. However, if this main effect did not emerge, this could indicate an interesting boundary condition.

4.1. Participants

92 undergraduate students (51 female) participated in exchange for course credit (mean age = 19.6, range = 18–23).

4.2. Procedure

To induce a fixed versus growth mindset, participants read similar

articles as in Study 2. A few modifications were made to the articles, and these differences are described in the Supplemental Materials. After the manipulation, all participants completed a ten-minute breath awareness task that instructed people to focus their attention on the sensations of their breathing. Specifically, they were instructed to put on headphones, close their eyes, and bring their awareness to the sensations of their breath, including the movement in their chest and abdomen (Mrazek, Smallwood, & Schooler, 2012). Participants were told that when they became distracted from their breath, they should simply return their attention back to the sensations of breathing. Fifteen thought probes were embedded into the task in order to periodically query participants as to whether their attention was focused on their breath or if their mind had been wandering in that moment. Thought probes were signaled by an audible chime that cued participants to press the space bar if their attention had been on their breath when they heard the chime or to press nothing if their attention had been elsewhere. Attention regulation was computed as the percentage of times participants reported being focused on their breath across these 15 probes. Distraction during a thought probe was coded as 0 and focus was coded as 1. On average, participants kept their attention on their breath 76% of the time (*SD* = 24%). Upon finishing, participants completed the attributions of mental fatigue scale and perceived effort measure from Study 2 among other measures reported in the supplemental materials. The same attention check question from Study 2 was included to catch participants that were not paying adequate attention to the questionnaires.

4.3. Results

Due to internet malfunction for two participants and failed attention checks for eight participants, data from the remaining 82 participants were analyzed. This sample provided a statistical power of 0.80 to detect effects equivalent to *d* = 0.61. As in Studies 1 and 2, those in the growth mindset condition were more likely to appraise fatigue as a sign of expansion than those in the fixed mindset condition, *F*(1, 80) = 5.33, *p* = .02; Growth: M = 3.78, SD = 0.49; Fixed: M = 3.51, SD = 0.56; *d* = 0.51. However, analyses revealed no main effect of mindset condition on attention regulation, *F*(1, 80) = 1.63, *p* = .21. Performance on the mindful breathing task was not significantly correlated to appraisal of mental fatigue (*r* = 0.04, *p* = .74).

4.4. Discussion

These results suggest a potential boundary condition for the effect of a brief growth mindset intervention. Although this was the third study to show that a growth mindset consistently alters appraisals about the meaning of fatigue—and this alone may be sufficient to improve persistence—it is not necessarily sufficient to enhance performance on all

effortful tasks. One potential reason why the growth mindset did not improve performance on this particular task is that attentional control is a cognitive skill that may require practice—rather than just greater persistence—in order to improve (Moore, Gruber, Derose, & Malinowski, 2012; Slagter et al., 2007; Tang et al., 2007). Exploratory analyses further investigating how motivation may affect this cognitive skill are discussed in the Supplemental Materials. A second potential reason for the null result in this study could be due to insufficient power to detect small effects. A third potential reason why the growth mindset did not improve attentional control entails a reactance effect. It is possible that unskillful attempts to control one's attention in this setting may lead to ironic monitoring where individuals—and perhaps particularly those with a growth mindset who are motivated to improve—would be more likely to monitor their performance in a manner that increased the accessibility of distraction (Wegner, 1994). Knowing that a growth mindset may be more helpful for some tasks that others, we next explored how a growth mindset intervention may affect outcomes more conceptually related to effort yet distinct from persistence.

5. Study 4

Given the consistent finding across Studies 1–3 that a growth mindset changes appraisal of fatigue, we next explored how else a growth mindset may influence effort. As noted earlier, effort is generally viewed as aversive, and people typically opt for the easier of two tasks when given a choice (Inzlicht, Bartholow, & Hirsh, 2015; McGuire, 1969). Effort avoidance is the well-established tendency to pursue the least physically or cognitively demanding course of action available (Baroody & Ginsburg, 1986; McGuire, 1969; Taylor, 1981). The *demand selection task* is a widely-used measure of effort avoidance. In this task, participants complete math problems on a trial by trial basis from one of two decks—which are ostensibly either easy or hard—and typically they tend to choose less demanding problems (Kool et al., 2010). Yet if a growth mindset changes one's perception of fatigue, it could in principle also reduce the degree to which individuals avoid exerting effort. Study 4 examined this possibility by administering the brief growth mindset intervention prior to a behavioral test of effort avoidance. We hypothesized that, compared to the fixed condition, the growth mindset manipulation would reduce effort avoidance, buffering against the usual tendency to choose easy rather than difficult problems. Studies 2 and 3 only compared a growth mindset to a fixed mindset, so it remains unclear which condition was driving the effects. Therefore, Study 4 added a neutral condition to explore the extent to which any observed outcomes were driven by the growth or fixed mindset.

5.1. Participants

100 undergraduate Psychology students were recruited to participate. Data on age and gender were not collected. Each participant received course credit in exchange for participation.

5.2. Procedure

Participants were randomly assigned to one of three mindset conditions. The growth and fixed mindset articles were slightly modified from earlier studies to increase their relevance to the math task, for instance by framing the discussion in terms of study habits rather than completing a to-do list. A third condition presented a neutral article discussing the experience of "déjà vu" and did not mention mental control or self-regulation (see Supplemental Materials for full text). As in Studies 2 and 3, participants were then asked to summarize the main arguments of the article and to describe the most compelling piece of evidence from the article.

Next, participants completed a computerized demand selection task (Kool et al., 2010), which entailed repeatedly choosing between easy or difficult subtraction problems. There were 200 trials. On each trial, participants had the choice to click on either a blue deck of cards or a red deck of cards shown on the screen. One deck was easier because it led to a subtraction problem that did not require a carrying operation (e.g., 56–24) and the other was more difficult because it led to a subtraction problem that required a digit to be carried (e.g., 56–28; deck color and spatial position were counterbalanced). Importantly, the two decks were not labeled as easy or difficult; instead, the participant was left to discover the difference through their own experience after completing several problems from each deck. The outcome of interest was the proportion of questions chosen from the difficult deck, with a greater proportion of difficult questions indicating less effort avoidance. No extrinsic incentives were provided based on their performance during the task. Due to a programming error, response data for trial 200 was not recorded.

Additional questionnaires reported in the Supplemental Materials assessed attitudes about self-regulation and math, whether participants noticed a difference in difficulty between the decks in the demand selection task, learning/performance goal orientation, explicit growth mindset beliefs, and participants' hypotheses about the study's objective.

5.3. Results

Seven participants were excluded from the analysis because they were unable to complete the study within the time allotted (1 h), and thus had incomplete datasets. Three more participants were excluded because their answers to the debriefing questions indicated suspicion that the mindset article was meant to influence the difficulty of problems selected on the demand selection task, although their inclusion did not impact the statistical significance of the results.[5] After applying these exclusionary criteria, 90 participants remained in the analysis. This sample provided a statistical power of 0.80 to detect main effects equivalent to $d = 0.66$.

The distribution of problem difficulty scores (i.e., the proportion of difficult items chosen) was significantly positively skewed, $Z = 2.69$, $p < .01$. A series of Wilcoxon signed-rank tests were conducted to determine whether participants chose the easy problems at a rate greater than chance. This nonparametric test examines whether deviations from chance in either direction are smaller than expected from a random sample, making it an appropriate alternative to the one sample t-test for non-normally distributed data (Whitley & Ball, 2002). Across the entire sample, participants demonstrated a tendency toward effort avoidance, choosing difficult problems only 34% of the time and significantly less than expected by chance, $Z = 4.48$, $p < .01$. However, among subjects in the growth mindset condition, no effort avoidance was displayed; the proportion of difficult problems chosen was not significantly different from chance like it was in the fixed and neutral conditions, Growth 46%, $Z = 0.63$, $p = .53$; Fixed 25%, $Z = 3.73$, $p < .01$; Neutral 31%, $Z = 3.21$, $p < .01$.

A Kruskal-Wallis test was used to determine whether the proportion of difficult (vs. easy) problems chosen on the DST differed by mindset condition. The Kruskal-Wallis test is a nonparametric alternative to the conventional analysis of variance (ANOVA). This test involves ranking each observation and comparing the sum of ranks, rather than the original observations, across experimental conditions (Kruskal & Wallis, 1952). The Kruskal-Wallis test indicated a significant difference in the proportion of difficult (vs. easy) problems chosen by participants in each condition, $H(2) = 7.10$, $p = .03$, $d = 0.59$.[6] As hypothesized, post

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[5] Including the three participants who failed the suspicion check, the Kruskal-Wallis test, $H(2) = 7.33$, $p = .03$, $d = 0.59$, and omnibus F-test, $F(2, 90) = 3.92$, $p = .02$, $d = 0.59$, still indicated a significant difference.

[6] An omnibus F-test also yielded significant results, $F(2, 87) = 3.99$, $p = .02$, $d = 0.61$.
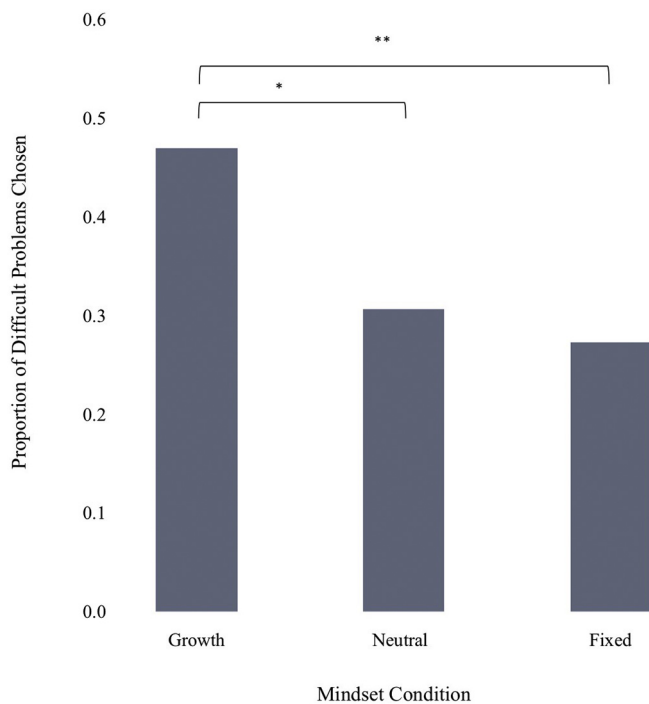
Fig. 3. Mindset Condition Affects Effort Avoidance in Study 4.
Group differences in the proportion of difficult problems chosen in the demand selection task. Confidence intervals are not included due to the significant skew of the problem difficulty scores $^*p < .05$, $^{**}p < .01$.

hoc Dunn tests showed that participants in the growth condition chose significantly more difficult problems than those in the fixed condition, $Z = 2.50$, $p = .01$, $d = 0.53$, and those in the neutral condition, $Z = 2.05$, $p = .04$, $d = 0.43$ (Fig. 3). There was no significant difference in effort avoidance between the fixed and neutral conditions, $Z = 0.47$, $p = .64$, suggesting that participants naturally avoid effort to a similar extent as those presented with a fixed mindset. Group differences in effort avoidance therefore appear to be driven by the growth mindset manipulation rather than the fixed mindset.

5.4. Discussion

Taken together, the results of Study 4 indicate that a growth mindset of self-regulation increases the willingness to exert effort. This builds on Studies 1–3 by suggesting a second consequence of growth mindsets. Not only do individuals with a growth mindset appraise the meaning of fatigue differently, but they are also more willing to exert effort. To further understand the relationship between these variables, Study 5 investigated whether a growth mindset affects willingness to exert effort via appraisal of fatigue or whether appraisal of fatigue and effort exertion are separate consequences of the growth mindset.

6. Study 5

Studies 1–3 suggested that exposure to a growth mindset may increase persistence by changing the way individuals interpret mental fatigue, and Study 4 demonstrated that this mindset may reduce the normative tendency to avoid effort. However, it remains unclear how appraisal of mental fatigue and effort avoidance may be related. In addition to replicating the Study 4 result, Study 5 aimed to examine the relationship between behavioral effort avoidance and appraisal of mental fatigue. We hypothesized that the growth mindset would reduce effort avoidance and increase appraisal of fatigue as a sign of expansion, and we had no strong a priori hypotheses about how these constructs would be related to one another. On the one hand, it would be plausible

that appraisals of fatigue could play a mechanistic role in the relationship between growth mindsets and effort avoidance. On the other hand, appraisals of fatigue and effort avoidance may be two related but distinct outcomes of the growth mindset.

6.1. Participants

100 undergraduate Psychology students were recruited to participate. Data on age and gender was not collected. Each participant received course credit in exchange for participation.

6.2. Procedure

Participants were randomly assigned to read about a growth mindset of self-regulation, a fixed mindset of self-regulation, or a neutral article on déjà vu following the same procedure as in Study 4. Next, they completed a 150-problem version of the demand selection task from Study 4 and the same follow-up questions. Due to a programming error, response data for trial 150 was not recorded. Finally, participants reported the degree of perceived effort they experienced during the task as in Studies 2 and 3, the degree to which they construed mental fatigue as a sign of expansion as in Studies 1–3, and additional measures reported in Supplemental Materials.

6.3. Results

One participant was excluded from the analysis because of missing responses to one or more questions, leaving 99 participants in the analysis. This sample provided a statistical power of 0.80 to detect main effects equivalent to $d = 0.63$.

The distribution of problem difficulty scores was significantly positively skewed, $Z = 3.05$, $p < .01$. A series of Wilcoxon signed-rank tests were conducted to determine whether participants chose the easy problems at a rate greater than chance. As in Study 4, across the entire sample, participants demonstrated a tendency toward effort avoidance, choosing difficult problems only 33% of the time and significantly less than expected by chance, $Z = 4.89$, $p < .01$. Moreover, as in Study 4, effort avoidance was displayed among participants in the fixed and neutral conditions, but not the growth condition, Growth $Z = 1.27$, $p = .20$; Fixed $Z = 3.27$, $p < .01$; Neutral $Z = 3.84$, $p < .01$ (Fig. 4). Participants in the growth condition chose the difficult problems 43% of the time, while those in the fixed and neutral conditions both chose the difficult problems 28% of the time. A Kruskal-Wallis test indicated a significant difference in the proportion of difficult (vs. easy) problems chosen by participants in each group, $H(2) = 6.93$, $p = .03$, $d = 0.55$.[7] Post hoc Dunn tests showed that participants in the growth condition chose significantly more difficult problems than those in the fixed condition, $Z = 2.43$, $p = .02$, $d = 0.49$, and those in the neutral condition, $Z = 2.12$, $p = .03$, $d = 0.43$. There was no significant difference in difficulty between the fixed and neutral conditions, $Z = 0.37$, $p = .71$. These findings support those of Study 4, suggesting that a growth mindset of self-regulation mitigates the normative tendency to avoid effort.

Next, we examined whether the growth mindset manipulation affected construal of fatigue. An omnibus F-test showed a significant group difference in the appraisal of fatigue as a sign of expansion, $F(2, 96) = 15.89$, $p < .01$, $d = 1.15$. Post hoc LSD tests showed that participants in the growth condition scored higher on this measure than those in the fixed condition, $t(63) = 5.50$, $p < .01$, $d = 1.37$, and the neutral condition, $t(64) = 3.3$, $p < .01$, $d = 0.80$, consistent with Studies 1–3, Growth: M = 4.84, SD = 0.73; Fixed: M = 3.85, SD = 0.72; Neutral: M = 4.27, SD = 0.68 (Fig. 5). Participants in the

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[7] An omnibus F-test also yielded significant results, $F(2, 96) = 3.18$, $p = .046$, $d = 0.51$.
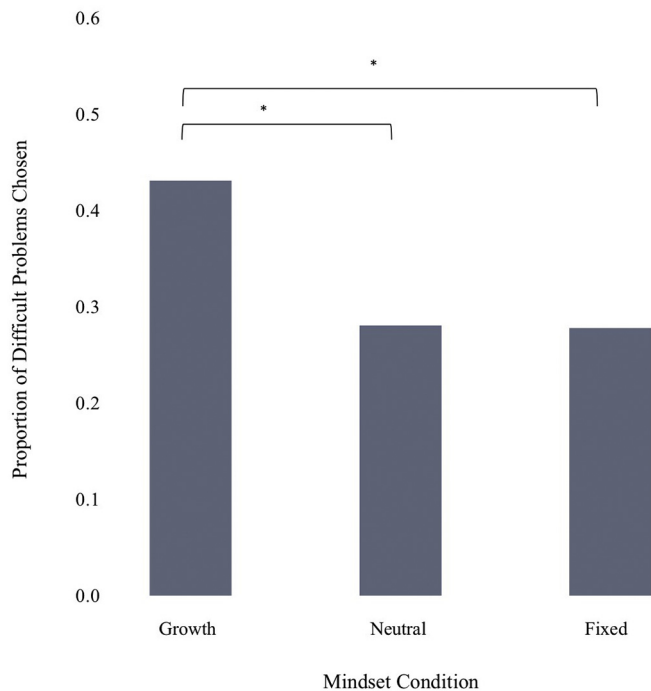
Fig. 4. Mindset condition affects effort avoidance in Study 5.
Group differences in the proportion of difficult problems chosen in the demand
selection task. Confidence intervals are not included due to the significant skew
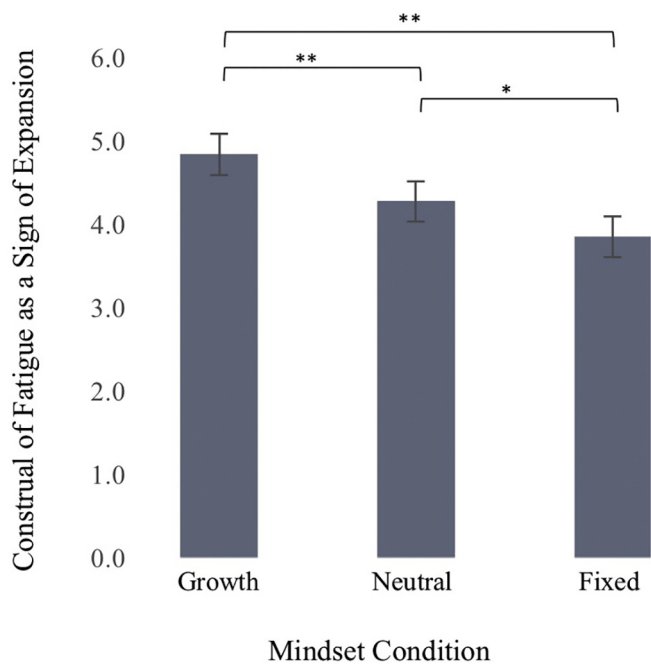of the problem difficulty scores * $p < .05$, ** $p < .01$.

Fig. 5. Mindset condition on construal of fatigue.
Group differences in the construal of fatigue as a sign of expanding self-reg-
ulatory skills. Error bars are 95% confidence intervals * $p < .05$, ** $p < .01$.

fixed condition were less likely to consider fatigue to be a sign of self-
regulatory expansion than those in the neutral condition, $t(65) = 2.48$,
$p = .02$, $d = 0.61$. These findings suggest that both a growth mindset
and a fixed mindset of self-regulation change the meaning attributed to
fatigue. Interestingly, there was no correlation between construal of
fatigue and effort avoidance ($r = 0.06$, $p = .55$).

Given these differences in behavioral effort avoidance and appraisal

of fatigue, two omnibus F-tests were conducted to determine whether
mindset condition influenced the experience of perceived effort or fa-
tigue during the demand selection task. No significant group differences
were found for subjective effort, $F(2, 96) = 0.21$, $p = .81$, nor sub-
jective fatigue, $F(2, 96) = 1.31$, $p = .27$. In line with the results of
Study 2, this suggests that the growth mindset intervention may lead to
changes in the allocation of effort without impacting the perceived ef-
fort or fatigue experienced during the task.

6.4. Discussion

The primary novel question of Study 5 was how effort avoidance
and construal of fatigue may be related. Interestingly, there was no
correlation between construal of fatigue and effort avoidance. This
suggests that the impact of the mindset manipulation on effort avoid-
ance was not driven by changes in the construal of fatigue. Instead, this
research highlights two distinct outcomes of a growth mindset of self-
regulation: reduced effort avoidance and increased construal of fatigue
as sign of expansion.

Additionally, we explored whether the conditions differed with re-
gard to the trajectory of participants' choices in the DST across trials. In
this study as well as Study 4, there were no significant interactions
between condition and time on the proportion of difficult problems
chosen (see Supplemental Materials).

7. General discussion

The majority of people fail to reach even their most salient personal
goals (Baumeister & Heatherton, 1996). This simple fact reveals the
need for the identification of potent and deliverable interventions to
enhance self-regulation. The present research suggests that one pro-
mising intervention is the use of targeted instructions to cultivate a
growth mindset specifically about self-regulation. This type of inter-
vention seems to be particularly promising due to the effects it can have
on appraisal and exertion of effort. Many of the goals we set for our-
selves crucially rely on consistent effort and perseverance; and in a
world with increasing distractions and temptations, we have our work
cut out for us. The evidence from these mindset studies not only re-
inforces the growing theoretical consensus on the importance of effort
experiences in self-regulation, but it also suggests a concrete approach
that individuals can utilize to reach their personal goals.

The broad intervention in Study 1 initially suggested that a growth
mindset of self-regulation can be successfully taught and potentially
lead individuals to perceive fatigue in a more positive, mastery-oriented
way, which can in turn partially mediate improvements in persistence.
Although the broad nature of the intervention and potential for demand
effects limited the causal claims that could be made, Study 2 replicated
the effects of a growth mindset of self-regulation on appraisals of fa-
tigue and persistence using a more targeted intervention that was less
susceptible to demand effects.

Studies 4 and 5 further demonstrated that a growth mindset inter-
vention reduced effort avoidance, leading participants to opt for a
greater number of more challenging math problems. The human ten-
dency to avoid effort aligns with several motivational theories de-
scribed earlier that attempt to elucidate the causes of self-regulatory
failure (Inzlicht et al., 2014; Kurzban et al., 2013; Molden et al., 2016).
For example, Kurzban and colleagues argue in their opportunity cost
model that subjective effort is a representation of the opportunity cost
of engaging in the current task. This cost is weighed against the benefits
of continued engagement, motivating an individual to reallocate cog-
nitive resources away from inefficient pursuits. As a result, when pre-
sented with two courses of action that entail equal results but require
different degrees of effort, people tend to pursue the less demanding
option (i.e., effort avoidance; Kool et al., 2010). In both Studies 4 and 5,
the presentation of a growth mindset reduced effort avoidance.

Although the growth mindset intervention increased persistence

and reduced effort avoidance, it did not significantly impact performance on a measure of sustained attention in Study 3. This suggests a potential boundary condition on the short-term effects of a growth mindset of self-regulation. Rather than serving as a panacea for improving task performance across all domains, a growth mindset of self-regulation may change fatigue appraisal and effort allocation in the short-term, and not necessarily *performance* on all tasks, particularly those in which such performance requires more than just current increases in effort. Alternatively, given the only moderate power of Study 3 these results could instead reflect Type 1 error. Further research with larger samples would be required to conclusively establish the boundary conditions of this mindset.

7.1. Growth mindsets and appraisals versus experiences of effort

Across these studies, we aimed to identify some of the key mechanisms that may underlie the effects of growth mindsets on self-regulatory behavior by building on recent motivational theories suggesting that effort expenditure and mental fatigue play key roles in self-regulatory pursuits. Our findings suggest that a growth mindset of self-regulation can improve persistence and reduce effort avoidance; the former was partially mediated by fatigue attributions whereas the latter was not. Thus, mindsets may affect effort allocation and persistence in distinct ways (Molden et al., 2016). Presumably, when individuals view fatigue as something beneficial rather than taxing, it may particularly affect willingness to persevere while experiencing effort. In contrast, a different mechanism may be at play for the effects of mindsets on willingness to engage in effort in the first place, such as attention to or interpretations of the costs and benefits associated with the current task (see Molden et al., 2016; Molden, Hui, & Scholer, 2018).

Indeed, recent theoretical models have suggested that the decline of self-regulation over time is likely due to motivational causes triggered by experiences with effortful fatigue (Inzlicht et al., 2014; Kurzban et al., 2013; Molden et al., 2016). However, the present research suggests that the experience of effortful fatigue does not necessarily trigger a decline in self-regulation. Unlike those with a fixed mindset, individuals with a growth mindset experienced effort yet this effort did not prompt them to discontinue nor avoid initiating such effortful pursuits. Instead, perhaps due to how growth mindsets affected the way in which people interpreted the costs and benefits associated with effort, such mindsets resulted in sustained motivations for self-regulation. Therefore, the present research suggests that (a) it may be possible for individuals to reshape their mindset of self-regulation to prevent downward motivational shifts that may destabilize goal pursuit, and (b) future work should more directly assess how mindsets affect the perceived costs and benefits of effort.

It is important to note that in Studies 2 and 5, improvements in persistence and willingness to expend effort were not accompanied by reported increases in subjective experiences of effort. This finding suggests that there can be a dissociation between experiences of effort and how people interpret, and behave in response to, those experiences. Given the importance of how people interpret the larger meaning of effort (Eisenberger, 1992; Job et al., 2010; Job, Bernecker, et al., 2015), future work could further confirm this disassociation to more fully understand when and how these mindsets will also affect behavior and performance.

7.2. Distinguishing growth mindsets from non-limited theories of willpower

Although both growth mindsets of self-regulation and non-limited theories of willpower (Job et al., 2010; Job et al., 2013; Job, Bernecker, et al., 2015; Job, Walton, et al., 2015) describe beliefs about mental energy and can have similar effects, it is worth reiterating how they differ. There are two key distinctions. First, a non-limited theory of willpower emphasizes lack of capacity while a growth mindset of self-regulation emphases malleability. The former is a belief system that

does not acknowledge an immediate upper boundary for continued self-regulation in the moment, whereas the latter is a belief system that negates the stability or fixedness of the ability over time. Second, a non-limited theory of willpower suggests that exerting self-regulation is self-sustaining rather than taxing in the short term and is similar to the notion of momentum where one picks up speed after getting started. In contrast, on a longer time scale, a growth mindset of self-regulation suggests that these abilities can grow over time with practice and effort in the present. Given the differences in the time scale over which these theories may apply, future research should further examine their independent and interactive effects on self-regulation.

Speculatively, if an individual were to adopt both a growth mindset of self-regulation and hold a non-limited resource theory (Mukhopadhyay & Johar, 2005), they might experience a synergistic effect. The growth mindset might lead them to approach effort because they see the utility in doing so for the long-term; meanwhile they might experience a heightened momentum in the short-term that would further reinforce their positive associations with effort and practice. Future research could test this hypothesis adding greater clarity to the understanding of how these theories relate to one another.

7.3. Limitations and future directions

The present research suggests that a growth mindset of self-regulation can be manipulated even in a brief computer-based laboratory intervention. Previous research suggests that brief interventions can have effects that last months or years, particularly if they lead to positive feedback loops of adaptive beliefs and actions (Cohen & Sherman, 2014). However, it remains unclear whether this particular brief manipulation can have enduring effects. Growth mindsets in other domains like achievement and personality are known to have effects that endure for years to affect college enrollment, GPA, and attributions of others in interpersonal settings (Paunesku et al., 2015; Yeager et al., 2014). This suggests the possibility that even brief interventions promoting a growth mindset of self-regulation might have enduring effects, particularly if they lead individuals to allocate greater effort in ways that further reinforce the mindset in a virtuous circle (Dweck, 2006). It would be informative for future research to identify the type (multifaceted vs. narrow) and length (intensive vs. brief) of growth mindset intervention that provides the most advantageous and long-lasting effects.

Although the present findings suggest that cultivating a growth mindset is a promising strategy for enhancing self-regulation, it is also worth considering whether there could be any drawbacks to this belief. For example, prominent theories of self-regulation often emphasize that every action we take entails an opportunity cost in terms of the actions we could have taken but did not (Kurzban et al., 2013). From this perspective, perseverance on every possible goal is clearly not the most adaptive choice. One might even question the wisdom of the increased persistence observed in Studies 1 and 2 on what appear to be exceedingly difficult anagrams (participants did not know they were impossible). This is a clear indication of increased perseverance, but the real-life implications of this change would depend crucially on where the persistence is directed. Future research could examine the possibility that a growth mindset of self-regulation in the absence of discernment about the value of competing goals could lead to less than optimal allocation of effort.

Although not unique to the present research, it is important to note that the growth mindset is a framework hinging on development, not necessarily change itself. Throughout all five studies, the growth mindset described self-regulation as a skillset that could improve with effort, rather than a skillset that could improve with effort *or* deteriorate without practice. This optimistic framing centering on *growth* is analogous to research in other domains like personality and intelligence. As such, one could argue that the growth mindset manipulates two constructs (malleability and valence) while the fixed mindset

manipulates only one construct (malleability). For future researchers interested in this discrepancy, it may be worthwhile to design an experiment that describes self-control as either (a) stable or (b) malleable in the sense that it can improve or decline. Alternatively, it may be interesting to design a three-condition study where participants either learn that self-regulation is fixed, they learn that it can improve with effort, or they learn that it can decline without effort. Although not the focus of this line of research, teasing apart what components of the growth mindset are particularly motivating for different individuals would be an interesting endeavor.

It would also be interesting for future work to examine how awareness of the necessity for self-control in any given moment plays a role in a longer chain of events for self-regulatory success. In Study 1, compared to the relationship training condition, over time those in the self-regulation condition consistently noticed the need for self-control, which led them to attempt resisting desires and successfully do so with greater frequency. Using the current design and analysis protocol, awareness of self-control opportunities necessarily contributed to the observed increases in frequency of self-regulatory attempts and successes, because an individual could only report attempting to resist a temptation if they also reported noticing the need to resist. Interestingly, despite resisting temptations more often, those in the self-regulation training reported exerting less effort in the process. These results highlight the importance for future research to measure the sequential components of self-control (e.g. awareness of dilemma, calculation of anticipated effort, attempt to regulate, allocation of effort, successful regulation; (Duckworth et al., 2017)) to more fully understand how self-regulatory interventions may operate.

Another interesting avenue for future research would be to investigate patterns of engagement with effort and demand-seeking over time. One possibility is that for those with a newly developed growth mindset, their engagement with effort may increase over time. One could imagine that a new growth mindset about self-regulation may be up against an entire personal history of effort avoidance, leading initially to an inconsistent exertion of effort. However, this exertion may become more consistent over time if the mindset gets strengthened by experiences that reinforce the possibility of growth through practice. It would also be interesting to explore whether any particular individual differences play a role in these trajectories over time.

Future work should also assess the effect of a growth mindset of self-regulation in various contexts with larger sample sizes. The present work suggests that a growth mindset of self-regulation can change attributions and allocation of effort in meaningful ways that may affect persistence and willingness to attempt challenging tasks. However, improvements emerged on some tasks and not others. The null effects observed could be due to actual boundary conditions, but there is also a possibility that they could be due to insufficient power. As the field moves toward using larger sample sizes in psychological studies, this research could also benefit from being conducted in more contexts with larger samples.

The current work suggests that a growth mindset of self-regulation consistently alters effort allocation and construal of fatigue. Additionally, there may be other key mechanisms to further explore when attempting to understand the effects of this mindset. Although no evidence of this type of effect was observed here (see also Job et al., 2010; Job, Walton, et al., 2015), it is possible that in some contexts a growth mindset might affect individuals' tendencies to experience effort. In addition, it might affect their expectations about how well they can exert the required effort for a task and their general efficacy for this type of exertion. Some preliminary findings do suggest that a growth mindset increases individuals' self-efficacy with regard to their ability to successfully self-regulate (see Supplemental Materials). This increased efficacy, among other variables, could play an important role in initiating and sustaining self-regulation, particularly for daunting tasks. Self-regulation measures can vary dramatically in nature—from inhibiting an impulse to sustainably pursuing a goal—and different

mediators may play greater or lesser roles depending on the nature of the self-regulatory task. Future research on growth mindset interventions to improve self-regulation should thus focus on a variety of possible mediating processes in order to evaluate and optimize the overall effectiveness of such interventions.

One example of an area for future research related to mindsets and self-regulation is the concept of flow, which is defined as intense involvement in a task, to the exclusion of other stimuli including self-awareness (Csikszentmihalyi, 1975; Magyaródi, Nagy, Soltész, Mózes, & Oláh, 2013). Indeed, Kool et al. (2010) have speculated that the pleasant state of flow may counterbalance the costs of exerting cognitive effort, leading individuals to seek more cognitively demanding tasks. Future research should investigate the relationship between a growth mindset of self-regulation and absorption states involved in the experience of flow. It is possible that a growth mindset could facilitate an absorbed, flow-like state by changing the experience and interpretation of effort, leading to greater focus on tasks and reduced effort avoidance. Preliminary data supports this possibility (see Supplemental Materials Study 5).

7.4. Conclusions

The present studies illustrate some benefits that can stem from promoting a growth mindset of self-regulation. Nonetheless, the observed improvements may represent only a modest preview of what could ultimately be achieved through interventions that skillfully promote adaptive mindsets, strategies, and behaviors. Our research suggests that to determine the extent to which self-regulation can be enhanced through training, it will be important for both individuals, and for the psychological scientists who study them, to move beyond the notion that self-regulation represents an enduring and fixed capacity. Recognizing self-regulation as something that can expand through practice may elicit the effort and perseverance required to effectively reach our most valued goals.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jesp.2018.07.003.

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