



OPEN ACCESS

EDITED BY

Filipe Manuel Clemente,
Polytechnic Institute of Viana do Castelo,
Portugal

REVIEWED BY

Samuel Honório,
Polytechnic Institute of Castelo Branco,
Portugal
Luis Alex Alzamora De Los Godos Urcia,
Cesar Vallejo University, Peru
Rui Sofia,
University of Minho, Portugal

*CORRESPONDENCE

Hermundur Sigmundsson
✉ Hermundur.sigmundsson@ntnu.no

RECEIVED 25 May 2024

ACCEPTED 21 October 2024

PUBLISHED 22 November 2024

CITATION

Sigmundsson H, Hauge H, Leversen JSR and Hage M (2024) I CAN intervention to increase grit and growth mindset: exploring the intervention for 15-year-olds Norwegian adolescents.

Front. Educ. 9:1438280.

doi: 10.3389/feduc.2024.1438280

COPYRIGHT

© 2024 Sigmundsson, Hauge, Leversen and Hage. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

I CAN intervention to increase grit and growth mindset: exploring the intervention for 15-year-olds Norwegian adolescents

Hermundur Sigmundsson^{1*}, Håvard Hauge¹,
Jonas S. R. Leversen¹ and Monika Hage²

¹Department of Psychology, Norwegian University of Science and Technology, Trondheim, Norway,

²Department of Teacher Education, Norwegian University of Science and Technology, Trondheim, Norway

The purpose of the current study was to examine the effects of a 2 × 45 min intervention to increase the beliefs of 'I CAN'. Four hundred and twenty-one 15-year-old students participated in this study. The participants were selected from 38 schools in Norway which carried out the program MOT. The adolescents were randomly selected to either an experimental group or control group. Both groups carried out an intervention program that was completely new for them. The experimental group carried out the new I CAN intervention and the control group carried out an intervention with focus on parts of the brain. The participants completed a pre-test assessment of the Grit-S Scale and Growth Mindset scale. This was followed up by the novel intervention I CAN for 256 of the participants (experimental group) and control intervention for 165 of the participants. The results showed a significant increase in Grit for the males in the experimental group. Our aim was to create an intervention where the participants would "turn on the switch," meaning that they develop stronger beliefs, i.e., changing beliefs. The results indicate that we may have been successful. These promising results are now being following up on high school students, age 16–19, in Norway.

KEYWORDS

I CAN, grit, growth mindset, adolescents, beliefs, learning, achievements

1 Introduction

Norwegian adolescents generally report having good quality of life. However, studies show concerning descending trends amongst youths' mental health with a noticeable increase in feelings of loneliness, stress, psychological discomfort (Ungdata, 2021), depression, and anxiety (Krokstad et al., 2022) and secondary school students often struggle with boredom and low motivation, where motivation hits its lowest point in 10th grade (NOU 2022:13, 2022).

To address these issues and work preventatively, the Norwegian Ministry of Education has prioritized mental health in schools. The overarching school curriculum emphasizes topics important for mental health, such as identity- and self-image development, and posits that these topics should be included in related school subjects (Ministry of Education and Research, 2017). However, the core curricula lack clear guidelines on how important health topics should be merged into subjects and how this could be practically worked with. Including vague descriptions of goals and concepts in curricula can lead to ineffective implementation of the objectives in practice (Herold, 2020). Given this matter and the mentioned descending trends, schools might benefit from targeted programs designed to enhance motivation and well-being.

Over the years, school interventions based on positive psychology have become popular to enhance youths' psychological resources (Sin and Lyubomirsky, 2009; Tejada-Gallardo et al., 2020). Meta-analyses reveal that positive psychological interventions have beneficial effects on adolescents' well-being, resilience and performance, and alleviate negative outcomes such as depression, stress and anxiety (Bolier et al., 2013; Carr et al., 2021; Waters, 2011).

To our knowledge, there is still no best practice on how positive psychological interventions should be developed and carried out. We recently conducted a pilot study ($N=38$, pre-post design), investigating whether a 35–40 min intervention could increase grit, mindset and self-efficacy in a sample of university students (Sigmundsson and Haga, 2024). The intervention was grounded in fundamental principles of learning, brain development and the significance of deliberate practice and perseverance. The results showed a significant increase in grit post-test, i.e., 8 weeks after the intervention.

In the current study, we base our intervention on the same theoretical framework as in the pilot study. As we collaborated with the ideal non-profit foundation, MOT.no,¹ the intervention also integrated principles from their intervention program, which is explained more thoroughly in the method section. As such, a novel 'positive psychological' intervention was developed, aiming to investigate its effect on grit and growth mindset in Norwegian adolescents.

2 MOT.no

MOT have been working with adolescents for over 25 years and have substantial pedagogical experience. MOT's main aim is to develop resilient adolescents and they are currently collaborating with 308 schools, reaching out to more than 77,000 adolescents across Norway. Their approach is practical and places emphasis on creating engagement and evoking positive emotions. Social learning theory (Bandura, 1977) is an important foundation for their work, and they value the use of positive feedback strongly. Their program is optional and schools that choose to participate in the program undergo a thorough integration process. This includes providing specialized training to teachers, ensuring that the program's core values are implemented within the educational environment. In this paper, teachers who have completed MOT's internal training with an emphasis on the program's values and ways of interacting with students are referred to as MOT coaches. MOT's program consists of 14 lessons in secondary school: six lessons in 8th grade, four lessons in 9th grade and four lessons in 10th grade. Each lesson lasts 120 min, a total of 28 h throughout secondary school. In 8th grade the lessons centers around: showing courage (Sept–Oct), the school class as a team (Sept–Oct), increased awareness of strengthening the good in myself and others (Oct), digital inclusion (Nov–Feb), intrinsic strength (March–April), importance of feeling valuable (March–June). In 9th grade the lessons focus on taking the right choices (Sept), choosing role models (Oct–Nov), having dreams (Jan–Feb), feeling good about myself (March–June). In 10th grade the lessons are with

the following focus: feeling secure (Aug–Oct), being conscious about your values (Dec), I CAN (Jan–March), your future (March–May).

3 Theoretical foundation for the intervention

3.1 Skill-and knowledge development

Firstly, the intervention is based on neuronal group selection theory (NGST), put forward by Edelman (1987). The theory purposes that the brain neuronal network (primary repertoire) is formed by a complex, probabilistic process between genes and internal-and external stimuli—highlighting the role of individual differences from an early stage (Edelman, 1993). With targeted training and experiences, the networks are reinforced, which serve a decisive role in developing further knowledge and skills (Edelman, 1987, 1993; Haga, 2008). Groups of neurons used frequently are strengthened through a re-entry process (frequent connection signaling) and neurons that are not adequately activated eventually decay (Hadders-Algra, 2000). Mainly, the formation of the neuronal groups in the brain depends on how frequently these specific brain circuits are activated (i.e., through use and repetition), however, our genes can also influence the group formation process.

This line of thinking is in consistent with the theory of probabilistic epigenesis (Gottlieb, 1998), which states that external stimuli, including environmental exposure, actions and behaviors shape neuronal networks and even affect individuals at a genetical level. Therefore, it is possible to argue that educational interventions that affect the school environment and how adolescents' take action may have long-lasting effects on adolescents behaviour (Gottlieb, 1998; Sigmundsson et al., 2017).

Secondly, the intervention place emphasis on the theory of deliberate practice, which focuses on learning and skill development (Ericsson et al., 1993). The theory states that considerable practice and experience is required to excel at a certain skill or knowledge (Ericsson et al., 1993), but the main contribution from Ericsson's work derives from *how* these hours in practise and experience should be spent. Practice needs to be effortful, specific, and individuals should get immediate feedback from the task at hand (Ericsson and Pool, 2016). Providing goal-directed training and follow-up in the skill/area/theme one wants to improve is also crucial. In this study's intervention, the importance of specificity and effort is taken care of by focusing on the need to put in high effort continuously over time in a limited area to achieve positive results (Ericsson et al., 1993). Others have also found support for the importance of specificity. Meta-analyses have revealed that skill-acquirement in one area is not transferable to other domain, even if the domains seem closely related (Kassai et al., 2019; Melby-Lervåg and Hulme, 2013). For instance, performance in different math tasks have shown to only be low-to moderately related to each other (Sigmundsson et al., 2013). Bearing this in mind, it can be important for adolescents to be aware of that mastering a new topic (e.g., geometry), requires specific training, even if they are already proficient in a related area (e.g., algebra).

3.2 Changing beliefs

A key aspect in skill and knowledge development and excellence seems to be the need of 'deliberate practice' in the sense of targeted

¹ <https://www.mot.no/>

specific training and follow-up (Ericsson et al., 1993; Ericsson and Pool, 2016), on the contrary, beliefs can be changed like ‘turning on a switch’ (Yeager et al., 2019; Sigmundsson and Haga, 2024). The neurological explanations could be related to greater activation of the amygdala (emotional processing) (Wing et al., 2018) increased focus, i.e., enhanced gamma synchrony (Wyart and Tallon-Baudry, 2008), or dopamine activity (Gershman and Uchida, 2019). In this respect, Vander Weele et al. (2018, p. 1) argue that: “dopamine may underlie a diversity of functions by modulating the signal-to-noise ratio in subpopulations of mPFC neurons.” With respect to our investigation, this may mean that interventions can alter adolescents’ beliefs by reducing debilitating self-doubt found in the emotional and decision-making processes in the mPFC. Heider (1958) argues that the factors “can” and “trying” may have an influence of behavioral outcomes. That is, “Can,” signals whether the goals could be reached or not. This is closely associated to the concept of power and ability of the individual, which might be linked to both grit (Duckworth, 2016) and growth mindset (Dweck, 2017). Moreover, “trying,” or the motivation to try, may be associated to passion for achievement or strong interest (Sigmundsson et al., 2020a, 2020b) and courage (Sigmundsson and Haga, 2024). Based on Heider’s (1958) view, the I CAN intervention could create belief that facilitates a person courage and willingness to take on new challenges (Sigmundsson et al., 2020a, 2020b). Additionally, research suggests that strong emotional experiences can induce lasting changes in brain function and behavior. Intense emotional experiences can activate the amygdala, a region involved in emotional processing, which enhances memory encoding and attention (Phelps, 2006). When the amygdala is strongly engaged, it can increase neuroplasticity—particularly in areas like the prefrontal cortex, responsible for decision-making and self-regulation (Cahill and McGaugh, 1998). This means that emotionally charged interventions, even brief ones, can facilitate changes in brain networks related to learning and mindset. The I CAN intervention leveraged this by creating motivational, emotionally resonant moments to reinforce beliefs about personal growth and perseverance, tapping into the brain’s ability to adapt after meaningful emotional stimuli.

4 Targets for intervention

The respective intervention chose to focus on two constructs that have been studied extensively—grit and mindset. Both constructs have been suggested to be important for adolescents health (Bashant, 2014; Pappano, 2013; Rege et al., 2021; Yeager and Dweck, 2023), and to have cultivation potential (Alan et al., 2019; Burnette et al., 2020; Eskreis-Winkler et al., 2016; Santos et al., 2021; Yeager et al., 2019).

4.1 Grit

Grit was developed as a predictor of achievement and has been defined as having perseverance and passion for long-term goals (Duckworth et al., 2007). Grit has been extensively studied in relation to students’ academic success, reflected in several published meta-analyses (Credé et al., 2017; Fernández-Martín et al., 2020; Lam and Zhou, 2019). Grit has been related to less problematic internet use (Maddi et al., 2013), as a protective factor against eating disorders

(Knauff et al., 2019), and linked to several other beneficial outcomes (see Datu, 2021).

Several studies also indicate that one subscale of grit—“perseverance of interest” (hereafter perseverance), is associated to how satisfied one is with life (Singh and Jha, 2008), various types of well-being (Disabato et al., 2016; Vainio and Daukantaitė, 2016), and engagement in general (Von Culin et al., 2014). Additionally, a recent meta-analysis revealed that grit contributed to unique variance in subjective well-being, after controlling for one of the big-five trait; conscientiousness (Hou et al., 2022). Although grit as a trait is heritable, a genetic study showed that about two thirds of the subscale perseverance is explained by non-shared environmental variance (Rimfeld et al., 2016).

Grit is also linked to executive functions of the brain (frontal cortex), which houses planning, inhibition, and decision-making (Hwang and Nam, 2021). This part of the brain is still developing in adolescents (Foulkes and Blakemore, 2018), and secondary school may therefore be a good time to improve grit by intervening (Hwang and Nam, 2021).

Although there has been much research on grit as a predictor and its association to other variables, the evidence on grit interventions are scarce (Hwang and Nam, 2021). However, a large study conducted nationally in Macedonia ($N=33,000$), found that enrolling 7th grade children 1h a week for 5 weeks, increased the one sub-scale, perseverance in the follow up assessments (Santos et al., 2021). Santos et al. (2021) also discovered that the effect was higher when teachers got involved with the intervention material. Another study, that has substantial theoretical overlap with our current investigation, found that an intervention focusing on improving mindset, deliberate practice and goal-setting, increased students math performance scores compared to the control group in a 2.5 years follow-up assessment (Alan et al., 2019). Lastly, Eskreis-Winkler et al. (2016) conducted an intervention aimed at increasing students deliberate practice performance, and found a post-test improvement in grade performance and willingness to work deliberately. Especially, the improved willingness to work harder is interesting because it demonstrates the practical potential of grit-based intervention in students.

4.2 Mindset

Mindset theory posits that an individual who hold an incremental or growth-oriented view, perceive their own abilities as malleable and views challenges as an opportunity for growth (Dweck, 2017). Contrary, entity theory or a fixed mindset defines how an individual believes that abilities and traits are innate (Dweck, 1999). According to Dweck (1998), a fixed mindset is associated with performance-oriented goals (i.e., sole focus on outcome) and avoidance of challenges in fear of failing.

Research suggests that holding a growth mindset is adaptive for adolescents, helping them to be less prone to mental health problems (Calvete et al., 2019; Tao et al., 2022), and improve their motivation (Ng, 2018; Rhew et al., 2018). A recent study also found that an intervention combining mindset theory and a ‘stress-as-adaptive’ view, made adolescents more resilient against stress (Yeager et al., 2022). As in line with grit, findings also indicate that mindset may be important for achievement

(Blackwell et al., 2007; Hochanadel and Finamore, 2015; Paunesku et al., 2015).

In recent years, mindset interventions have also gained a lot of interest. Across the US, large amount of money have been used to structurally enroll students into adopting a growth mindset (Macnamara and Burgoyne, 2023). That is, convincing the youth that abilities and personal characteristics are malleable.

Also in Norway, a large mindset program is ongoing to improve performance, school absence and completion rates among high school students (Rege et al., 2021). The projects' pilot study yielded promising results, where an intervention with two sessions at different time points made adolescents persevere longer at math tasks 3 weeks later, compared to the control group (Bettinger et al., 2018). However, the effects were solely accounted for by those who scored low on mindset at pre-test assessments. In the mindset literature, this is a reoccurring theme, that is, mindset interventions seem to primarily benefit those who score low on certain measures such as socio-economic status and grades (Sisk et al., 2018).

5 The current study

Earlier findings suggest that grit and mindsets' are related constructs (Hochanadel and Finamore, 2015; Sigmundsson et al., 2021; Tang et al., 2019). In fact, a longitudinal study measuring students grit and mindset at four time points across two school years discovered that grit and mindset was connected and mutually reinforcing across the different times of measuring (Park et al., 2020). Therefore, developing an intervention to increase both grit and mindset seems viable.

In our intervention, we aim to investigate the effects of a novel intervention named "I CAN," on 10th-grade students. The intervention aims at enhancing participants knowledge on; Brain-development and malleability to *affect mindset*; The importance of stimuli and repetition for building solid networks in the brain (Edelman, 1993; Kleim and Jones, 2008) to *promote perseverance*; and the importance of deliberate practice (Ericsson et al., 1993) for *reaching your potential*.

Based on these focus areas, we aim to answer the following question: Does a novel I CAN-intervention increase grit and growth mindset in adolescents?

6 Method

6.1 Sample

Four hundred and twenty-one 15-year-old students participated in this study. The participants were selected from 38 schools in Norway which carried out the program MOT. The adolescents were randomly selected to either an experimental group or control group. Both groups carried out an intervention program that was completely new for them. The experimental group carried out the new I CAN intervention and the control group carried out an intervention with focus on parts of the brain.

6.1.1 Experimental group

Two hundred and fifty-six students were code-matched and completed the pre-and post-questionnaire and the intervention. The

mean age of participants in this group was 15.05 years (SD = 0.50). The group consisted of 132 females (51.5%) and 120 males (47%) and four categorized themselves as "other/do not want to state" (1.5%).

6.1.2 Control group

One hundred and sixty-five students were code-matched and completing the pre-and post-assessment and the intervention. The mean age of participants in this group was 15.05 years (SD = 0.34). The group consisted of 80 females (48.5%) and 85 males (51.5%).

6.2 Measurements

6.2.1 Grit

To assess adolescents grit, the short grit scale (Grit-S) was deployed (Duckworth and Quinn, 2009). Grit-S is the most utilized Grit-scale and consists of two subscales, each containing four items. The first subscale—Perseverance of effort (PE), attempts to capture individual differences in sustained and effortful work despite hardships with items such as "I am a hard worker." The latter subscale, "consistency of interest" (CI) only contains reversed items and was developed to assess how passionate one is about goals over time with items such as "I often set goals, but later choose to pursue a different one" (Duckworth and Quinn, 2009). This subscale has been criticized for its incremental validity (Credé et al., 2017) and others have argued that the emotional component embedded in passion is missing in "consistency of interest" (Jachimowicz et al., 2018). As such, we decided to not only measure grit as two-factor construct, but also assess the two components separately in subsequent analyses.

6.2.2 Growth mindset scale

The Growth Mindset scale (Sigmundsson and Haga, 2024) was used to measure the participants level of Growth Mindset. The participants scored eight items, using the rating of 1 = not like me at all to 5 = very much like me. The 5-point Likert scale is one of the most commonly applied rating scales (Likert, 1932) and was used for possible comparison to other central factors related to motivational factors such as passion and grit. For an overview of the 8-items, see Table 1. The average maximum score on this scale is 5 (high Growth Mindset) and the lowest is 1 (low Growth Mindset).

Internal consistency: All individual item scores showed a positive correlation with the total score and ranged between 0.45 and 0.63. The

TABLE 1 Mean and standard deviation for pre-test in the experimental group ($n = 256$) and the control group ($n = 165$) for grit, perseverance of effort (PE), consistency of interest (CI) and growth mindset (GM).

	Pre-test		
	Experimental group	Control group	
	Mean group	Mean group	p^*
Grit	2.99 (0.56)	3.01 (0.54)	0.72
PE	3.41 (0.62)	3.34 (0.69)	0.28
CI	2.56 (0.77)	2.69 (0.77)	0.09
GM	4.15 (0.63)	4.16 (0.55)	0.87

Standard deviation in parenthesis, p^* = independent t-test.

Cronbach's alpha value was 0.83 for the standardized items for the same sample ($N=723$, mean age 29.84, $SD=13.06$).

Construct validity: Pearson's correlation coefficient between the total score of the Growth Mindset Scale and the total score of Theories of intelligence scale was $r=0.168$ ($p<0.001$). In this study Cronbach's alpha proved a good internal consistency ($\alpha=0.83$).

6.3 Procedure prior to the intervention

Adolescents from 80 MOT-affiliated schools, well-distributed across Norway, were invited to participate in the study. The selection criteria for these schools included (1) long-term affiliation with the MOT program, (2) a history of good response rates in collaboration with MOT, and (3) comprehensive implementation of MOT's holistic program (i.e., a whole-school approach). Out of these, 38 schools agreed to participate. They were entered into a random number generator, which was set to assign schools either as a number 1 (experimental group) or a number 2 (control group), aiming for an equal distribution between the two groups.

After randomization, the MOT coaches in the experimental and the teachers/MOT coaches in the control groups received separate training sessions due to differences in their respective PowerPoint presentations. The primary objective of these sessions was to optimize standardization the intervention, given that regular MOT lessons typically allow teachers considerable autonomy. Aside from the distinct PowerPoint presentations, the instructions were identical for both groups. It was also emphasized that adolescents could withdraw from the study at any time and the importance of adhering to the coding system.

6.4 Study design

The study followed to the Declaration of Helsinki's ethical guidelines and did not require collection of sensitive personal information, allowing for the use of passive consent as in line with the Norwegian Centre for Research Data (SIKT). Given that some participants were under the age of 15, consent letters were sent to their parents through teachers to ensure informed consent. The data was collected online on "nettskjema.no." The pre-test collected demographic information (age and gender) and responses on scales measuring Grit and Mindset. The post-test (8–9 weeks later) repeated the measurement of these scales to assess any changes. All adolescents were prompted to make an individual identification code, so that we could match their answers at post-test assessments.

6.5 The I CAN intervention

The intervention "I CAN" lasted about two school hours (90 min) and was carried out under the supervision of a MOT coach, who also was a teacher at the school. The start and end of the intervention included a slide of three bullet points which underlined the most important aspects for the adolescents to remember, being that:

- (1) You can achieve more than you realize if you invest sufficient effort.

This builds on the work of K.A. Ericsson regarding skill development. His theory of 'deliberate practice' argue that experts are made, not born. A key aspect of Ericsson's theory is that anyone can improve their skills or knowledge through deliberate practice (Ericsson et al., 2007; Ericsson and Pool, 2016). If we visualize the learning process in terms of increasing skill levels (see Figure 1), we find a continuum that ranges from Novice at one end to Expert at the other.

An individual which is currently at Level A in a skill he wishes to develop, is considered novice. For instance, when children begin school, their initial goal may be to learn the letters of the alphabet. A child might start by knowing two letters (novice), and through deliberate practice over time, they can learn additional letters. This process demonstrates that with practice, effort, and consistent interest, it is possible to progress to Level B. This perspective reflects a positive view of the learning process, as outlined in Eriksson's theory. It suggests that everyone has the potential to improve their skills and learn with the right training and support (Sigmundsson, 2024, p. 14). This concept also aligns with Angela Duckworth's theory of grit, which emphasizes the importance of perseverance in pursuing long-term goals. Grit is characterized by sustained effort and diligence, which contributes to the maintenance of effort and interest (Duckworth et al., 2007).

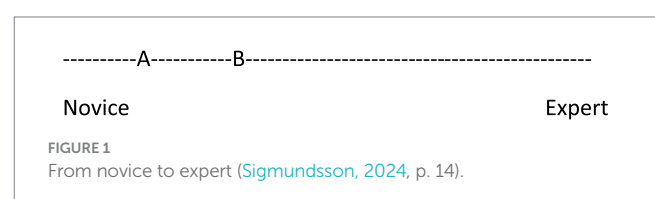
- (2) When faced with challenges, you can overcome them if you put your mind to it.

This aligns with Carol Dweck's theory of mindset, which emphasizes the importance of viewing challenges as opportunities rather than obstacles. Dweck's research highlights the belief in the malleability and development of personal attributes (Dweck and Yeager, 2019). A growth mindset (Dweck and Leggett, 1988), is essential for individuals to maintain focus and engage in sufficient practice and training (Sigmundsson et al., 2020a, 2020b).

- (3) Self-belief and a positive focus are keys to success.

We included self-belief and a positive focus as key elements because they are closely linked to self-efficacy (Dweck and Yeager, 2019; Bandura, 1977). High self-efficacy, defined as the belief in one's ability to accomplish tasks, is vital for approaching challenges with confidence and an open mind. When individuals believe in their potential for success, they are more likely to engage persistently with tasks, resulting in improved outcomes. These achievements, in turn, reinforce self-belief, creating a positive feedback loop in which confidence continually builds upon itself (Sigmundsson, 2024).

In, this way, self-efficacy and a positive mindset are crucial in shaping not only the outcomes of tasks but also future perceptions of one's capabilities. This is particularly important for the younger generation to address (Sigmundsson, 2024).



According to Csikszentmihalyi's framework (1975), the challenges we encounter should align with our individual skill levels and competencies. When this alignment occurs, we can experience a state of flow, which is vital for effective learning. In a flow state, individuals often feel a sense of mastery or self-efficacy, which enhances the belief of "I CAN." This belief serves as a powerful motivator for embracing new challenges.

To achieve optimal results, mentors—such as parents, trainers, or teachers—should select challenges that are appropriate for each individual. Identifying the right level of challenge may require assessing the child's skills and competencies (Sigmundsson, 2024, pp. 22–23). Achieving success necessitates a passion for achievement and grit or perseverance to pursue long-term goals. A greater passion fosters increased grit. The underlying mechanism for this relationship is the growth mindset (see Sigmundsson and Haga, 2024).

The intervention included:

- (1) Information about brain development, placing emphasis on the magnitude of brain cells and its development and different parts of the brain to elucidate that this combination lays an excellent foundation for learning. We instructed the teachers to articulate it in the following manner:

«In summary, we have an enormous number of brain cells and different parts of the brain that can solve countless tasks. This combination lays an excellent foundation for learning».

- (2) A significant emphasis on themes common in mindset-interventions, such as information about brain plasticity (Blackwell et al., 2007; Good et al., 2003; Yeager et al., 2014), and having a "not yet" mentality (Yeager et al., 2019).
- (3) The importance of deliberate practice. Drawing on Ericsson and Pool's work (2016), we used an example of how a university student, consistently employing deliberate practicing over time, went from recalling a string of seven digits (e.g., 3–4–1–5–6–4–2) to 82 digits. Since our intervention included several topics, we did not include principles of deliberate practice such as immediate feedback and guidance from a mentor, but rather focused on the importance of high-consistent effort for prolonged time periods, and that great results therefore also require patience.
- (4) Introduction to neuroplasticity, describing the remarkable capacity of the brain to reorganize and undergo changes in response to individual behavior. We used Maguire et al. (2000) example to demonstrate how sustained effort over time increased the hippocampal volume of taxi drivers who passed the exam (i.e., was able to increase 'the knowledge').
- (5) Inspirational stories, which MOT places great emphasis on; like that of a Norwegian snowboarder who succeeded despite having one hemisphere removed at the age of five due to a rare disease (i.e., Rasmussen's encephalitis), attempting to foster a belief in adolescents' ability to overcoming challenges and setbacks.
- (6) Utilizing metaphors such as "climbing your own ladder," to illustrate individual potential for improvement and acknowledging inherent differences in starting points, but not in endpoints.

- (7) Short in-between games or activities, often used by MOT to boost alertness and attention.
- (8) The creation of a personal 'reminder note,' where each participant wrote down the one thing from the intervention that resonated with them the most, which they were instructed to take home.

To maintain attentiveness, the intervention included short active breaks (see point 7 in Section 6.5) designed to boost alertness. This strategy is supported by research, such as Santos et al. (2021), which highlights the importance of interactive elements in maintaining engagement. Moreover, the intervention used relatable examples of students and teenagers to make the content relevant to the audience's age group. Complex concepts were made accessible through metaphors, such as "climbing your own ladder," to illustrate the potential for personal improvement over time, a method effective for engaging adolescents. These strategies helped ensure that students remained attentive and connected to the content.

6.6 The control intervention

The PowerPoint presentation "Our brain" provided students with basic information about the brain, a control design used in other interventions as well (Bettinger et al., 2018; Yeager et al., 2019). The main purpose was to give students information without any kind of encouragement, which is common in mindset control interventions (Macnamara and Burgoyne, 2023). The control intervention lasted about 45 min and included:

- (1) Explanation of how evolutionary brain development and how we gradually evolved into *homo sapiens* with a more complex brain structure.
- (2) How neurons function, its anatomical structure, including a mapping and pictures of dendrites, axons, cell bodies and synapses.
- (3) A simplistic explanation of the four different lobes in our brain, including its location and general function. Most of the time was spent on this section, and we used analogies to make it easier and only explained the most general functions of each lobe. An example includes:

"The frontal lobe may be considered as the main chief of your brain located in the front of your brain (with picture). It is responsible for several important things. The frontal lobe allows you to make decisions. When you must choose between studying for a test or watching a series, it is the frontal lobe that helps you make the decision. It also enables you to understand the consequences of your actions."

- (4) Short, general information about the cerebellum and the brainstem.
- (5) A short presentation of how different brain parts do not work in isolation. We used an example of how the occipital lobe and parietal lobe collaborate when perceiving pain.

6.7 Data analyses

The analysis was conducted using SPSS (version 29). To evaluate the differences between the pre-test and post-test results across grit and mindset, we used a paired sample t-test. A *p*-value of less than 0.05 was considered to indicate statistical significance.

7 Results

In **Table 1** we present the results from pre-test for experimental group and the control group.

TABLE 2 Mean and standard deviation for post-test in the experimental group (*n* = 256) and the control group (*n* = 165) for grit, perseverance of effort (PE), consistency of interest (CI) and growth mindset (GM).

Post-test			
	Experimental group	Control group	
	Mean group	Mean group	<i>p</i> *
Grit	3.03 (0.54)	3.03 (0.52)	1.0
PE	3.45 (0.64)	3.36 (0.64)	0.12
CI	2.60 (0.81)	2.70 (0.83)	0.22
GM	4.15 (0.65)	4.11 (0.65)	0.54

Standard deviation in parenthesis, *p** = independent t-test.

There was no significant difference between the groups in the pre-test.

In **Table 2** we present the results from post-test for experimental group and the control group. There were no significant differences between the groups in the post-test.

In **Table 3** we present the results from pre-test and post-test for experimental group. There were marginal significant differences (*p* = 0.06, Cohen's *d* = -0.076, 95% confidence interval -0.093 to 0.010) in grit for the group as a whole. The group scored higher in the post-test (2.99 versus 3.03). There was a significant difference between pre-test and the post-test for the males (*p* = 0.046, Cohen's *d* = -0.133, 95% confidence interval -0.312 to 0.047). The males scored higher in the post-test (3.07 versus 3.13). It is interesting to note that of total 12 scores for the groups as a whole, female and males 10 of the scoring were higher after the post-test (83%), one score was the same in pre-test and post-test and one was lower.

In **Table 4** we present the results from pre-test and post-test for the control group. There were no significant differences between pre-test and post-test in the variables for the group as a whole, female and male groups. Six scores out of total 12 scores for the groups, female and males was higher after the post-test (50%).

8 Discussion

The aim of the current investigation was to examine the effects of a novel intervention on grit and growth mindset, in collaboration with

TABLE 3 Mean and standard deviation for pre-and post-test in the experimental for the whole group (*n* = 256), females (*n* = 132) and males (*n* = 120), measuring grit, perseverance of effort (PE), consistency of interest (CI) and growth mindset (GM).

Experimental group									
Pre-test	Pre-test			Post-test					
	Mean group	Mean female	Mean male	Mean group	<i>p</i> *	Mean female	<i>p</i> *	Mean male	<i>p</i> *
Grit	2.99 (0.56)	2.93 (0.60)	3.07 (0.50)	3.03 (0.54)	0.058	2.96 (0.54)	0.24	3.13 (0.51)	0.046*
PE	3.41 (0.62)	3.38 (0.65)	3.48 (0.57)	3.45 (0.64)	0.16	3.41 (0.63)	0.23	3.51 (0.64)	0.31
CI	2.56 (0.77)	2.49 (0.79)	2.65 (0.73)	2.60 (0.81)	0.14	2.50 (0.81)	0.40	2.76 (0.79)	0.06
GM	4.15 (0.63)	4.11 (0.64)	4.20 (0.59)	4.15 (0.65)	0.49	4.15 (0.59)	0.23	4.17 (0.71)	0.25

Standard deviation in parenthesis, *p** = paired samples t-test (one-tailed). * = <0.05.

TABLE 4 Mean and standard deviation for pre-and post-test in the control group for the whole group (*n* = 165), females (*n* = 80) and males (*n* = 85), measuring grit, perseverance of effort (PE), consistency of interest (CI) and growth mindset (GM).

Control group									
Pre-test	Pre-test			Post-test					
	Mean group	Mean female	Mean male	Mean group	<i>p</i> *	Mean female	<i>p</i> *	Mean male	<i>p</i> *
Grit	3.01 (0.54)	2.95 (0.58)	3.08 (0.49)	3.03 (0.52)	0.38	2.91 (0.54)	0.16	3.14 (0.48)	0.093
PE	3.34 (0.69)	3.30 (0.65)	3.39 (0.73)	3.36 (0.64)	0.38	3.23 (0.67)	0.13	3.49 (0.58)	0.10
CI	2.69 (0.77)	2.60 (0.77)	2.77 (0.77)	2.70 (0.83)	0.46	2.59 (0.86)	0.41	2.80 (0.80)	0.36
GM	4.16 (0.55)	4.06 (0.56)	4.25 (0.53)	4.11 (0.65)	0.11	4.03 (0.71)	0.31	4.18 (0.57)	0.12

Standard deviation in parenthesis, *p** = paired samples t-test (one-tailed). * = <0.05.

the school organization MOT. Four hundred and twenty-one 15-year-old students participated in this study. Two hundred fifty-six adolescents were in the experimental group (I CAN intervention) and 165 participants were in the control group (Our brain intervention).

The main finding after the I CAN intervention was that the whole group had a marginal significant higher score in the construct grit and the males had a significant higher score in grit. So, it is possible to argue that we have been able to “turn on the switch.” A 2 × 45 min lesson seems to effect grit.

8.1 Experimental group

For the whole sample we found that three out of 4 scores (grit, perseverance of effort, PE, consistency of interest, CI) were higher after the intervention. One score, the growth mindset score, was the same in pre- and post-test. In females, four out of 4 scores (grit, PE, CI, GM) were higher in the post-test than the pre-test, however, none of these improvements were significant. In the male group, three of 4 scores (grit, PE, CI) were higher after the intervention. However, only grit was significantly higher ($p = 0.046$). The score for growth mindset was lower in the post-test than the pre-test.

It is interesting to note that males had significantly higher score after the post-test in the construct grit. Yeager et al. (2019) found in his study that mindset intervention with over 12,000 students mainly benefited lower-achieving students. Adolescents' boys are clearly having more academic challenges in schools compared to females in Norway (OECD, 2023). In reading comprehension, 34% of the males have challenge (i.e., under level 2), which indicate that they have problems related to understanding the text they read, while in girls this group is about 20%. It is therefore possible to speculate it there is a larger unlocked potential in males than females.

The observed gender difference might also be explained by grit's relation to passion. In a study exploring gender differences, Sigmundsson et al. (2021) found that grit was highly correlated to passion in males, but only moderately correlated in females. In our intervention, we used a substantial amount of time to emphasize the different aspects and value of reaching a high level in an area. To make sense of this information, you might need a specific interest such as hobby or a theme you are dedicated to or engaged in, which is more common for males to have (Su et al., 2009). Therefore, the intervention may have been tailored more toward males and affected their grit levels differently. If this is the case, future interventions should pay attention to how the material might affect different groups differently. Either way, these results are promising and may indicate that I CAN is an intervention that potentially can increase grit in participants, consequently building more robust individuals.

8.2 Control group

All the scores in the control group were non-significant at post-test assessments. At post-test, half of the scores were higher (compared to the pre-test), and half of the scores were lower. Therefore, it does not seem like the control intervention led to a systematic improvement in grit or mindset. However, in the male control group, we observed an increase in grit at post-test. Although the increase was

non-significant in males, the post-test was trending toward significance. Since the control intervention only included information about brain evolution and different brain parts, we do not see any reason as to why the intervention should be more beneficial for boys. However, an explanation for this increase may be that boys leverage more from school breaks compared to girls. As mentioned, boys perform worse academically (OECD, 2023) and could welcome the intervention as a positive break from the common school day. However, reports suggest that adolescent boys in Norway are generally more satisfied with life (Bakken, 2022). This may be related to gender differences on how time is spent outside of school. Since the pre-test was conducted before Christmas holiday, and the post-test the first 2 weeks after the Christmas-holiday, boys may have spent time in ways that make them more inclined to feel motivated, and therefore score higher at post-test assessments.

8.3 Effects on mindset

There are some possible reasons as to why there were no increase in mindset. One explanation might be that students in affiliation with MOT already have had their mindset levels influenced by previous MOT lessons. Adolescents' mindset may also have been inspired by the teachers. According to Hecht et al. (2021), school environment affects mindset and supportive teachers who already hold a growth mindset may affect their student's mindset positively. This might especially be the case in our study, since the intervention was solely conducted by MOT coaches who have had psychosocial training by MOT before the intervention. Also, mindset interventions primarily seem to benefit those who struggle at school. In our study, we did not measure grades or socioeconomic background. As such, our targeted group may not have been at risk and therefore harder to affect positively.

Further, the current one-lesson intervention design may also be too short to observe a mindset increase. Although previous research has found effects on mindset after just a single intervention (Yeager et al., 2019), these interventions were solely mindset orientated. As we focused on several aspects, this may have caused an insufficient focus time on mindset to observe an effect. Lastly, scholars have stated that rational facts are not the primary force to belief change. Rather, belief change should be regarded as a transaction, where it is most likely that change occurs when it is beneficial for the person itself (Sharot et al., 2023). In our intervention, we mainly discussed what brain plasticity is and examples of how ordinary people with a growth mindset achieved extraordinary results. Therefore, we could possibly have affected adolescents more if time was spent on explaining how a growth mindset could benefit them in their everyday life, such as experiencing more motivation, positive emotions and advancement in areas they care about.

9 Limitations

In our intervention study, there are some shortcomings. The study design only allowed for an evaluation of possible effects 8–9 weeks after the intervention. Some may argue that it is favorable to do follow-up measurements (i.e., several waves)

months or years after the initial intervention, to investigate longitudinal effects. Further, there might have been some problems with implementation fidelity. The MOT coaches who conducted the interventions are used to improvise and draw upon own experiences when they are conducting regular MOT-sessions. Although we instructed the teachers to follow the manuscript for the intervention as rigorously as possible, we do not have any guarantee that the teachers successfully managed to adapt and this could have affected the interventions' utility across classrooms (Carroll et al., 2007). Our study design included a somewhat close collaboration with MOT coaches, with digital training 1 week before the intervention, including use of a manuscript they had to learn, and a classroom intervention. Such a design may be challenging to replicate and scale up for other schools who are not part of an external school program.

It is possible to argue that the intervention of the control group should not have focused on the brain at all. That might be done different in further studies. However as pointed out in section 6.6 the students did not get any form of encouragement in the control group. Lastly, it may be argued that a limitation of the study is the number of participants. Our research group is planning to conduct an intervention with high school students (16–19 years), where we aim at 500 participants in each condition (experimental and control), using the most essential measures from our pilot study in grit and growth mindset (Sigmundsson and Haga, 2024).

10 Conclusion

By applying a novel 'I CAN' intervention on 10th graders, we observed a significant increase in grit for the male group and a marginal significant effect on grit for the entire group. Additionally, in the experimental group, 10 out of 12 scores improved in the post-test assessment, whereas only six out of 12 scores improved in the control group. As an exploratory study, this research represents an early step in understanding how the I CAN intervention affects grit and growth mindset. While promising, especially for males, it highlights the need for further investigation, particularly on how to more effectively engage girls. The intervention's simplicity—a PowerPoint presentation—makes it easy to scale, cost-effective, and adaptable to various educational settings. However, future studies could explore alternative approaches to better target female students, such as incorporating content that resonates more with their interests or needs. This could enhance the intervention's overall efficacy and ensure broader gender inclusivity.

References

- Alan, S., Boneva, T., and Ertac, S. (2019). Ever failed, try again, succeed better: results from a randomized educational intervention on grit*. *Q. J. Econ.* 134, 1121–1162. doi: 10.1093/qje/qjz006
- Bakken, A. (2022). Ungdata 2022. Nasjonale resultater. In 62 [Report]. NOVA/OsloMet. Available at: <https://oda.oslomet.no/oda-xmlui/handle/11250/3011548> (Accessed January 10, 2024).
- Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychol. Rev.* 84, 191–215. doi: 10.1037/0033-295X.84.2.191
- Bashant, J. (2014). Developing grit in our students: why grit is such a desirable trait, and practical strategies for teachers and schools. *J. Leader. Instr.* 13, 14–17.
- Bettinger, E., Ludvigsen, S., Rege, M., Solli, I. F., and Yeager, D. (2018). Increasing perseverance in math: evidence from a field experiment in Norway. *J. Econ. Behav. Organ.* 146, 1–15. doi: 10.1016/j.jebo.2017.11.032
- Blackwell, L. S., Trzesniewski, K. H., and Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: a longitudinal study and an intervention. *Child Dev.* 78, 246–263. doi: 10.1111/j.1467-8624.2007.00995.x
- Bolier, L., Haverman, M., Westerhof, G. J., Riper, H., Smit, F., and Bohlmeijer, E. (2013). Positive psychology interventions: a meta-analysis of randomized controlled studies. *BMC Public Health* 13:119. doi: 10.1186/1471-2458-13-119
- Burnette, J. L., Knouse, L. E., Vavra, D. T., O'Boyle, E., and Brooks, M. A. (2020). Growth mindsets and psychological distress: a meta-analysis. *Clin. Psychol. Rev.* 77:101816. doi: 10.1016/j.cpr.2020.101816
- Cahill, L., and McGaugh, J. L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends Neurosci.* 21, 294–299.
- Calvete, E., Fernández-Gonzalez, L., Orue, I., Echezarraga, A., Royuela-Colomer, E., Cortazar, N., et al. (2019). The effect of an intervention teaching adolescents that people

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Ethics statement

Ethical approval was not required for the study involving human samples in accordance with the local legislation and institutional requirements because no personal data was collected. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

HS: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. HH: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. JL: Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. MH: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

- can change on depressive symptoms, cognitive schemas, and hypothalamic-pituitary-adrenal axis hormones. *J. Abnorm. Child Psychol.* 47, 1533–1546. doi: 10.1007/s10802-019-00538-1
- Carr, A., Cullen, K., Keeney, C., Canning, C., Mooney, O., Chinsellaigh, E., et al. (2021). Effectiveness of positive psychology interventions: a systematic review and meta-analysis. *J. Posit. Psychol.* 16, 749–769. doi: 10.1080/17439760.2020.1818807
- Carroll, C., Patterson, M., Wood, S., Booth, A., Rick, J., and Balain, S. (2007). A conceptual framework for implementation fidelity. *Implement. Sci.* 2:40. doi: 10.1186/1748-5908-2-40
- Credé, M., Tynan, M. C., and Harms, P. D. (2017). Much ado about grit: a meta-analytic synthesis of the grit literature. *J. Pers. Soc. Psychol.* 113, 492–511. doi: 10.1037/pspp0000102
- Csikszentmihalyi, M. (1975, 1975). *Beyond boredom and anxiety*. San Francisco, CA, USA: Jossey-Bass.
- Datu, J. A. D. (2021). Beyond passion and perseverance: review and future research initiatives on the science of grit. *Front. Psychol.* 11:545526. doi: 10.3389/fpsyg.2020.545526
- Disabato, D. J., Goodman, F. R., Kashdan, T. B., Short, J. L., and Jarden, A. (2016). Different types of well-being? A cross-cultural examination of hedonic and eudaimonic well-being. *Psychol. Assess.* 28, 471–482. doi: 10.1037/pas0000209
- Duckworth, A. L., Peterson, C., Matthews, M. D., and Kelly, D. R. (2007). Grit: perseverance and passion for long-term goals. *J. Pers. Soc. Psychol.* 92, 1087–1101. doi: 10.1037/0022-3514.92.6.1087
- Duckworth, A. L., and Quinn, P. D. (2009). Development and validation of the short grit scale (GRIT-S). *J. Pers. Assess.* 91, 166–174. doi: 10.1080/00223890802634290
- Duckworth, A. (2016). *Grit: The Power of Passion and Perseverance*. New York, NY, USA: Scribner. 234.
- Dweck, C. S. (1998). The development of early self-conceptions: their relevance for motivational processes. eds. J. Heckhausen and C. S. Dweck. *Motivation and self-regulation across the life span* Cambridge University Press, 257–280. doi: 10.1017/CBO9780511527869.012
- Dweck, C. S. (1999). *Self-theories: their role in motivation, personality, and development*. Philadelphia: Psychology Press, xiii, 195.
- Dweck, C. (2017). *Changing the way you think to fulfil your potential*. Hachette, UK: Little, Brown Book Group.
- Dweck, C. S., and Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychol. Rev.* 95, 256–273. doi: 10.1037/0033-295X.95.2.256
- Dweck, C. S., and Yeager, D. S. (2019). Mindsets: A view from two eras. *Perspect. Psychol. Sci.* 14, 481–496.
- Edelman, G. M. (1987). *Neural Darwinism: the theory of neuronal group selection*. Basic Books, New York: Basic Books, xxii, 371.
- Edelman, G. M. (1993). Neural Darwinism: selection and reentrant signaling in higher brain function. *Neuron* 10, 115–125. doi: 10.1016/0896-6273(93)90304-A
- Ericsson, K. A., Krampe, R. T., and Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. *Psychol. Rev.* 100, 363–406. doi: 10.1037/0033-295X.100.3.363
- Ericsson, A., and Pool, R. (2016). *Peak: secrets from the new science of expertise*. Random House.
- Ericsson, K. A., Prietula, M. J., and Cokely, E. T. (2007). The making of an expert. *Harv. Bus. Rev.* 85, 114–21, 193
- Eskreis-Winkler, L., Shulman, E. P., Young, V., Tsukayama, E., Brunwasser, S. M., and Duckworth, A. L. (2016). Using wise interventions to motivate deliberate practice. *J. Pers. Soc. Psychol.* 111, 728–744. doi: 10.1037/pspp0000074
- Fernández-Martín, F. D., Arco-Tirado, J. L., and Hervás-Torres, M. (2020). Grit as a predictor and outcome of educational, professional, and personal success: a systematic review. *Educ. Psychol.* 26, 163–173. doi: 10.5093/psed2020a11
- Foulkes, L., and Blakemore, S.-J. (2018). Studying individual differences in human adolescent brain development. *Nat. Neurosci.* 21, 315–323. doi: 10.1038/s41593-018-0078-4
- Gershman, S. J., and Uchida, N. (2019). Believing in dopamine. *Nat. Rev. Neurosci.* 20, 703–714. doi: 10.1038/s41583-019-0220-7
- Good, C., Aronson, J., and Inzlicht, M. (2003). Improving adolescents' standardized test performance: an intervention to reduce the effects of stereotype threat. *J. Appl. Dev. Psychol.* 24, 645–662. doi: 10.1016/j.appdev.2003.09.002
- Gottlieb, G. (1998). Normally occurring environmental and behavioral influences on gene activity: from central dogma to probabilistic epigenesis. *Psychol. Rev.* 105, 792–802. doi: 10.1037/0033-295X.105.4.792-802
- Hadders-Algra, M. (2000). The neuronal group selection theory: promising principles for understanding and treating developmental motor disorders. *Dev. Med. Child Neurol.* 42, 707–715. doi: 10.1111/j.1469-8749.2000.tb00687.x
- Haga, M. (2008). The relationship between physical fitness and motor competence in children. *Child Care Health Dev.* 34, 329–334. doi: 10.1111/j.1365-2214.2008.00814.x
- Hecht, C. A., Yeager, D. S., Dweck, C. S., and Murphy, M. C. (2021). “Beliefs, affordances, and adolescent development: lessons from a decade of growth mindset interventions” in *Advances in child development and behavior*, vol. 61 (JAD), 169–197. doi: 10.1016/bs.acdb.2021.04.004
- Heider, F. (1958). *The Psychology of Interpersonal Relations*. 9, 326. Hoboken, NJ, USA: John Wiley and Sons Inc.
- Herold, F. (2020). “There is new wording, but there is no real change in what we deliver”: Implementing the new National Curriculum for Physical Education in England. *Eur. Phys. Educ. Rev.* 26, 920–937.
- Hochanadel, A., and Finamore, D. (2015). Fixed and growth mindset in education and how grit helps students persist in the face of adversity. *J. Int. Educ. Res.* 11, 47–50. doi: 10.19030/jier.v11i11.9099
- Hou, X.-L., Becker, N., Hu, T.-Q., Koch, M., Xi, J.-Z., and Möttus, R. (2022). Do grittier people have greater subjective well-being? A meta-analysis. *Personal. Soc. Psychol. Bull.* 48, 1701–1716. doi: 10.1177/01461672211053453
- Hwang, M.-H., and Nam, J. K. (2021). Enhancing grit: possibility and intervention strategies. In Zyll, E. van, C. Olckers and L. van der Vaart (Eds.), *Multidisciplinary perspectives on grit: contemporary theories, assessments, applications and critiques* (pp. 77–93). Springer Nature: Springer International Publishing.
- Jachimowicz, J. M., Wihler, A., Bailey, E. R., and Galinsky, A. D. (2018). Why grit requires perseverance and passion to positively predict performance. *Proc. Natl. Acad. Sci. U. S. A.* 115, 9980–9985. doi: 10.1073/pnas.1803561115
- Kassai, R., Futo, J., Demetrovics, Z., and Takacs, Z. K. (2019). A meta-analysis of the experimental evidence on the near-and far-transfer effects among children's executive function skills. *Psychol. Bull.* 145, 165–188. doi: 10.1037/bul0000180
- Kleim, J. A., and Jones, T. A. (2008). Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage. *J. Speech Lang. Hear. Res.* 51, S225–S239. doi: 10.1044/1092-4388(2008)018
- Knauff, K., Ortiz, S., Velkoff, E., Smith, A., and Kalia, V. (2019). Keep calm and carry on? Grit buffers against disordered eating unless expressive suppression is used to regulate emotions. *J. Soc. Clin. Psychol.* 38, 321–342. doi: 10.1521/jscp.2019.38.4.321
- Krokstad, S., Weiss, D. A., Krokstad, M. A., Rangul, V., Kvaløy, K., Ingul, J. M., et al. (2022). Divergent decennial trends in mental health according to age reveal poorer mental health for young people: repeated cross-sectional population-based surveys from the HUNT study, Norway. *BMJ Open* 12:e057654. doi: 10.1136/bmjopen-2021-057654
- Lam, K. K. L., and Zhou, M. (2019). Examining the relationship between grit and academic achievement within K-12 and higher education: a systematic review. *Psychol. Sci.* 56, 1654–1686. doi: 10.1002/pits.22302
- Likert, R. (1932). A technique for the measurement of attitudes. *Arch. Psychol.* 22:55.
- Macnamara, B. N., and Burgoyne, A. P. (2023). Do growth mindset interventions impact students' academic achievement? A systematic review and meta-analysis with recommendations for best practices. *Psychol. Bull.* 149, 133–173. doi: 10.1037/bul0000352
- Maddi, S. R., Erwin, L. M., Carmody, C. L., Villarreal, B. J., White, M., and Gundersen, K. K. (2013). Relationship of hardiness, grit, and emotional intelligence to internet addiction, excessive consumer spending, and gambling. *J. Posit. Psychol.* 8, 128–134. doi: 10.1080/17439760.2012.758306
- Maguire, E. A., Gadian, D. G., Johnsrude, I. S., Good, C. D., Ashburner, J., Frackowiak, R. S. J., et al. (2000). Navigation-related structural change in the hippocampi of taxi drivers. *Proc. Natl. Acad. Sci.* 97, 4398–4403. doi: 10.1073/pnas.070039597
- Melby-Lervåg, M., and Hulme, C. (2013). Is working memory training effective? A meta-analytic review. *Dev. Psychol.* 49, 270–291. doi: 10.1037/a0028228
- Ministry of Education and Research. (2017). *Verdier og prinsipper for grunnopplæringen—Overordnet del av læreplanverket. Fastsett som forskrift ved kongelig resolusjon. Læreplanverket for Kunnskapsløftet 2020*. Available at: <https://www.regjeringen.no/no/dokumenter/verdier-og-prinsipper-for-grunnoppleringen/id25700003/> (Accessed January 10, 2024).
- Ng, B. (2018). The neuroscience of growth mindset and intrinsic motivation. *Brain Sci.* 8:2. doi: 10.3390/brainsci8020020
- NOU 2022:13. (2022). Available at: <https://www.regjeringen.no/no/dokumenter/nou-2022-13/id2929000/> (Accessed January 17, 2024).
- OECD. (2023). *PISA 2022 results (volume I): the state of learning and equity in education*. Organisation for Economic Co-operation and Development. Available at: https://www.oecd-ilibrary.org/education/pisa-2022-results-volume-i_53f23881-en (Accessed January 17, 2024).
- Pappano, L. (2013). *Harvard education letter*. Available at: <https://intellectualvirtues.org/wp-content/uploads/2013/01/Harvard-Ed-Letter-on-the-New-Character-Ed.pdf> (Accessed January 12, 2024).
- Park, D., Tsukayama, E., Yu, A., and Duckworth, A. L. (2020). The development of grit and growth mindset during adolescence. *J. Exp. Child Psychol.* 198:104889. doi: 10.1016/j.jecp.2020.104889

- Paunesku, D., Walton, G. M., Romero, C., Smith, E. N., Yeager, D. S., and Dweck, C. S. (2015). Mind-set interventions are a scalable treatment for academic underachievement. *Psychol. Sci.* 26, 784–793. doi: 10.1177/0956797615571017
- Phelps, E. A. (2006). Emotion and cognition: insights from studies of the human amygdala. *Annu. Rev. Psychol.*, 57, 27–53.
- Rege, M., Hanselman, P., Solli, I. F., Dweck, C. S., Ludvigsen, S., Bettinger, E., et al. (2021). How can we inspire nations of learners? Investigating growth mindset and challenge-seeking in two countries. *Am. Psychol.* 76, 755–767. doi: 10.1037/amp0000647
- Rhew, E., Piro, J. S., Goolkasian, P., and Cosentino, P. (2018). The effects of a growth mindset on self-efficacy and motivation. *Cog. Educ.* 5:1492337. doi: 10.1080/2331186X.2018.1492337
- Rimfeld, K., Kovas, Y., Dale, P. S., and Plomin, R. (2016). True grit and genetics: predicting academic achievement from personality. *J. Pers. Soc. Psychol.* 111, 780–789. doi: 10.1037/pspp0000089
- Santos, I., Petroska-Beska, V., Carneiro, P., Eskreis-Winkler, L., Munoz Boudet, A. M., Berniell, I., et al. (2021). Can grit be taught? Lessons from a nationwide field experiment with middle-school students. Policy Research Working Paper; No. 9831. © World Bank, Washington, DC. Available at: <http://hdl.handle.net/10986/36482>
- Sharot, T., Rollwage, M., Sunstein, C. R., and Fleming, S. M. (2023). Why and when beliefs change. *Perspect. Psychol. Sci.* 18, 142–151. doi: 10.1177/17456916221082967
- Sigmundsson, H. (2024). How we learn and become experts. Lighting the spark. Springer Nature: Springer.
- Sigmundsson, H., Guðnason, S., and Jóhannsdóttir, S. (2021). Passion, grit and mindset: exploring gender differences. *New Ideas Psychol.* 63:100878. doi: 10.1016/j.newideapsych.2021.100878
- Sigmundsson, H., Haga, M., and Hermundsdottir, F. (2020a). The passion scale: aspects of reliability and validity of a new 8-item scale assessing passion. *New Ideas Psychol.* 56:100745. doi: 10.1016/j.newideapsych.2019.06.001
- Sigmundsson, H., Haga, M., and Hermundsdottir, F. (2020b). Passion, grit and mindset in young adults: exploring the relationship and gender differences. *New Ideas Psychol.* 59:100795. doi: 10.1016/j.newideapsych.2020.100795
- Sigmundsson, H., and Haga, H. (2024). Growth mindset scale: aspects of reliability and validity of a new 8-item scale assessing growth mindset. *New Ideas Psychol.* 75:101111. doi: 10.3390/brainsci14010033
- Sigmundsson, H., Polman, R. C. J., and Lorås, H. (2013). Exploring individual differences in Children's mathematical skills: a correlational and dimensional approach. *Psychol. Rep.* 113, 23–30. doi: 10.2466/04.10.PR0.113x12z2
- Sigmundsson, H., Trana, L., Polman, R., and Haga, M. (2017). What is trained develops! Theoretical perspective on skill learning. *Sports* 5:38. doi: 10.3390/sports5020038
- Sin, N. L., and Lyubomirsky, S. (2009). Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: a practice-friendly meta-analysis. *J. Clin. Psychol.* 65, 467–487. doi: 10.1002/jclp.20593
- Singh, K., and Jha, S. D. (2008). Positive and negative affect, and grit as predictors of happiness and life satisfaction. *J. Indian Acad. Appl. Psychol.* 34, 40–45.
- Sisk, V. F., Burgoyne, A. P., Sun, J., Butler, J. L., and Macnamara, B. N. (2018). To what extent and under which circumstances are growth mind-sets important to academic achievement? Two meta-analyses. *Psychol. Sci.* 29, 549–571. doi: 10.1177/0956797617739704
- Su, R., Rounds, J., and Armstrong, P. (2009). Men and things, women and people: a meta-analysis of sex differences in interests. *Psychol. Bull.* 135, 859–884. doi: 10.1037/a0017364
- Tang, X., Wang, M.-T., Guo, J., and Salmela-Aro, K. (2019). Building grit: the longitudinal pathways between mindset, commitment, grit, and academic outcomes. *J. Youth Adolesc.* 48, 850–863. doi: 10.1007/s10964-019-00998-0
- Tao, W., Zhao, D., Yue, H., Horton, I., Tian, X., Xu, Z., et al. (2022). The influence of growth mindset on the mental health and life events of college students. *Front. Psychol.* 13:821206. doi: 10.3389/fpsyg.2022.821206
- Tejada-Gallardo, C., Blasco-Belled, A., Torrelles-Nadal, C., and Alsinet, C. (2020). Effects of school-based multicomponent positive psychology interventions on well-being and distress in adolescents: a systematic review and meta-analysis. *J. Youth Adolesc.* 49, 1943–1960. doi: 10.1007/s10964-020-01289-9
- Ungdata. (2021). Stress, press og psykiske plager blant unge. Available at: <https://www.ungdata.no/stress-press-og-psykiske-plager-blant-unge/>. (Accessed February 15, 2024).
- Vainio, M. M., and Daukantaitė, D. (2016). Grit and different aspects of well-being: direct and indirect relationships via sense of coherence and authenticity. *J. Happiness Stud.* 17, 2119–2147. doi: 10.1007/s10902-015-9688-7
- Vander Weele, C. M., Siciliano, C. A., Matthews, G. A., Namburi, P., Izadmehr, E. M., Espinel, I. C., et al. (2018). Dopamine enhances signal-to-noise ratio in cortical-brainstem encoding of aversive stimuli. *Nature* 563, 397–401. doi: 10.1038/s41586-018-0682-1
- Von Culin, K. R., Tsukayama, E., and Duckworth, A. L. (2014). Unpacking grit: Motivational correlates of perseverance and passion for long-term goals. *J. Posit. Psychol.* 9, 306–312.
- Waters, L. (2011). A review of school-based positive psychology interventions. *Aust. Educ. Dev. Psychol.* 28, 75–90. doi: 10.1375/aedp.28.2.75
- Wing, E. A., Iyengar, V., Hess, T. M., LaBar, K. S., Huettel, S. A., and Cabeza, R. (2018). Neural mechanisms underlying subsequent memory for personal beliefs: an fMRI study. *Cogn. Affect. Behav. Neurosci.* 18, 216–231. doi: 10.3758/s13415-018-0563-y
- Wyart, V., and Tallon-Baudry, C. (2008). Neural dissociation between visual awareness and spatial attention. *J. Neurosci.* 28, 2667–2679. doi: 10.1523/JNEUROSCI.4748-07.2008
- Yeager, D. S., Bryan, C. J., Gross, J. J., Murray, J. S., Krettek Cobb, D., Santos, P. H. F., et al. (2022). A synergistic mindsets intervention protects adolescents from stress. *Nature* 607, 512–520. doi: 10.1038/s41586-022-04907-7
- Yeager, D. S., and Dweck, C. S. (2023). Mindsets and adolescent mental health. *Nat. Mental Health* 1, 79–81. doi: 10.1038/s44220-022-00009-5
- Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., et al. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature* 573, 364–369. doi: 10.1038/s41586-019-1466-y
- Yeager, D. S., Purdie-Vaughns, V., Garcia, J., Apfel, N., Brzustoski, P., Master, A., et al. (2014). Breaking the cycle of mistrust: wise interventions to provide critical feedback across the racial divide. *J. Exp. Psychol. Gen.* 143, 804–824. doi: 10.1037/a0033906