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MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

„Truly implicit, implicit theories of intelligence - Metacognition as a moderator on the relationship between growth mindset and effort“

verfasst von / submitted by

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Disclaimer

This study was designed as a follow up study to the work of Sik et al. (in prep.) and the work of myself as part of a team of master students under Univ.-Prof. Dr. Veronika Job Sutnar during the summer and winter semesters of 2022 at the University of Vienna. The main goal of these studies was the implicit measurement of growth mindset, which was proposed by Cummins and De Houwer (2021). After the conclusion of the previous study in February of 2022 our Supervisor Kata Sik began the design of this study. As the study was planned with a German speaking sample size in mind, Ulrich Rozanski, BSc and Julia Weiß, BSc translated the scales used in this study into German in September 2022. Data collection began at the start of October and ran for six weeks until the 11th of November. Julia Weiß, BSc, and myself worked together to perform the data analysis using the free statistical program R (R core team, 2022).

I hereby declare that this master thesis is my own and autonomous work. All sources and aids used have been indicated as such. All texts either quoted directly or paraphrased have been indicated by in-text citations. Full bibliographic details are given in the reference list which also contains internet sources containing URL and access date. This work has not been submitted to any other examination authority.

Introduction

Have you or others you know of ever struggled to learn a seemingly difficult task? Like for example math homework back in elementary school or riding a bicycle? Of course, these tasks might seem trivial to adults nowadays, but some might have struggled with these or similar tasks back in the day before mastering them. But how exactly did they manage to learn them? Maybe some managed to come up with some sort of study plan or revisited test examples in their textbooks. Possibly they were able to monitor their progress over time or evaluated their achievements bit by bit. Or maybe some sought help from friends or a parent to identify and reflect about what they did wrong. Afterall, the excuse that a dog had anything to do with it only works a couple of times at best.

Planning, monitoring, evaluation, testing and revision are known to be a part of metacognition (Baker & Brown, 1980). It is the thinking about one's own cognition and is already taught to students in school. Learning strategies, the approach to a problem to reach a solution, awareness of the learning progress and critical thinking are all part of a metacognitive skill set. These skills can make learning easier due to a better management of behavior and information (Coutinho, 2007). Therefore it might not be a surprise that metacognition has been linked to academic success before (Zulkiply, 2006; Coutinho, 2007) and can play a major role in topics related to learning.

Now thinking back to previous struggles to master a new skill. Maybe in addition to these skills some were encouraged along the way by friends or teachers to keep on trying, to assure them that they can master these tasks eventually. This belief that continuous effort can lead to an improvement in skills is in turn known as a growth mindset. It is an implicit belief that experience, mentoring and learning strategies can be used to develop and improve intelligence and other skills (Dweck, 2006; Dweck & Yaeger, 2019). It is a widely studied area of research that began several decades ago (Diener & Dweck, 1978). The established way to measure the growth mindset of a participant is the usage of questionnaires. Some commonly used examples are the Implicit Theory of Intelligence Scale (Dweck, 2000) and the Three-item growth mindset scale from Dweck et al. (1995). Although the usability of these scales has been called adequate (Rammstedt et al., 2022), some authors

have expressed doubt that all of the items fit a unidimensional model (Midkiff et al., 2017; Troche & Kunz, 2020). Midkiff et al. (2017) identified that only four out of the eight items they used fitted a unidimensional model well. Another issue could be response bias. Questionnaires are prone to several biases like central tendency and acquiescence bias (Bogner & Landrock, 2016). Troche and Kunz (2020) also found that especially social desirability might affect the assessment of growth mindset in a negative way.

According to Cummins and De Houwer (2021) it is instead possible to measure beliefs across domains implicitly with the usage of a mouse tracking task. They state that the Propositional Evaluation Paradigm (PEP) utilizes mandatory responses of participants, which are either consistent or at odds with their own opinion to a given sentence, to assess these beliefs in an effective way (Cummins & De Houwer, 2021).

This study was designed based on these findings. The main goal is the prediction of effort with implicitly assessed growth mindset as opposed to only explicitly measured growth mindset with questionnaires. In addition several questions about metacognition were added as part of my master thesis as well. As aforementioned can metacognition be described as the thinking about one's own thoughts and thought processes and has been linked to academic success before (Zulkiply, 2006; Coutinho, 2007). While not many studies exist that link metacognition to growth mindset directly, some did find a possible relationship between growth mindset and metacognition. According to Wang et al. (2021) could the utilization of growth mindset be dependent on metacognition. The effect of growth mindset on math engagement was only predictive for those students who exhibited both growth mindset and metacognition (Wang et al., 2021). Hempel et al. (2020) have shown that the promotion of growth mindset and the development of metacognitive skills both have a positive effect on student performance. While Beziat et al. (2018) were able to find a general level of metacognitive skills and growth mindset present in teachers and principals, and speculated that both might be needed to instill a beneficial mindset for students, they were unable to correlate metacognitive awareness with one’s mindset. Are metacognition and growth mindset simply both beneficial for academic success or is there a direct relationship between the two

constructs? To pursue this question, I have chosen to include metacognition as my master thesis.

Do people who exhibit a growth mindset show more effort at a given learning opportunity? Is the implicit measurement of growth mindset, which was developed by Cummins and De Houwer (2021), as good as or even better than the established measurement of growth mindset with questionnaires? And does metacognition play a role in the relationship between growth mindset and effort shown? We designed this study to be able to answer these research questions. These findings might not only be able to improve the ongoing research about growth mindset, but also contribute to the development and acquisition of metacognitive skills as well as growth mindset in the academic field.

Theoretical background

Metacognition

Metacognition describes the awareness, understanding and thinking about one's own cognition, learning and thinking. It consists of the knowledge and regulation of cognition and is teachable (Schraw, 1998). The self-regulatory aspect of metacognition encompasses skills of planning, monitoring, evaluation, testing, revising and checking of outcomes (Baker & Brown, 1980). These skills can make learning easier due to a better management of behavior and information (Coutinho, 2007). People, according to Bransford et al. (1999), who utilize these metacognitive skills are not only more aware of their own strengths and weaknesses in regard to academia, but also endeavor to improve learning skills further.

Metacognition has been linked to academic success before (Zulkiply, 2006; Coutinho, 2007). In the research of Wang et al. (2021), the belief of students that intelligence is capable of growth only predicts their engagement in math when they also exhibited metacognitive skills. This indicates that metacognitive skills might be necessary to apply growth mindset effectively. Teachers and other members of the academia seem to possess a general level of metacognition and growth mindset (Beziat et al., 2018). The promotion of growth mindset and the development of metacognitive skills both have a positive effect on student performance as well (Hempel et al., 2020).

As not many studies exist on a possible relationship between metacognition and growth mindset I decided to include metacognition as my master thesis on top of the original study design about growth mindset.

Growth and fixed mindset

People who believe that learning and improvement of oneselves are the basis for success and achievement exhibit a growth mindset, an implicit belief system that encompasses the conviction that intelligence can be developed through mentoring, learning strategies and experience (Dweck, 2006; Dweck & Yaeger, 2019). Carol Dweck began her research on the changes in achievement cognition, performance and strategies after experiencing a setback already over 40 years ago (Diener &

Dweck, 1978). Over the course of her research, she detected major differences in the responses of participants. While some of them were dejected over their failure in the task at hand others saw this as an opportunity to learn and improve themselves. Dweck, after decades of work, came to the conclusion that people can be classified based on their implicit views. Those who believe that achievements are grounded on improving and learning exhibit an incremental theory of intelligence, a growth mindset (Dweck, 2006). Others attribute their successes and failures to their innate ability. According to Dweck and Yaeger (2019) these individuals show a more fixated theory of intelligence, tend to avoid challenges and are inclined to give up more quickly.

Do these implicit beliefs, beliefs that one might not even be aware of, have a significant impact on our lives? Several studies in the past aimed to connect these implicit beliefs to performance in academia and during hardship. Hong et al. (1999) and Robins and Pals (2002) were able to show an effect of growth mindset on academic success. And, according to Yeager et al. (2016), a growth mindset is more beneficial when one encounters challenges in comparison to those who do not as well. Other positive associations that could be shown were improved academic performance of university students, development of talents and beneficial challenge seeking in a variety of tasks (Barbouta et al., 2020; Brougham & Kassubeck-West, 2017; Dweck, 2009).

To stay in the academic framework we used a learning opportunity as the outcome variable. We calculated the relationship between the exhibition of growth mindset and the effort a participant shows at a given learning opportunity.

Learning and effort

Learning is described by some as changes in behavior which arise from experience. This definition is flawed however, as experience is not always shown in behavioral changes or is only shown at certain times (De Houwer et al., 2013). According to De Houwer et al. (2013) is learning better defined as changes in behavior based on regularities in the environment. People who exhibit a growth mindset are more likely to believe that learning, practicing and effort lead to a development of abilities and intelligence (Dweck & Yeager, 2019). Therefore we used

effort in this study to measure the impact of growth mindset of participants at a given learning opportunity (see Measures).

The commonly used questionnaires as a measurement tool, however, might be inadequate as aforementioned.

Explicit measurement

Psychological constructs can be measured in a variety of ways. While the most common method to acquire such data is the questionnaire, it comes with a set of disadvantages. Questionnaires are prone to several biases, such as social desirability, central tendency and acquiescence bias (Bogner & Landrock, 2016). Choi and Pak (2005) managed to identify 48 different types of biases in questionnaires related to public health. Avoiding these biases can result in a better research practice and more accurate results.

Troche and Kunz (2020) found that social desirability might affect the assessment of growth mindset in a negative way. Social desirability is the falsification of answers due to social norms or the wish to look good. Growth mindset has become better known in recent years and is deemed desirable by companies like Microsoft (2023) or institutions like PISA (Gouëdard, 2018).

Central tendency describes the effect that participants avoid extreme answers of a scale. This leads to a distorted result towards the middle. This effect is connected to the scale format, as odd numbered scales (e.g. 1-2-3-4-5) lead to more neutral answers (Choi & Pak, 2005).

Acquiescence bias, which is also called agreement bias, is manifested through the tendency of participants to agree with given statements. This might be a problem due to the statements in the established questionnaires we are using (see Appendix).

Therefore the implicit measurement of growth mindset that Cummins & De Houwer (2021) developed might be more adequate and give us better results. Both the questionnaire and the implicit dataset were analyzed and compared (see Results).

Implicit measurement

In contrast, implicit measurements are able to bypass some of the limitations of explicit measurement tools. They aim to measure psychological constructs through automatic processing and answering (Gawronski et al., 2020). In the Implicit-association test participants are instructed to sort words into one of two categories several times with the use of two buttons. For example, in the first task participants can be instructed to sort words into the categories black and white. In the second task, they are supposed to sort words into the categories pleasant and unpleasant. Now in the following tasks a combination of the categories are used (e.g. black/unpleasant and white/pleasant, white/unpleasant and black/pleasant and so on). The stronger the implicit opinion of the participant matches the given pairings the faster and less mistakes they make. Other, similar measurement tools exist as well. Some established implicit measures, however, are too insensitive or do not give enough information about the nature of the relation of concepts (Gawronski & Hahn, 2018). The usual way associations between concepts are measured can lead to *propositional blindness* (Müller & Rothermund, 2019). They give the following example:

> “ [...] both the statements “I want to be thin” and “I am thin” associate the concepts “I” and “thin.” Both statements differ substantially in meaning, yet this difference cannot be captured by traditional indirect measures that focus on mere associations.” (Müller & Rothermund, 2019).

De Houwer et al. (2015) developed the Relational Responding Task (RRT) to improve upon these issues (Müller & Rothermund, 2019). In the RRT participants are instructed in one block to respond to given statements in a certain way. In another block, however, they are instructed to answer in the opposite way. If no sentence was stated, participants had to react to statements like correct or invalid, which measured the implicit belief of the participants (De Houwer, 2015).

The Propositional Evaluation Paradigm is based on the response of participants to given propositions (Müller & Rothermund, 2019). These propositions are sentences, which propose a certain relation between concepts to the participants, e.g.:

"Wenn man neue Dinge lernt, bleibt die Intelligenz gleich." adapted from Spinath & Schöne (2003).

Participants are then required to respond to the proposition given. How they do so is dependent on the task given.

Later Cummins and De Houwer (2021) developed the Propositional Evaluation Paradigm further by combining it with mouse tracking. In this form, the responses of the participants take place with mouse movement to the possible answers instead of simple buttons. They utilize mandatory responses of participants, which are either consistent or at odds with their own opinion to a given proposition, and the inclination of the movement of the mouse to calculate the implicit belief of the participants (Cummins & De Houwer, 2021).

Self-efficacy

Self-efficacy was included as an important control variable for the relationship between mindset and effort. Bandura (1994) describes self-efficacy as a form of self-perception and self-regulation. Several aspects like motivation, abilities, learning and performance stand in relation to the behavior of a person and the environment (Bandura, 1986; Bandura, 1994). For example can the performance expectations of oneself lead to more effort and even increased enjoyment of said effort (Hutchinson et al., 2008). Self-efficacy is related to growth mindset as well, as both can be predictors for the same construct (Cho et al., 2021).

Summary

Metacognition consists of the knowledge and regulation of cognition and is teachable (Schraw, 1998). It is linked to academic success (Zulkiply, 2006; Coutinho, 2007) and might be needed to fully apply a growth mindset (Wang et al., 2021). Growth mindset is the implicit belief that learning and improvement of oneselves are the basis for success and achievement (Dweck & Yaeger, 2019). It is connected to academic success as well (Hong et al., 1999; Robins and Pals, 2002) and measures with questionnaires. These, however, might be inadequate (Midkiff et al., 2017; Troche & Kunz, 2020). Implicit measurements are able to bypass some of the limitations, but are prone to propositional blindness themselves (Müller & Rothermund, 2019). Cummins and De Houwer (2021) developed the Propositional

Evaluation Paradigm further by combining it with mouse tracking to measure implicit beliefs more accurately. The effort shown at a given learning opportunity after a setback was used as the outcome variable. Self-efficacy is an important control variable (Cho et al., 2021) and was therefore included.

Hypotheses

Therefore, based on the goals of this study and my master thesis on the impact of metacognition, the following hypotheses were worked out to test for the interactions between metacognition, growth mindset and effort:

H1: The implicit score of growth mindset is predictive for the effort to practice shown at the given learning opportunity.

H2: The interaction between growth mindset and effort to practice at the given learning opportunity is moderated by metacognition.

As self-efficacy has been shown to be a control variable for growth mindset, it was included in our research model. In the main research model growth mindset is predictive for effort to practice while controlling for self-efficacy (see Figure 1). Due to the addition of metacognition as a moderator as my master thesis, metacognition was included in the additional research model of my master thesis (see Figure 2).

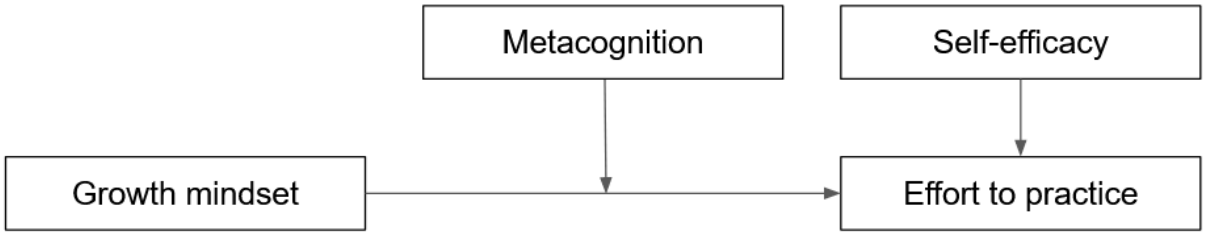
Figure 1

Main research model of this study

Note. Independent variable = Growth mindset, dependent variable = Effort to practice, control variable = Self-efficacy. Own illustration.

Figure 2

Research model of my master thesis



Note. Independent variable = Growth mindset, dependent variable = Effort to practice, moderator = Metacognition, control variable = Self-efficacy. Own illustration.

Methods

Sample size and exclusion criteria

The required sample size for the relationship between growth mindset and effort to practice was calculated a priori by using the free statistical program g*Power, which can be used to compute analyses for a variety of studies, statistical tests and regressions (Faul et al., 2007; Faul et al., 2009). We assumed a significance level α of .05 and a target power of at least .80. According to Sik et al. (in prep.) the effect size of the implicit score totals to d = 0.16, while the effect to control for people's self-efficacy amounts to d = 0.18. This resulted in an effect size f^2 of .0615 from the predictor correlations, which led to a total sample size of at least n = 160.

To ensure improved accuracy several exclusion criteria have been set prior to the start of the study. To ensure the correct understanding of the input prompts used in the mouse tracking task this study was only accessible to those participants who are native german speakers. Non-native speakers will therefore be excluded. In addition, all participants that did not at least achieve an accuracy of 80% in the mouse tracking task will be excluded as well. Aborted protocols or those of participants who did not approve of the usage of their data will also be removed from the data set. Lastly, all data sets where the participants skipped the entire solutions part have to be removed as well. This is due to the fact that in those cases there is no explainable variance when t = 0 is given. Based on Sik et al. (in prep.) we expected around 11% of participants who won't look at any solutions in addition to 17% of the participants who will have to be excluded based on the other exclusion criteria. Thus, the actual required sample size to achieve a significance level α of .05 and a target power of .80 consists of n = 208 participants before exclusions.

In the end, the datasets from 208 participants were acquired. Out of these three did not finish the protocol, three were non-native speakers, four wished not to include their data, five achieved less than 80% accuracy on the implicit measure and 16 did not spend any time on the solutions. This led to a valid remaining sample size of n = 177 participants (47 male, 128 female, 2 nonbinary, mean age = 21.73).

Participants were recruited with the *Laboratory Administration for Behavioral Sciences* (LABS) website of the University of Vienna before and during the study. A maximum number of twelve participants could be allocated per time slot.

Study design

This study is a correlational study. We are investigating the relationships between growth mindset, metacognition and effort to practice without manipulating any of the variables. The main goal of this study is to take a more in-depth look at the impact of implicitly measured growth mindset on the effort to practice shown at a given learning opportunity. In addition, moderating effects of metacognition might occur. In order to achieve this the study contains several questionnaires and tasks, including mouse tracking and raven matrices. As the mouse tracking task requires the use of a computer, the whole study was designed as a computer study to be conducted at a laboratory. This was done to ensure constant surroundings, screen sizes and mouse speeds across all participants.

Participants were invited to a research laboratory in Vienna. After consenting to the University of Vienna's declaration of data protection the participants were prompted to fill out several questionnaires. These entailed questions about the participants' mother tongue, IQ importance and field of study. Afterwards questionnaires about growth mindset, self-efficacy, metacognition and failure mindset followed (see Appendix).

Next participants were tasked to complete several mouse tracking tasks. These were designed as training units to not only prepare the participants for the main mouse tracking task but also to check their understanding of the procedure. These mouse tracking tasks were time sensitive and increased in difficulty as the variety of input prompts increased. Afterwards the actual implicit assessment of growth mindset began in the main mouse tracking task.

This was followed by an IQ block, consisting of twelve raven matrices, which was very difficult. The chosen task items were all of a high difficulty level and a short time limit was set in place per item. On average, participants were supposed to only solve a handful of items and experience a setback. This was done to activate the participants' implicit belief system about growth. A feedback on the performance at

the difficult IQ block was given and immediately followed by the solutions part. The times spent at the solutions part were measured as the outcome variable. At the end, a simple IQ task, which was not relevant for the data collection but included to give the participants a feeling of improvement, was conducted and final demographic questions were assessed (see Figure 3; see Appendix).

It took participants around 50 minutes to complete the study. A maximum number of twelve participants could be allocated per time slot.

Figure 3

Tasks used in the study in consecutive order

Note. Mouse tracking refers to both the trial runs and the implicit assessment of growth mindset. Own illustration.

Measures

Explicit growth mindset

Data on the participants' growth mindset was collected in two ways. Initially, participants filled out a six items long questionnaire which utilized a six-point Likert scale to reduce central tendency biases. The items were adapted from the “Skalen zur Erfassung subjektiver Überzeugungen zu Bedingungen von Erfolg in Lern- und Leistungskontexten” (SE-SÜBELLKO) from Spinath & Schöne (2003) and encompassed questions about the changeability of intelligence (see Appendix). The scale was used to compile the explicit growth mindset of the participants and its internal consistency was excellent (Cronbach's $\alpha = .904$). The mean values of their responses, after taking reverse coded items into account, were calculated to get their respective mindset scores. In total three out of the six items were reverse coded to circumvent acquiescence biases.

Implicit growth mindset

Later on, growth mindset was assessed implicitly with the recent adaptation of the propositional evaluating paradigm by Cummins and De Houwer (2021) as well (see Figure 4). At the beginning of each task participants were instructed to click on a small starting button at the bottom of the screen. Afterwards a cross was displayed in the middle of the screen in order to draw the participants attention followed by one of six sentences. These sentences consisted of the same six items taken from the SE-SÜBELLKO from Spinath & Schöne (2003), which were already used in the questionnaire to assess growth mindset explicitly (see Appendix), written in bold letters and shown word by word, e.g.:

> “JEDER BESITZT EIN BESTIMMTES AUSMAß AN INTELLIGENZ DAS NICHT VERÄNDERT WERDEN KANN” adapted from Spinath & Schöne (2003).

After one of the sentences was displayed the participants had to click on the start button again. This led to one of two tasks. In the so-called catch trial participants were given the prompt “??Wahr oder Falsch??” in the middle of the screen. This prompted participants, as already instructed in the training mouse tracking tasks before, to click on one of two possible answers “Wahr” (true) or “Falsch” (false) on the top the screen based on their agreement to the given statement.

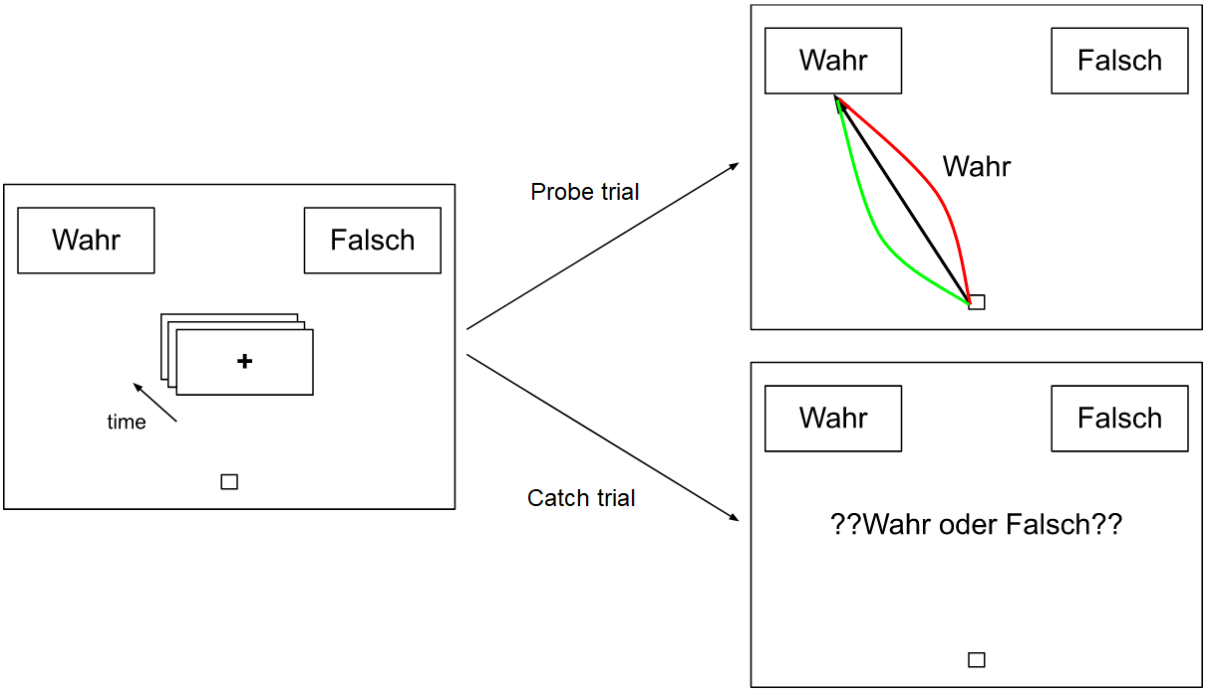
In the probe trial task participants were either given the prompt “Wahr” or the prompt “Falsch”. Depending on the prompt participants had to click the respective answer on the top of the screen independent of their agreement to the given statement. These probe trail tasks were included in order to cross-validate the accuracy of their answers and mouse movements throughout the task.

The mouse movement deviation from the ideal trajectory towards the two possible answers “Wahr” or “Falsch” creates an area under the curve in each task. For example, if a participant is instructed to submit “Falsch” as the answer but initially moves their mouse towards “Wahr” before submitting “Falsch”, their implicit belief leans towards agreement to the statement that was presented (Cummins & De Houwer, 2021). In the end the maximum deviation between the ideal trajectory and

the average mouse trajectory of the participants was used to calculate the implicit growth mindset score of each of the participants.

Figure 4

Overview over the mouse tracking task



Note. Wahr = true, Falsch = wrong. The mouse movement deviation from the neutral path (black) towards true (green) or wrong (red) creates an area under the curve in each task. Own illustration.

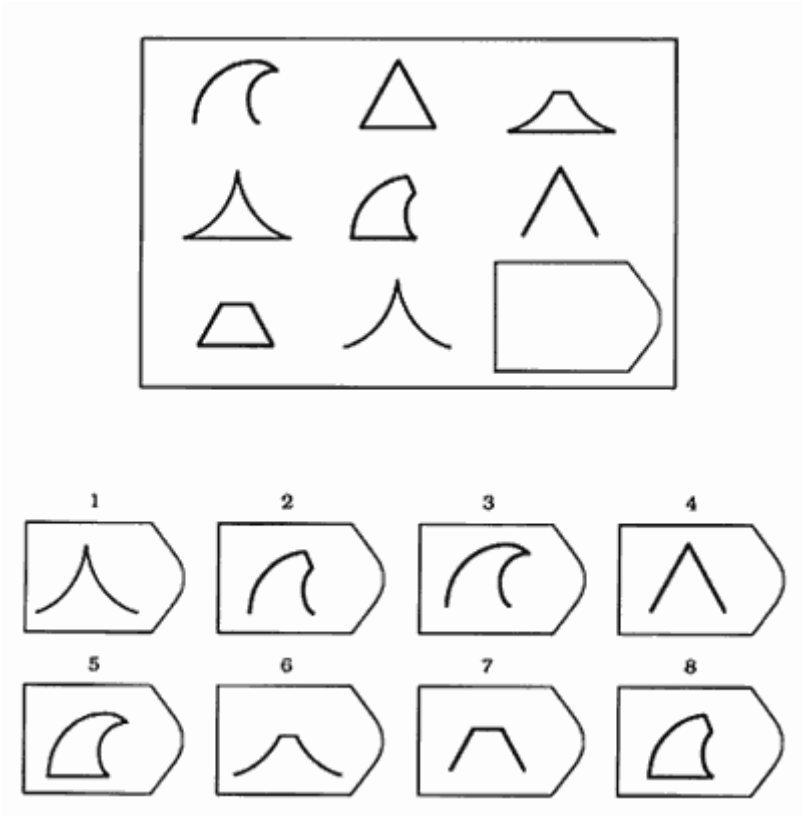
These tasks were time sensitive and failed if the participants exceeded the time limit of 250 milliseconds to move their mouse. This was in order to ensure that the implicit belief systems of the participants were in fact measured implicitly and less susceptible to falsification due to the aforementioned response biases such as social desirability to confound the data. According to Cummins & De Houwer (2022) this also allows for a more accurate representation of the construct due to the greater amount of information and data that is collected in comparison to the explicit measure.

Effort to practice

The individual effort shown by the participants was measured with an IQ block. This method was chosen as the entire study was advertised as a study about intellectual abilities and to remain consistent with our previous study. Over the course of the experiment the participants were tasked to complete twelve progressive raven matrices (Raven, 2000) which were declared to be a warm-up task (see Figure 5; see Appendix).

Figure 5

One of the twelve raven matrices



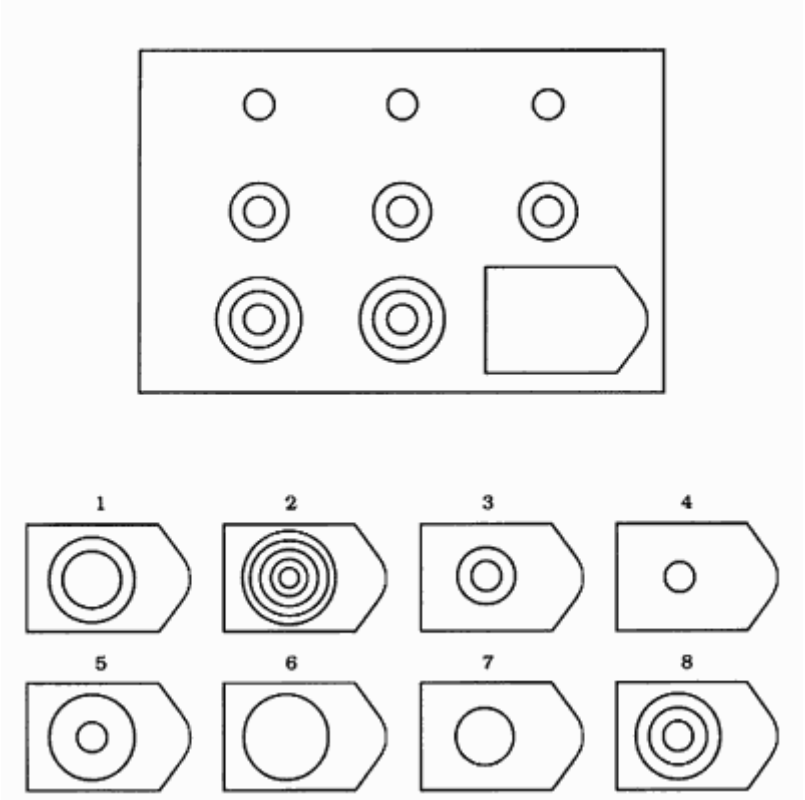
Note. Raven matrice D11 (Raven, 2000). The correct answer is number 5. Each of the three shapes in the first row (Wave, Pyramid, Arrow) appear in one of the forms. These are a bottomless form, a blunt form and a completed form. Only the completed form of the wave is missing in this matrix.

This however was a ruse, as the task itself was designed to be extremely difficult. Based on the previous study of Sik et al. (in prep.) only three out of the twelve matrices can be solved on average within the given 45 seconds time limit per task. This was done to let the participants experience failure and activate their mindsets. Then, immediately after getting feedback on how many of the twelve matrices were solved correctly, the participants were given a learning opportunity. They were offered to take a look at the solutions of the raven matrices, including relevant information on how to solve each and every one of them, in consecutive order. There was no time limit, however, participants were given the option to either skip the solutions in their entirety or to skip to the end after each individual solution instead of clicking to the next one. The times spent at the solutions part, which were transformed by taking their square roots to stabilize bigger numbers and normalize the distribution of the dependent variable, resulted in the effort to practice values that each participant spent to improve themselves and learn something new.

In order to give the participants a feeling of improvement and accomplishment, an easy Progressive Raven Matrices task was conducted near the end of the study. Twelve progressive raven matrices (Raven, 2000) that were easy to solve were used (see Figure 6). This easy IQ block, however, was not included in our data analysis in any way. The prior time limit of 45 seconds per task was removed as well.

Figure 6

One of the easy to solve raven matrices



Note. Raven matrice C1 (Raven, 2000). The correct answer is number 8. Each of the rings in the three rows increase in increments of one additional ring downwards for each column.

Metacognition

The metacognition of the participants was assessed with a ten items long questionnaire that was adapted from the Metacognitive self-regulation scale of the Motivated Strategies for Learning Questionnaire (MSLQ) from Pintrich et al. (1991) and translated into German. The items used were selected, adapted and translated by myself (see Appendix). One example of the translated and adapted items used comes below.

> “Ich stelle mir selbst Fragen, um sicherzugehen, dass ich alles verstanden habe.” adapted from Pintrich et al. (1991).

A six-point Likert scale and two reversed coded items were used to reduce biases. The mean value of all ten items, after accounting for the ones reverse coded, results in the metacognition values for each of the participants.

The internal consistency of the scale we used was, however, questionable (Cronbach's α = .650). Credé and Phillips (2011) on the other hand conducted a meta-analytic review across all of the subscales from Pintrich et al. (1991) and used 13 different studies to calculate the true score correlation between the grade point average (GPA) of college students and the Metacognitive self-regulation scale. They found a ρ score of .22, a moderate relationship according to Cohen (1987).

Self-efficacy

Self-efficacy is an important control variable as it mediates the effect of growth mindset on achievement goal adaption after experiencing failure (Song et al., 2020). It was assessed with seven items which were adapted from the Self-efficacy subscale of the *Motivated Strategies for Learning Questionnaire* (MSLQ) from (Pintrich et al., 1991) as well and translated into German (see Appendix). Credé and Phillips (2011) analyzed nine studies and found a true score correlation of ρ = .21 between the subscale and the grade point average of college students. We found an internal consistency of Cronbach's α = .802, which is a good result. In order to reduce biases and stay consistent with the rest of the study a six-point Likert scale was used. The self-efficacy score of a participant results from the mean value of the seven items.

Additional data collection

Several additional questionnaires were included in the study. All of these were <u>not</u> part of the main research question and only included for the purpose of an exploratory data analysis. Demographic data, year of birth and gender were assessed with fill in questions.

Importance of IQ

Participants were asked how important their IQ scores are to them. One item was used to assess their IQ importance.

Setback experience

After the difficult Raven Matrices task the setback experience of the participants was gauged with one item.

Success importance

One item was used to gather success importance. Participants were asked to evaluate how important their success at the easy IQ block was to them.

Task enjoyment

Task enjoyment was gauged with two items, none of them reverse coded. The mean value results in the enjoyment value of the participants.

Academic success

One item was used to inquire about the success in the respective field of study of the participants.

Scales and data usage

All of these questionnaires utilized a six-point Likert scale to remain consistent with the rest of the study and reduce response biases. The participants were asked about the purpose of the whole study with an open question design. None of the aforementioned scores will be used in the linear regression about the relationship between growth mindset and effort to practice. They were intended as additional data for comparison and exploratory data analyses.

Results

The free statistical program R of the R core team (2022) was used for the data analysis, data output and the generation of the layout of the tables.

Implicit growth mindset and effort

To test our main research model a linear regression was calculated (see Table 1) to predict effort to practice with implicit growth mindset and self-efficacy. The following relationships have been found:

The influence of implicit growth mindset is statistically significant and positive (beta = 3.72, 95% CI [0.05, 7.39], t(174) = 2.00, p = 0.047; Std. beta = 0.15, 95% CI [1.93e-03, 0.30]).

But on the other hand the effect of self-efficacy is statistically non-significant (beta = 0.71, 95% CI [-0.66, 2.09], t(174) = 1.02, p = 0.308; Std. beta = 0.08, 95% CI [-0.07, 0.22]).

Table 1

Linear regression with implicit growth mindset as independent variable, effort to practice as dependent variable and self-efficacy as control variable

	learning_sqrt						
Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*p*
pep effect	3.72	1.86	0.15	0.07	0.05 – 7.39	0.00 – 0.30	**0.047**
self efficacy	0.71	0.70	0.08	0.07	-0.66 – 2.09	-0.07 – 0.22	0.308
Observations	177						
R^2 / R^2 adjusted	0.028 / 0.017						

Note. pep effect = implicit growth mindset, learning_sqrt = effort to practice.

The relationship between implicitly assessed growth mindset and effort to practice was significant. The data gathered with the mouse tracking task is predictive for the effort spent at the solutions part. As a result, hypothesis H1 was accepted. The effect of self-efficacy as a control variable on the other hand could not be replicated. Therefore our main research model could not be accepted.

Metacognition as a moderator

In order to test my master thesis another linear regression was performed (see Table 2). This time we fitted a linear model to predict effort to practice with implicit growth mindset, metacognition and self-efficacy. According to my research model, the growth mindset of participants should be predictive for the effort shown while being moderator by metacognition. The higher the metacognitive skills the better could be the application of one's growth mindset. Self-efficacy was again a control variable.

The impact of implicit growth mindset on effort to practice is not statistically significant while attributing so many variables (beta = 6.54, 95% CI [-11.22, 24.30], t(172) = 0.73, p = 0.468; Std. beta = 0.15, 95% CI [3.04e-03, 0.30]).

Following this, the relationship of metacognition is statistically non-significant as well (beta = 0.10, 95% CI [-0.94, 1.15], t(172) = 0.20, p = 0.843; Std. beta = 1.73e-03, 95% CI [-0.15, 0.15]).

Afterwards we tested for possible effects of self-efficacy. Self-efficacy is also statistically non-significant (beta = 0.70, 95% CI [-0.71, 2.10], t(172) = 0.98, p = 0.329; Std. beta = 0.07, 95% CI [-0.08, 0.23]).

Lastly, the influence of implicit growth mindset × metacognition is statistically non-significant (beta = -0.64, 95% CI [-4.57, 3.29], t(172) = -0.32, p = 0.749; Std. beta = -0.03, 95% CI [-0.19, 0.14]).

Table 2

Linear regression with implicit growth mindset as independent variable, effort to practice as dependent variable, metacognition as moderator and self-efficacy as control variable

	learning_sqrt							
Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*p*	*std. p*
pep effect	6.54	9.00	0.15	0.08	-11.22 – 24.30	0.00 – 0.30	0.468	**0.046**
metacognition	0.10	0.53	0.00	0.08	-0.94 – 1.15	-0.15 – 0.15	0.843	0.982
self efficacy	0.70	0.71	0.07	0.08	-0.71 – 2.10	-0.08 – 0.23	0.329	0.329
pep effect × metacognition	-0.64	1.99	-0.03	0.08	-4.57 – 3.29	-0.19 – 0.14	0.749	0.749
Observations	177							
R^2 / R^2 adjusted	0.029 / 0.006							

Note. pep effect = implicit growth mindset, learning_sqrt = effort to practice.

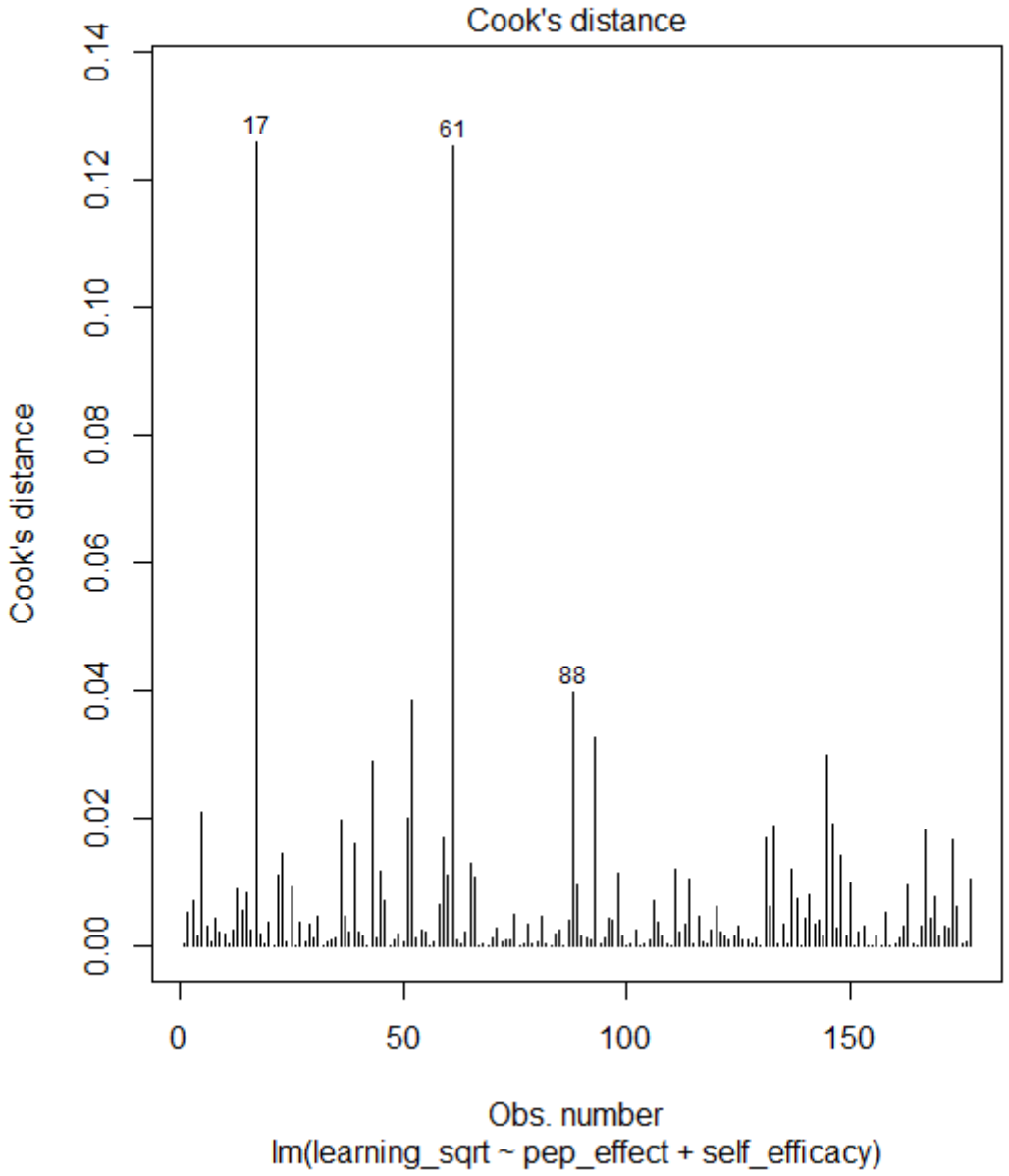
None of the results were significant. Both hypothesis H2 and my research model had to be rejected.

Post-hoc

After the rejection of both research models and hypothesis H2 a post-hoc analysis was conducted to find potential influential cases in the data set. Cook's Distance is a measure of an observation's influence on a linear regression (Cook, 1977). Data points with a large influence may be outliers, which are able to disturb the data analysis of the rest of the dataset. This in turn makes the dataset less suitable for linear regression, especially in the case of a large number of highly influential points. We used an exclusion criteria of cook's distance d(i) > 4/n which led to the identification of seven potential influential cases (see Figure 7).

Figure 7

Cook distances of every participant



Note. pep effect = implicit growth mindset, learning_sqrt = effort to practice. The higher the Cook's distance the larger the influence of a data point on the regression line. Generated with the free statistical program R (R core team, 2022).

Again we fitted a linear model to predict effort to practice with implicit growth mindset and self-efficacy (see Table 3).

The impact of implicit growth mindset on effort to practice is statistically significant and positive (beta = 4.69, 95% CI [0.97, 8.42], t(167) = 2.49, p = 0.014; Std. beta = 0.19, 95% CI [0.04, 0.34]).

But the effect of self-efficacy is still statistically non-significant (beta = 0.64, 95% CI [-0.66, 1.94], t(167) = 0.97, p = 0.331; Std. beta = 0.07, 95% CI [-0.08, 0.22]).

Table 3

Linear regression without the seven influential cases with implicit growth mindset as independent variable, effort to practice as dependent variable and self-efficacy as control variable

	learning_sqrt						
Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*p*
pep effect	4.69	1.89	0.19	0.08	0.97 – 8.42	0.04 – 0.34	**0.014**
self efficacy	0.64	0.66	0.07	0.08	-0.66 – 1.94	-0.08 – 0.22	0.331
Observations	170						
R^2 / R^2 adjusted	0.043 / 0.031						

Note. pep effect = implicit growth mindset, learning_sqrt = effort to practice.

Implicit growth mindset is still predictive for effort to practice without the seven influential cases, but self-efficacy remains non-significant. In comparison to the linear regression beforehand the significance value for the relationship between implicit growth mindset and effort to practice is over three times lower. Still, the research model could not be accepted as self-efficacy remains non-predictive for the time spent at the solutions part.

Exploratory data analysis

As aforementioned several additional questionnaires were assessed and available for an exploratory data analysis. In order to check for additional significant results in our dataset we conducted several exploratory hypotheses.

Explicit growth mindset

Growth mindset was, in addition to the mouse tracking task, assessed explicitly as well. As both the questionnaire and the mouse tracking task were designed to measure the growth mindset score of the participants, we analyzed the relationship between growth mindset and effort to practice again, but this time we calculated the influence of explicit growth mindset on the effort to practice (see Table 4). The resulting hypothesis was:

E1: Does explicit growth mindset predict effort to practice?

Again we fitted a linear model to predict effort to practice with explicit growth mindset and self-efficacy. The impact of explicit growth mindset is statistically non-significant (beta = 0.57, 95% CI [-0.17, 1.31], t(174) = 1.53, p = 0.129; Std. beta = 0.11, 95% CI [-0.03, 0.26]).

The effect of self-efficacy remains statistically non-significant (beta = 0.81, 95% CI [-0.58, 2.19], t(174) = 1.15, p = 0.253; Std. beta = 0.09, 95% CI [-0.06, 0.24]).

None of the results were significant. The growth mindset score that was calculated from the questionnaire was not predictive for the time spent at the solutions part. Hypothesis E1 was rejected. We conducted a secondary analysis without the aforementioned influential cases, which resulted in a marginally significant result. With more power, the results might have been significant.

The impact of explicit growth mindset is positive (beta = 0.70, 95% CI [-0.02, 1.43], t(167) = 1.91, p = 0.058; Std. beta = 0.15, 95% CI [-5.09e-03, 0.30]).

The effect of self efficacy remains statistically non-significant (beta = 0.78, 95% CI [-0.53, 2.09], t(167) = 1.18, p = 0.240; Std. beta = 0.09, 95% CI [-0.06, 0.24]).

Table 4

Linear regression with explicit growth mindset as independent variable, effort to practice as dependent variable and self-efficacy as control variable

	learning_sqrt						
Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*p*
iqms avg	0.57	0.37	0.11	0.08	-0.17 – 1.31	-0.03 – 0.26	0.129
self efficacy	0.81	0.70	0.09	0.08	-0.58 – 2.19	-0.06 – 0.24	0.253
Observations	177						
R^2 / R^2 adjusted	0.019 / 0.008						

Note. iqms avg = explicit growth mindset, learning_sqrt = effort to practice.

As implicitly assessed growth mindset was predictive for the effort shown at the solutions part, we visualized the collected data (see Figure 8; see Figure 9) and conducted a Wilcoxon-Test to check for possible differences in the assessment of growth mindset between the mouse tracking task and the questionnaire. The following hypothesis was formed:

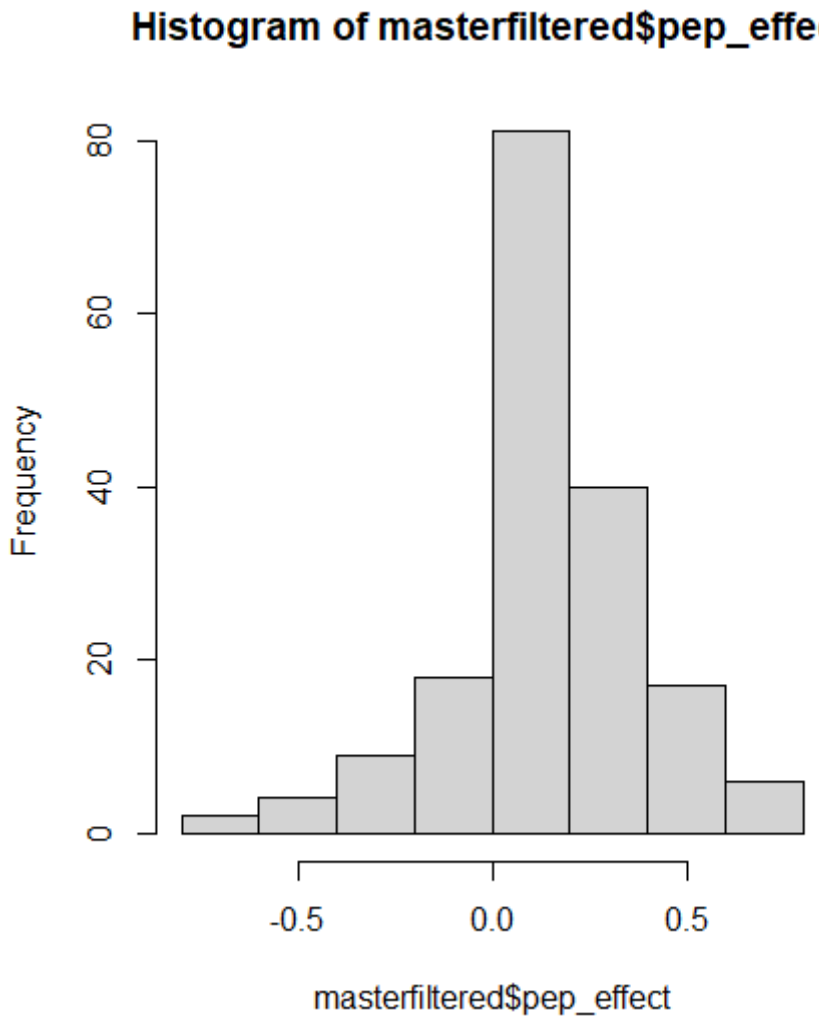
E2: Was there a significant difference in data collection between implicitly and explicitly assessed growth mindset?

Each participant exhibits a certain amount of growth mindset. Despite this, the results from the linear regression and the visual data representation seem to indicate that the questionnaire and the mouse tracking task measured growth mindset significantly differently. To check hypothesis E2 a Wilcoxon-Test was performed.

The Wilcoxon signed rank test with continuity correction testing the difference in ranks between implicit growth mindset and explicit growth mindset suggests that the effect is negative, statistically significant, and very large ($W = 0.00$, $p < .001$; r (rank biserial) = -1.00, 95% CI [-1.00, -1.00]). Therefore hypothesis E2 was accepted.

Figure 8

Histogram of the distribution of implicitly assessed growth mindset

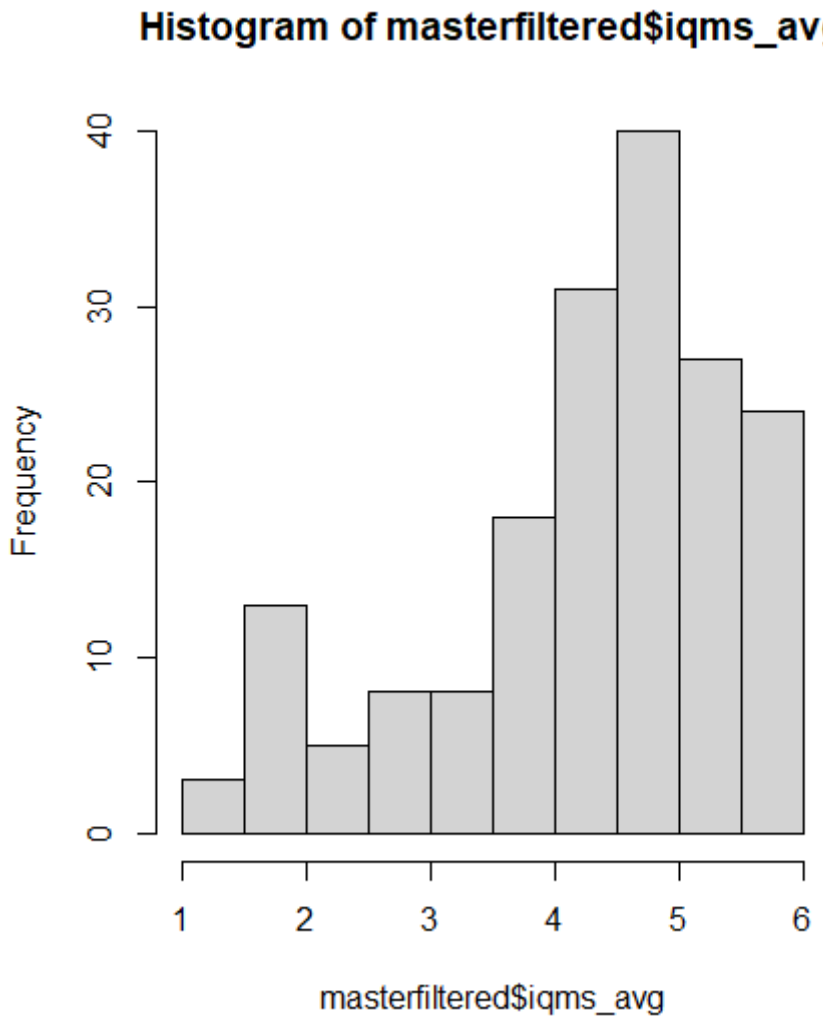


Note. pep_effect = implicit growth mindset. Generated with the free statistical program R (R core team, 2022).

A total of 177 participants are shown in the histogram (Mean = 0.15, SD = 0.24, Median = 0.14, range: [-0.65, 0.77], Skewness = -0.41).

Figure 9

Histogram of the distribution of explicitly assessed growth mindset



Note. iqms_avg = explicit growth mindset. Generated with the free statistical program R (R core team, 2022).

The questionnaire data from the same 177 participants are shown in the histogram (Mean = 4.36, SD = 1.20, Median = 4.67, range: [1, 6], Skewness = -0.98).

Gender differences

Are there personal variables that relate to growth mindset? To answer this question we took a look at possible gender and age differences next. Out of the 177

participants 47 were male, 128 female and 2 nonbinary. Due to the fact that the sample size of participants which identified themselves as nonbinary is too small, they were excluded from the analysis. Gender effects might influence the scoring of participants in the different tasks, which lead to the following exploratory hypotheses:

E3: Do participants score differently when their growth mindset is assessed implicitly or explicitly based on gender?

E4: Do participants show different effort at the given learning opportunity based on gender?

Several t-tests were conducted to test these hypotheses. The Welch Two Sample t-test testing the difference of implicit growth mindset by gender (mean in group 0 (female) = 0.16, mean in group 1 (male) = 0.11) suggests that the effect is statistically not significant (difference = 0.05, 95% CI [-0.02, 0.13], t(97.10) = 1.35, p = 0.182; Cohen's d = 0.27, 95% CI [-0.13, 0.67]).

The Welch Two Sample t-test testing the difference of explicit growth mindset by gender (mean in group 0 (female) = 4.36, mean in group 1 (male) = 4.34) suggests that the effect is statistically not significant (difference = 0.02, 95% CI [-0.39, 0.44], t(79.80) = 0.11, p = 0.913; Cohen's d = 0.02, 95% CI [-0.41, 0.46]). As no differences in the assessment of implicit or explicit growth mindset could be found, hypothesis E3 was rejected.

The Welch Two Sample t-test testing the difference of effort to practice by gender (mean in group 0 (female) = 12.70, mean in group 1 (male) = 10.86) suggests that the effect is positive, small and marginally significant (difference = 1.83, 95% CI [-0.08, 3.74], t(90.44) = 1.91, p = 0.060; Cohen's d = 0.40, 95% CI [-0.02, 0.82]). As the p-value is under .1 the gender difference in effort to practice could be a trend, which might have been significant with more power. Hypothesis E4 had to be rejected as well.

Age differences

Afterwards we analyzed the distribution of growth mindset inclination across the participants' ages. As growth mindset has been introduced in recent times, older

participants might not exhibit as much growth mindset. Age might also play a role in the effort shown at the given learning opportunity. This lead to the following hypotheses:

E5: Do older participants exhibit less growth mindset?

E6: Do participants show different effort at the given learning opportunity based on age?

97% of the participants were in the age range of 18 to 30 (see Figure 10). Only four participants out of the 177 were older than 30. Two were 31, one 32 and one 54 years old. To check the first hypothesis we fitted a linear model to predict implicit growth mindset with age (see Table 5). The effect of age is statistically non-significant (beta = 5.98e-03, 95% CI [-3.33e-03, 0.02], t(175) = 1.27, p = 0.207; Std. beta = 0.10, 95% CI [-0.05, 0.24]).

Table 5

Linear regression with age as independent variable and implicit growth mindset as dependent variable

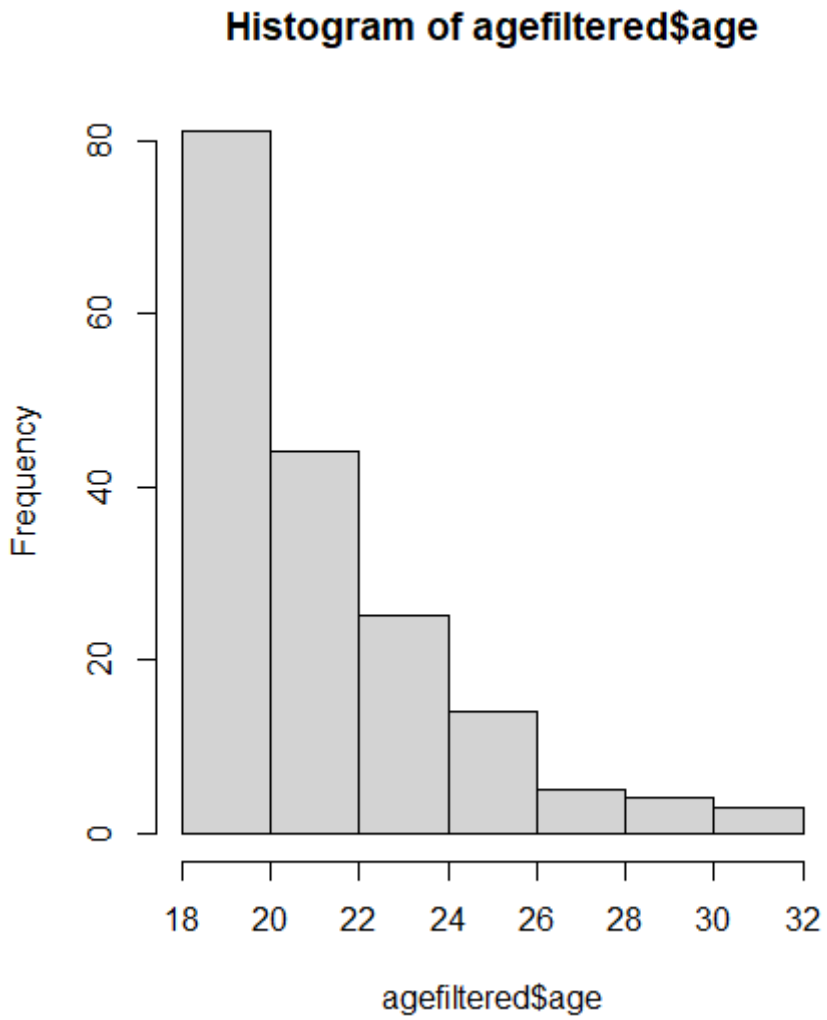
	pep_effect						
Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*p*
age	0.01	0.00	0.10	0.08	-0.00 – 0.02	-0.05 – 0.24	0.207
Observations	177						
R^2 / R^2 adjusted	0.009 / 0.003						

Note. pep_effect = implicit growth mindset.

As the results were non-significant hypothesis E5 was rejected.

Figure 10

Histogram of the distribution of age



Note. Generated with the free statistical program R (R core team, 2022).

The age distribution of 176 participants, as the one 54 year old participant was removed as an outlier (Mean = 21.55, SD = 2.94, Median = 21.00, range: [18, 32]).

Afterwards we fitted a linear model to predict effort to practice with age (see Table 6). The effect of age is statistically significant and positive (beta = 0.35, 95% CI [0.12, 0.58], t(175) = 3.06, p = 0.003; Std. beta = 0.23, 95% CI [0.08, 0.37]).

Table 6

Linear regression with age as independent variable and effort to practice as dependent variable

	learning_sqrt						
Predictors	*Estimates*	*std. Error*	*std. Beta*	*standardized std. Error*	*CI*	*standardized CI*	*p*
age	0.35	0.11	0.23	0.07	0.12 – 0.58	0.08 – 0.37	**0.003**
Observations	177						
R^2 / R^2 adjusted	0.051 / 0.045						

Note. learning_sqrt = effort to practice.

The age of the participants was predictive for the effort shown at the given learning opportunity. The older the participant the more time was spent at the solutions part on average. The hypothesis E6 was accepted.

Importance of IQ

What else predicts the outcome variable? As aforementioned self-efficacy is an important control variable. Despite this, other variables might play a role too for further research on this topic. Firstly, might participants who valued their IQ-scores highly have shown more effort at the solutions part, which lead to the following hypothesis:

E7: Do participants who value their IQ-scores highly show more effort to practice at the given learning opportunity?

Therefore we fitted a linear model to predict effort to practice with IQ importance. The effect of IQ importance is statistically significant and positive (beta = 0.80, 95% CI [0.11, 1.50], t(175) = 2.30, p = 0.023; Std. beta = 0.17, 95% CI [0.02, 0.32]). IQ importance was predictive of the effort shown, hypothesis E7 was accepted.

Success importance

Participants who rated success as important to them might be more inclined to show effort at the solutions part. The following hypothesis was formed:

E8: Do participants show more effort at the given learning opportunity the higher they rate the importance of success?

We fitted a linear model to predict effort to practice with success importance. The effect of success importance is statistically significant and positive (beta = 1.52, 95% CI [0.75, 2.30], t(175) = 3.87, p < .001; Std. beta = 0.28, 95% CI [0.14, 0.42]). As success importance was predictive for the time spent at the solutions part hypothesis E8 was accepted.

Task enjoyment

Lastly, the enjoyment of performing a task might have an effect on the relationship between growth mindset and effort to practice. The enjoyment that participants did derive from the tasks could affect the activation of their growth mindset. The following hypothesis was formed:

E9: The interaction between growth mindset and effort to practice at the given learning opportunity is moderated by task enjoyment.

We fitted a linear model to predict effort to practice with implicit growth mindset, task enjoyment and self-efficacy.

Firstly is the impact of implicit growth mindset statistically non-significant (beta = 2.17, 95% CI [-14.94, 19.27], t(172) = 0.25, p = 0.803; Std. beta = 0.13, 95% CI [-0.01, 0.28]).

The effect of task enjoyment is statistically significant and positive (beta = 1.46, 95% CI [0.19, 2.74], t(172) = 2.26, p = 0.025; Std. beta = 0.21, 95% CI [0.06, 0.36]).

Afterwards we calculated a possible effect of self-efficacy again and got no statistically significant results (beta = 0.50, 95% CI [-0.86, 1.87], t(172) = 0.73, p = 0.466; Std. beta = 0.05, 95% CI [-0.09, 0.20]).

Lastly, the influence of implicit growth mindset × task enjoyment is statistically non-significant (beta = 0.33, 95% CI [-4.46, 5.11], t(172) = 0.14, p = 0.893; Std. beta = 0.01, 95% CI [-0.15, 0.17]). As the impact of growth mindset x task enjoyment was

non-significant the hypothesis E9 had to be rejected. Despite this, the effect of task enjoyment on the effort shown is significant. Task enjoyment might therefore be a control variable.

Additional data analysis

In addition to the explicit measurement of growth mindset and the demographic data of the participants a variety of other questionnaires were added to the study. None of the following analyses resulted in any statistically significant or marginally significant results.

Setback experience

Participants who stated to have underperformed at the difficult Raven Matrices task could be more inclined to spend more time at the solutions part. The following hypothesis was formed:

E10: The experience of setback is predictive for the time spent at the solutions part.

We fitted a linear model to predict effort to practice with setback experience. The effect of setback experience is statistically non-significant (beta = 0.22, 95% CI [-0.80, 1.23], t(175) = 0.42, p = 0.678; Std. beta = 0.03, 95% CI [-0.12, 0.18]). Hypothesis E10 was rejected.

Academic success

The academic success of the participants in their respective fields of study were assessed as well. Multiple studies have shown that people who exhibit a growth mindset are more successful in academia. The following hypothesis was formed:

E11: Is growth mindset predictive for academic success?

We fitted a linear model to predict academic success with implicit growth mindset. The impact of growth mindset is statistically non-significant (beta = 0.24, 95% CI [-0.23, 0.70], t(175) = 1.00, p = 0.317; Std. beta = 0.08, 95% CI [-0.07, 0.22]). Therefore hypothesis E11 was rejected.

First generation students

Lastly we took a look at the students. Out of the 177 participants 105 were first generation students, whose parents didn't complete a university degree. As academic success has been linked with growth mindset in several studies before we formed the following hypothesis:

E12: Do first generation students exhibit more implicit growth mindset?

The Welch Two Sample t-test testing the difference of implicit growth mindset by first generation (mean in group 0 = 0.12, mean in group 1 = 0.16) suggests that the effect is statistically not significant (difference = -0.04, 95% CI [-0.11, 0.03], t(148.09) = -1.08, p = 0.280; Cohen's d = -0.18, 95% CI [-0.50, 0.14]). Therefore hypothesis E12 was rejected.

Discussion

Summary

Several hypotheses, including our main hypothesis H1 about the relationship between implicit growth mindset and effort to practice, were significant (see Table 7) or showed a trend (see Table 8).

Table 7

Overview over the significant hypotheses

Hypothesis	p-value	Std. beta
H1: The implicit score of growth mindset is predictive for the effort to practice shown at the given learning opportunity.	0.047	0.15
E2: Was there a significant difference in data collection between implicitly and explicitly assessed growth mindset?	<0.001	
E6: Do participants show different effort at the given learning opportunity based on age?	0.003	0.23
E7: Do participants who value their IQ-scores highly show more effort to practice at the given learning opportunity?	0.023	0.17
E8: Do participants show more effort at the given learning opportunity the higher they rate the importance of success?	<0.001	0.28

Note. Accepted hypotheses given a significance level α of .05.

Table 8

Overview over trends

Hypothesis	p-value	Direction
E1: Does explicit growth mindset predict effort to practice? (without influential cases)	0.058	positive
E4: Do participants show different effort at the given learning opportunity based on gender?	0.060	positive

Note. Marginally significant trends given a significance level α of under .10.

The assessment of growth mindset, which was either implicitly with mouse tracking or explicitly with questionnaires, did indeed result in different results. While implicit growth mindset was predictive for effort to practice ($p = .047$; $p = .014$ without the influential cases), explicit growth mindset was not ($p = .129$). A Wilcoxon signed rank test showed a very large difference between the two methods to measure growth mindset ($p < .001$).

Additionally, several exploratory data analyses were conducted to find possible personal variables or control variables, which could affect the relationship between growth mindset and effort to practice. While marginally significant ($p = .060$), did female participants show more effort than male participants at the solutions part. Also did older participants show more effort ($p = .003$), than younger ones. The IQ importance ($p = .023$), success importance ($p < .001$) and task enjoyment ($p = .025$) of the participants seemed to have an effect on the effort shown at the learning opportunity. They were, however, only assessed with one or two items each (see Appendix).

Implications

The main goal of this study (H1) was to predict effort to practice with implicitly assessed growth mindset as opposed to only explicitly measured growth mindset with questionnaires. The results were significant ($p = .047$) and even more so after the removal of the seven influential cases ($p = .014$). While these findings are in line

with the research of Cummins and De Houwer (2021) that the propositional evaluation paradigm is able to measure implicit beliefs, they do not replicate past research on the relationship between explicit growth mindset and effort ($p = .129$). However, the removal of the influential cases resulted in a positive trend ($p = .058$) between explicit growth mindset and effort to practice, which might have been significant with more power.

Questionnaires inherently come with several different problems. A variety of biases exist that distort the actual measurement of a construct (Bogner & Landrock, 2016; Choi & Pak, 2005). Especially social desirability can play a huge role in the assessment of growth mindset (Troche & Kunz, 2020). Implicit measuring tools on the hand use automatic processing and answering to assess a construct and can evade some of these problems (Gawronski et al., 2020). While not perfect themselves, they are preferable to use (Müller & Rothermund, 2019). Especially the Relational Responding Task (RRT) and the newly developed adaptation of the Propositional Evaluation Paradigm with mouse tracking can measure construct accurately and try to evade common problems of other tools (De Houwer et al., 2015; Cummins & De Houwer, 2021).

Metacognition (H2), on the other hand, could not be shown to interact with growth mindset in any way. While several studies not only show that both seem to be present in students, teachers and other members of the academia (Beziat et al., 2018; Hempel et al., 2020; Wang et al., 2021), they are both beneficial for performance and predictive for academic success (Bransford et al., 1999; Coutinho, 2007; Hong et al., 1999; Robins & Pals, 2002; Zulkiply, 2006). There are, however, several possible reasons why no significant results could be found. The scale used was chosen, adapted and translated by myself and showed only questionable internal consistency (Cronbach's $\alpha = .650$). In addition, the sample size might have been too small to find any relationship, as the inclusion of a moderator can almost double the required number of participants. The design of the study might have been inappropriate as well. While growth mindset was predictive for the time spent at the solutions part, this interaction could have been a bad fit for metacognitive skills. The main IQ block was very difficult in nature and the time limit of 45 seconds per task

was a heavy limitation for any planning, monitoring and self-reflective skills the participants could have possessed.

The explicitly assessed growth mindset was non-predictive for the effort shown at the solutions part. The Wilcoxon-test indicated that the assessment of growth mindset with the mouse tracking task and the questionnaire was non-identical ($p < .001$). The difference is plain to see in the histograms of implicitly (see Figure 8) and explicitly (see Figure 9) assessed growth mindset. One reason might be the higher deviation of the explicitly gathered growth mindset (Skewness = -0.98). This could either be due to aforementioned biases (Bogner & Landrock, 2016; Choi & Pak, 2005) or due to the fact that students and members of the academia seem to exhibit higher levels of growth mindset (Beziat et al., 2018; Hempel et al., 2020; Wang et al., 2021). This, however, is unable to explain the lower skewness of the implicitly measured growth mindset.

As only one of our main hypotheses could be accepted, we can only report on the predictive relationship of implicit growth mindset on effort to practice. But, while the results were indeed significant, we had to ask ourselves if the evidence to support our hypothesis H1 is actually strong enough. The relationship between implicitly assessed growth mindset and effort was barely significant at all ($p = .047$), and the explicitly measured growth mindset, which should have been significant as well, was indeed not predictive for the effort shown ($p = .129$). Did we actually purely measure growth mindset with our mouse tracking task? If so, then why wasn’t the growth mindset assessed with the established growth mindset scale significant? Past research almost purely relies on one of the aforementioned questionnaires to assess growth mindset, all the while finding significant results. Did the questions we chose and translated into German not assess growth mindset sufficiently enough or isn’t the mouse tracking task as reliable as it was assumed to be? The internal consistency of the scale we used to assess growth mindset was excellent (Cronbach's $\alpha = .904$), and the removal of the influential cases showed explicit growth mindset to have a positive trend ($p = .058$). We cannot say without additional data. Our findings can only indicate that the mouse tracking task could indeed be a suited form of assessment for growth mindset.

Several other hypotheses were tested in this study as well. While some of them had to be rejected due to non-significant results, some could be accepted. Older participants seem to show more effort than younger participants. The age distribution of the sample is, however, in favor of younger participants. Only four participants out of the 177 were older than 30. Nonetheless were the results significant ($p = .003$) and indicate an effect of age on the measurement.

IQ importance seems to play an important role as well. Those who valued their own IQ score as more important for themselves spent more time at the solutions part as well ($p = .023$). As aforementioned, only three out of the twelve difficult progressive raven matrices were solved on average. While this was designed in order to activate the participants' mindset, this might also have brought them to show more effort to practice due to their valuing of IQ scores. Success importance is predictive for effort to practice as well ($p < .001$). This again might be connected to their intended failure at the difficult IQ block. Lastly, task enjoyment might have an effect on effort to practice ($p = .025$). IQ importance, success importance and task enjoyment might therefore have to be controlled for in further research.

Limitations

As per the design of this study, some participants might have underperformed due to frustration. The first IQ block was falsely advertised as a warm-up task. With the immense task difficulty and the limited amount of time per Raven Matrix agitation among participants might have arisen. Another time-sensitive task that might have caused issues was the mouse tracking task. The measurement tool used in the study is new in comparison to the older, more established ways to ascertain growth mindset. The point of origin for each mouse tracking task was purposefully kept small to ensure standardization, which may have led to frustration and less viable participants due to the stated exclusion criteria of 80% accuracy.

While stated to be a study about intellectual ability in general the transparency of the study might be in danger due to the fact that the majority of the sample size consists of psychology students from the University of Vienna. This also led to a more homogeneous sample, affecting the meaningfulness of the study in a negative

way. The gender distribution was also in favor of female participants, as only 47 out of the 177 participants were male.

Future directions

We were able to find significant and marginal significant results for the assessment of growth mindset. A follow up study, which manages to yield significant results in both forms of assessment would be helpful to clarify the results. IQ importance, success importance and task enjoyment should be included as well, as they might be control variables for effort to practice. Also should the uneven distribution of gender and age be addressed, as they led to a homogenous sample size.

The inclusion of metacognition resulted in no significant results. Still, many studies indicate a possible relationship between metacognition and growth mindset. A greater sample size and a different form of outcome variable might be needed in future studies, as the application of metacognitive skills require time to think about one's own thoughts to begin with.

Growth mindset is popularized and teached at some schools and companies like Windows. Should a relationship with metacognition exist, then further research might lead to the inclusion and fostering of metacognitive skills as well.

Conclusion

Did people who exhibit a growth mindset show more effort at the given learning opportunity? Is the implicit measurement of growth mindset as good as or even better than the established measurement of growth mindset with questionnaires? And did metacognition play a role in the relationship between growth mindset and effort shown? While growth mindset, which was assessed with mouse tracking, did indeed predict effort, some questions remain. Does metacognition play a role in the application of growth mindset or not? How accurate and reliable is the mouse tracking assessment?

Even though we were unable to answer all of our research questions sufficiently, I am excited for further research on the topics of growth mindset and metacognition. Their appliance in schools, mentoring, academia and society might

have an beneficial effect on the education and self-realization of students and people in general.

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Appendix

Abstract

Growth mindset has been linked to achievement cognition, performance and academic success before (Diener & Dweck, 1978; Dweck, 2006; Dweck & Yaeger, 2019). While the established methods for assessment consist of a variety of available questionnaires (Dweck, 2000; Dweck et al., 1995), these could be too unreliable (Midkiff et al., 2017; Troche & Kunz, 2020). The adaption of the Propositional Evaluation Paradigma of Cummins and De Houwer (2021) with mouse tracking is a newly developed measurement tool to assess growth mindset implicitly. This study showed that implicitly measured growth mindset is indeed predictive for effort to practice ($p = .047$; Std. beta = 0.15) and was more significant than the explicitly measured growth mindset, which was measured with a six-items long questionnaire. In addition, a closer look at a possible relationship between growth mindset and metacognition has been taken. While no significant results could be found, both constructs are predictive for academic success and generally present in students (Beziat et al., 2018; Hempel et al., 2020; Wang et al., 2021).

Keywords: Growth mindset, metacognition, implicit measurement, academic success

Abstrakt

Growth Mindset steht bereits länger im Zusammenhang mit der Wahrnehmung von Erfolgen, Leistung und akademischem Erfolg (Diener & Dweck, 1978; Dweck, 2006; Dweck & Yaeger, 2019). Währenddessen es eine Vielzahl an Fragebögen als etablierte Messmethoden gibt (Dweck, 2000; Dweck et al., 1995), könnten diese zu ungenau sein (Midkiff et al., 2017; Troche & Kunz, 2020). Die neuerliche Verbindung zwischen Mausbewegung und Propositions Evaluations Paradigmas durch Cummins und De Houwer (2021) kann Growth Mindset dagegen implizit messen. Wir konnten zeigen, dass eine derartige Messung tatsächlich die Bemühungen von Versuchsteilnehmern voraussagen konnte ($p = .047$; Std. beta = 0.15) und das besser als ein 6 Fragen langer Fragebogen. Des Weiteren haben wir uns einen möglichen Zusammenhang zwischen Growth Mindset und Metakognition angesehen. Obwohl wir keinen signifikanten Zusammenhang finden konnten, sind

doch beide Prädiktoren für akademische Erfolge und generell bei Studenten anzutreffen (Beziat et al., 2018; Hempel et al., 2020; Wang et al., 2021).

Stichworte: Growth mindset, Metakognition, Implizite Messung, Akademische Erfolge

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Questionnaires in order of appearance

Importance of IQ. One item which was used in the preliminary study of Sik et al. (in prep.) as well:

“Bitte beantworten Sie folgende Fragen.”

	Gar nicht (1)	2 (2)	3 (3)	4 (4)	5 (5)	Sehr (6)
Wie selbstbewusst sind Sie bezüglich Ihres IQ? (1)	○	○	○	○	○	○
Wie wichtig ist Ihr IQ für Sie? (2)	○	○	○	○	○	○

Explicit growth mindset. Six items which were adapted from the SE-SÜBELLKO (Spinath & Schöne, 2003):

“Bitte lesen Sie die folgenden Aussagen und geben Sie an, wie sehr die einzelnen Aussagen auf Sie zutreffen.”

	Stimme gar nicht zu (1)	Stimme überwiegend nicht zu (2)	Stimme eher nicht zu (3)	Stimme etwas zu (4)	Stimme überwiegend zu (5)	Stimme völlig zu (6)
Jeder besitzt ein bestimmtes Ausmaß an Intelligenz, das nicht verändert werden kann. (1)	○	○	○	○	○	○

Jeder besitzt ein bestimmtes Ausmaß an Intelligenz, das verändert werden kann. (2)	○	○	○	○	○	○
Wenn man neue Dinge lernt, bleibt die Intelligenz gleich. (3)	○	○	○	○	○	○
Wenn man neue Dinge lernt, verändert sich die Intelligenz. (4)	○	○	○	○	○	○
Intelligenz ist etwas, das kaum verändert werden kann. (5)	○	○	○	○	○	○
Intelligenz ist etwas, das verändert werden kann. (6)	○	○	○	○	○	○

Self-efficacy. Seven items which were adapted from the self-efficacy subscale of the *Motivated Strategies for Learning Questionnaire* (MSLQ) from (Pintrich et al., 1991) and translated into German:

“Bitte lesen Sie die folgenden Aussagen und geben Sie an, wie sehr die einzelnen Aussagen auf Sie zutreffen.”

	Stimme gar nicht zu (1)	Stimme überwiegend nicht zu (2)	Stimme eher nicht zu (3)	Stimme etwas zu (4)	Stimme überwiegend zu (5)	Stimme völlig zu (6)
Im Vergleich zu anderen StudienteilnehmerInnen erwarte ich, dass ich gut abschneide. (1)	○	○	○	○	○	○
Ich erwarte, dass ich in dem folgenden Test über intellektuelle Fähigkeiten sehr gut abschneiden werde. (2)	○	○	○	○	○	○
Meine intellektuellen Fähigkeiten sind im Vergleich zu anderen StudienteilehmerInnen ausgezeichnet. (4)	○	○	○	○	○	○
Ich denke, ich werde im folgenden Test intellektueller Fähigkeiten eine hohe Punktzahl erhalten. (3)	○	○	○	○	○	○
Ich bin sicher, dass ich die Probleme und Aufgaben in diesem Test gut lösen kann. (5)	○	○	○	○	○	○
Verglichen mit anderen StudienteilnehmerInnen bin ich ein/e gute/r StudentIn. (6)	○	○	○	○	○	○
Ich weiß, dass ich in der Lage sein werde, die im Test gestellten Aufgaben zu verstehen. (7)	○	○	○	○	○	○

Metacognition. Ten items that were adapted from the *Metacognitive self-regulation scale* of the *Motivated Strategies for Learning Questionnaire* (MSLQ) from Pintrich et al. (1991) and translated into German:

“Bitte lesen Sie die folgenden Aussagen und geben Sie an, wie sehr die einzelnen Aussagen auf Sie zutreffen.”

	Stimme gar nicht zu (1)	Stimme überwiegend nicht zu (2)	Stimme eher nicht zu (3)	Stimme etwas zu (4)	Stimme überwiegend zu (5)	Stimme völlig zu (6)
Ich übersehe oft wichtige Punkte, weil ich an etwas anderes denke. (1)	○	○	○	○	○	○
Wenn ich etwas lese, dann erfinde ich Fragen dazu, um mich besser zu fokussieren. (8)	○	○	○	○	○	○
Wenn mich etwas verwirrt, dann lese ich es zum besseren Verständnis noch einmal durch. (9)	○	○	○	○	○	○
Wenn etwas zu schwer zu verstehen ist, dann ändere ich meine Herangehensweise. (10)	○	○	○	○	○	○
Bevor ich etwas gründlich lese, überfliege ich es zunächst, um den Aufbau zu verstehen. (11)	○	○	○	○	○	○

Ich stelle mir selbst Fragen, um sicherzugehen, dass ich alles verstanden habe. (12)	○	○	○	○	○	○
Nachdem ich etwas gelesen habe, weiß ich oft nicht mehr, worum es ging. (13)	○	○	○	○	○	○
Ich denke darüber nach, was ich von einer Thematik lernen möchte, anstatt sie nur durchzulesen. (14)	○	○	○	○	○	○
Wenn ich für einen Kurs lerne, dann überlege ich mir, welche Konzepte ich nicht gut verstehe. (15)	○	○	○	○	○	○
Ich setze mir selbst Ziele, um meine Tätigkeiten besser zu lenken. (16)	○	○	○	○	○	○

Failure mindset. Four items from Haimovitz & Dweck (2017) which were translated into German.:

“Bitte lesen Sie die folgenden Aussagen und geben Sie an, wie sehr die einzelnen Aussagen auf Sie zutreffen.”

	Stimme gar nicht zu (1)	Stimme überwiegend nicht zu (2)	Stimme eher nicht zu (3)	Stimme etwas zu (4)	Stimme überwiegend zu (5)	Stimme völlig zu (6)
Misserfolge zu erleben fördert das Lernen. (1)	○	○	○	○	○	○
Misserfolge zu erleben steigert meine Leistung. (17)	○	○	○	○	○	○
Misserfolge zu erleben verhindert mein Wachsen. (18)	○	○	○	○	○	○
Die Konsequenzen von Misserfolgen sind negativ und sollten vermieden werden. (19)	○	○	○	○	○	○

Manipulation check. One item which was used in the preliminary study of Sik et al. (in prep.) as well:

“Bitte beantworten sie folgende Frage.”

	Überhaupt nicht gut (1)	Überwiegend nicht gut (2)	Eher nicht gut (3)	Eher gut (4)	Überwiegend gut (5)	Sehr gut (6)
Wie gut haben Sie bei den Aufwärmübungen abgeschnitten? (1)	○	○	○	○	○	○

Success importance. One item which was used in the preliminary study of Sik et al. (in prep.) as well::

“Bitte beantworten sie folgende Frage.”

	Überhaupt nicht wichtig (1)	Überwiegend unwichtig (2)	Eher unwichtig (3)	Eher wichtig (4)	Überwiegend wichtig (5)	Sehr wichtig (6)
Wie wichtig war es für Sie, bei dieser Aufgabe gut abzuschneiden? (1)	○	○	○	○	○	○

Task enjoyment. Two items which were used in the preliminary study of Sik et al. (in prep.) as well:

“Bitte beantworten sie folgende Fragen.”

	Überhaupt nicht gut (1)	Überwiegend nicht gut (2)	Eher nicht gut (3)	Eher gut (4)	Überwiegend gut (5)	Sehr gut (6)
Wie gut hat Ihnen die Bearbeitung der Aufwärmübungen gefallen? (1)	○	○	○	○	○	○
Wie gut hat Ihnen die Bearbeitung des Haupttestes gefallen? (2)	○	○	○	○	○	○

Academic success. One item which was used in the preliminary study of Sik et al. (in prep.) as well:

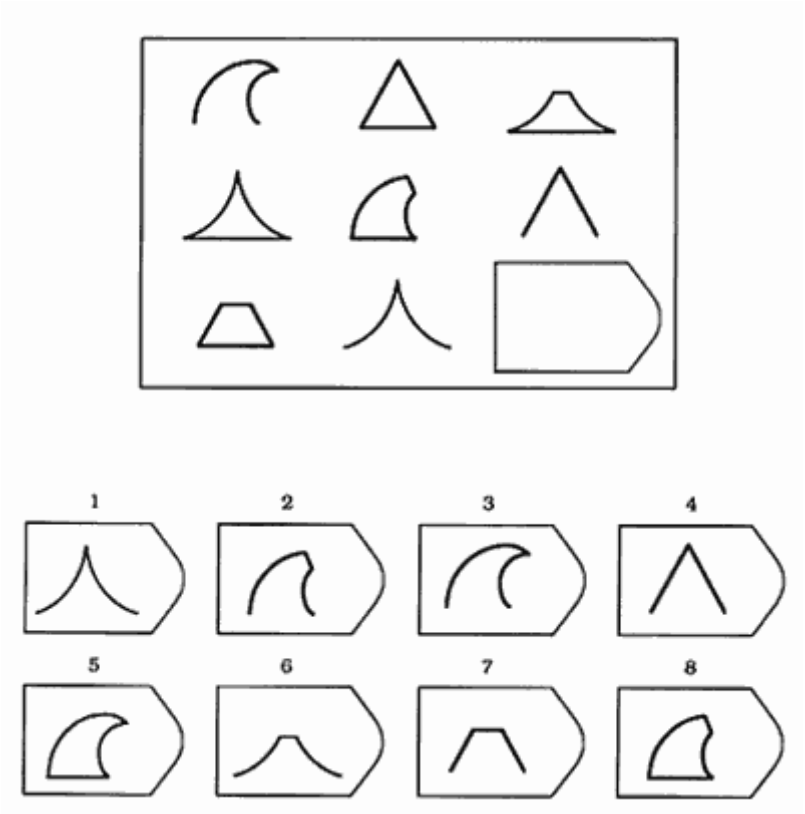
“Bitte beantworten Sie folgende Fragen.”

	eindeutig ein Erfolg (1)	eher ein Erfolg (2)	eher ein Misserfolg (3)	eindeutig ein Misserfolg (4)
Würden Sie Ihre akademischen Leistungen im letzten Semester nach Ihren persönlichen Maßstäben als Erfolg oder Misserfolg betrachten? (1)	○	○	○	○

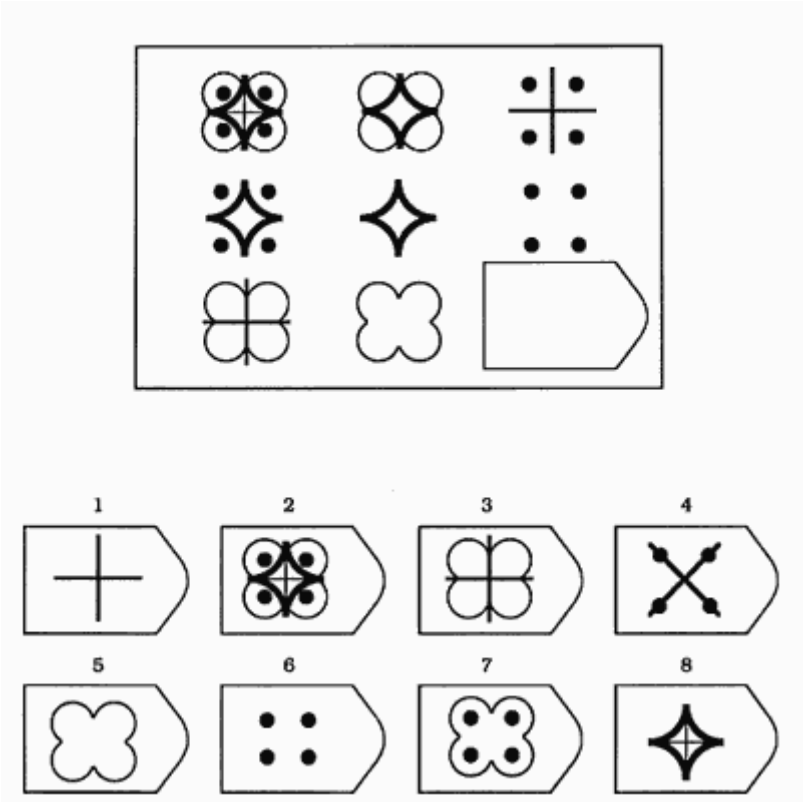
Progressive Raven Matrices

Twelve difficult items of Progressive Raven Matrices (Raven, 2000):

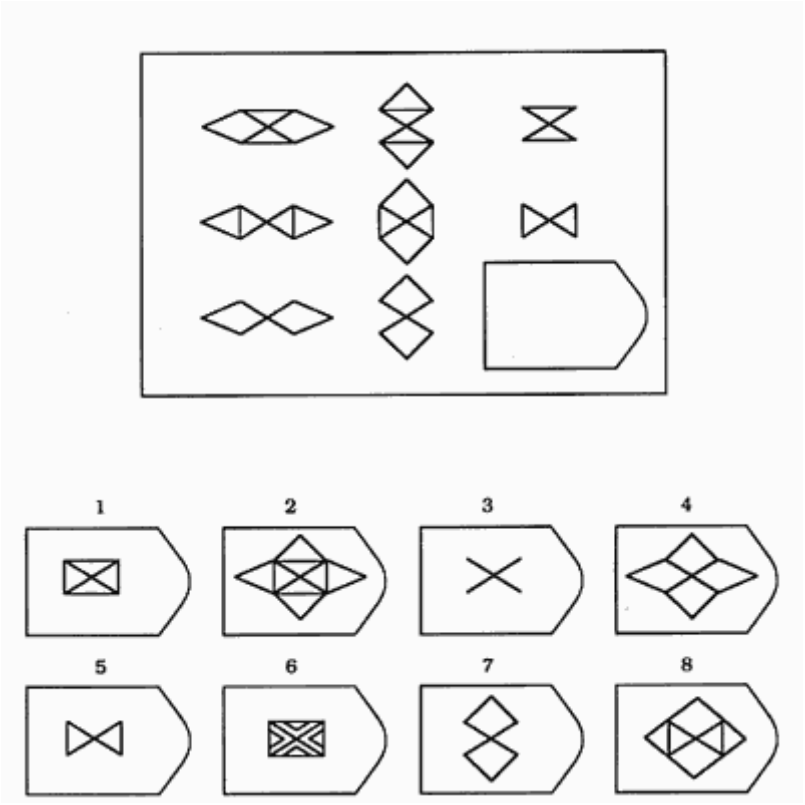
Raven D11.



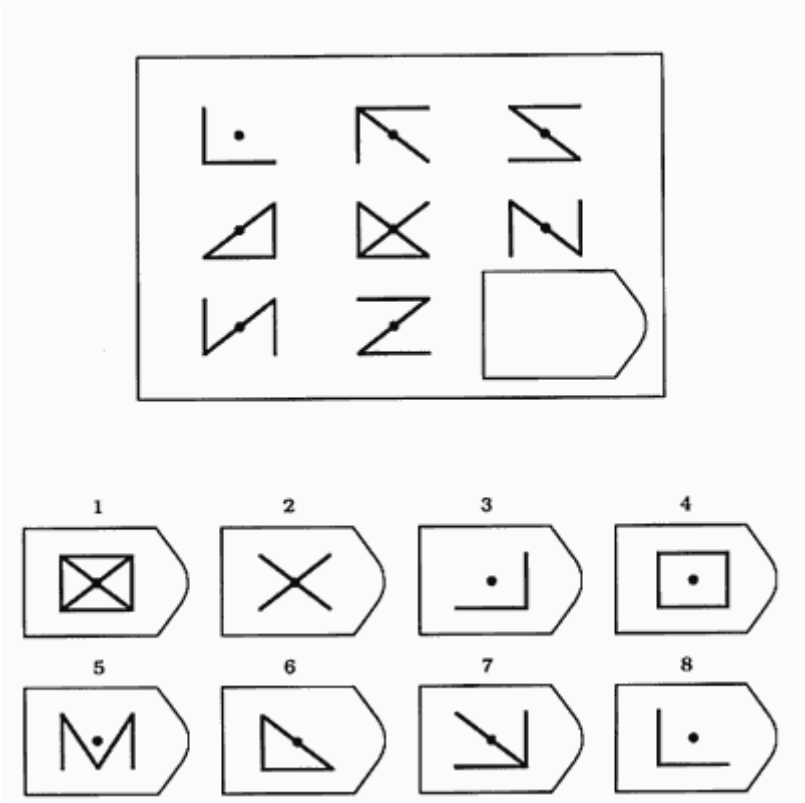
Raven E5.



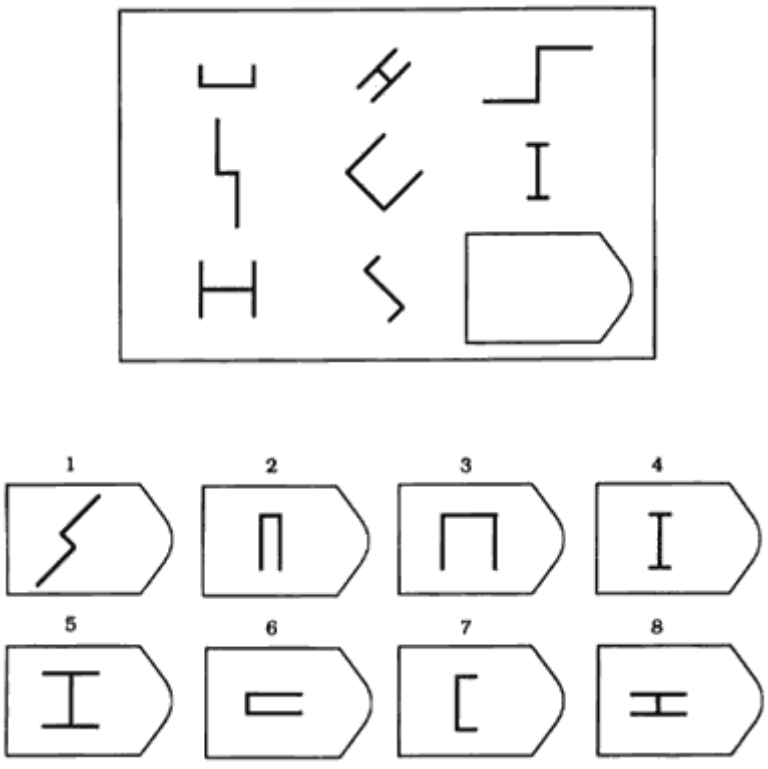
Raven E9.



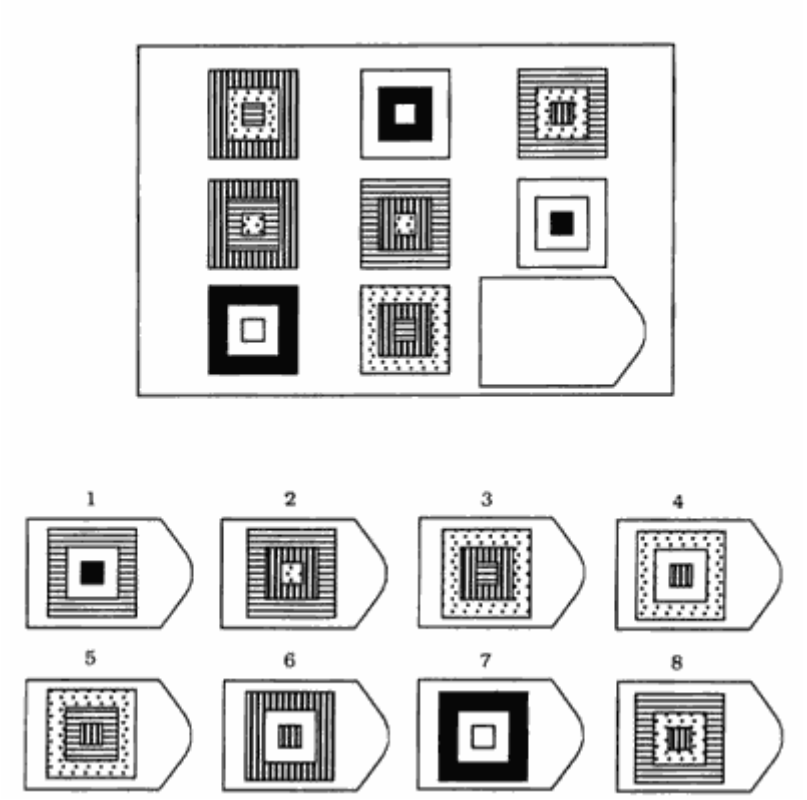
Raven E11.



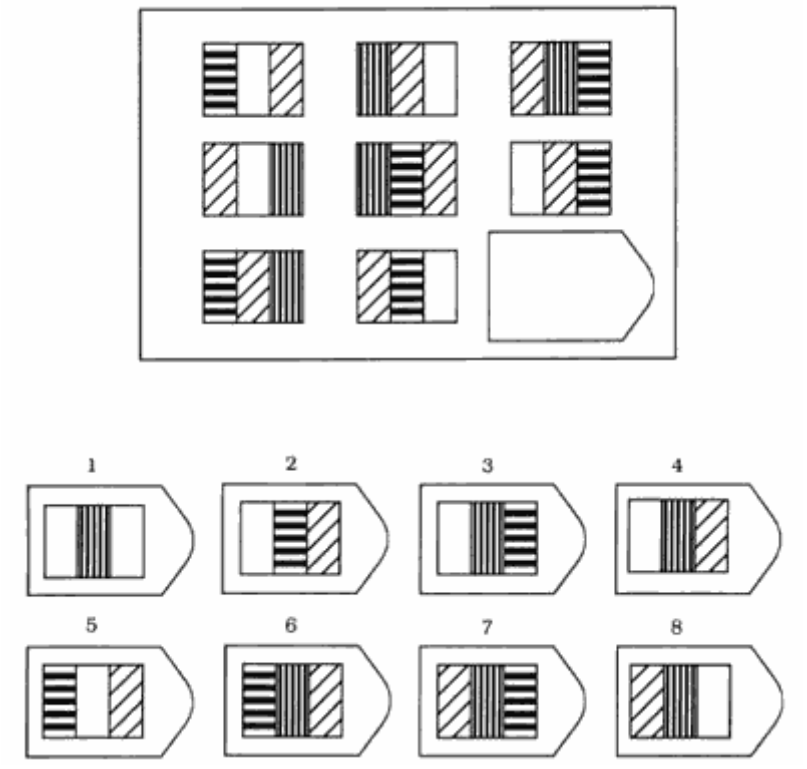
Raven F5.



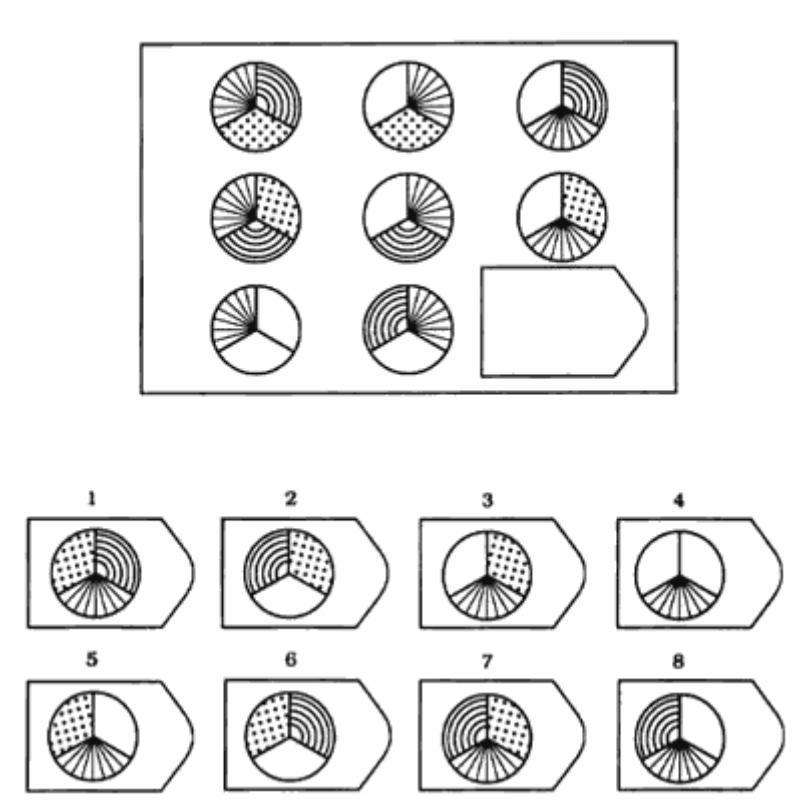
Raven F6.



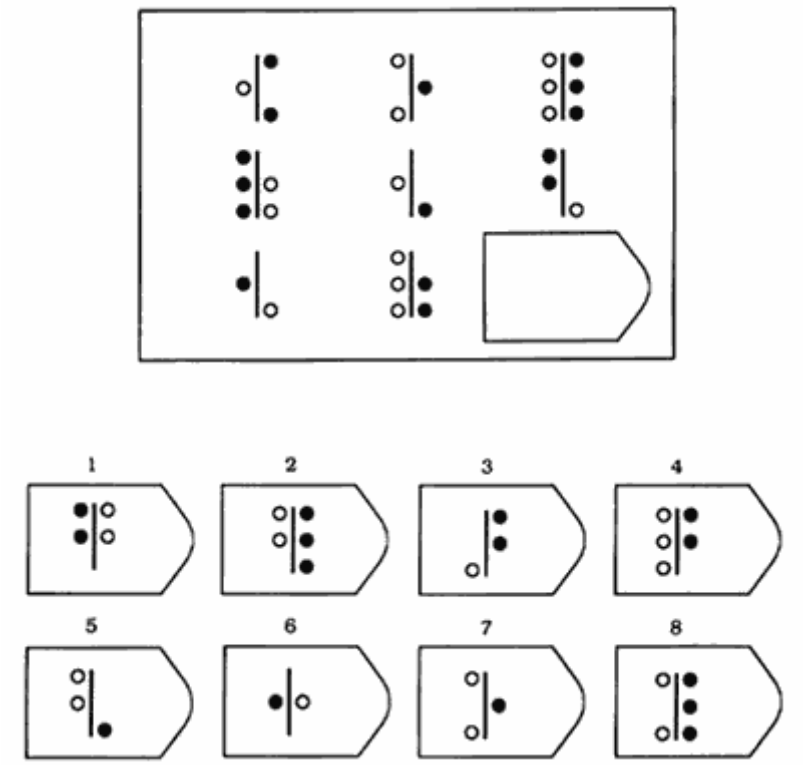
Raven F7.



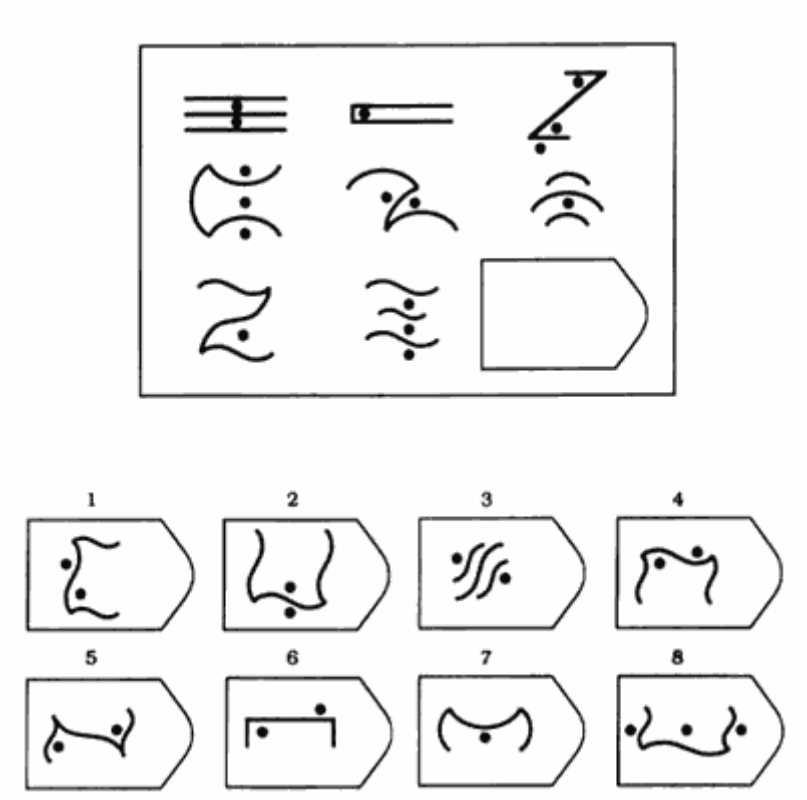
Raven F8.



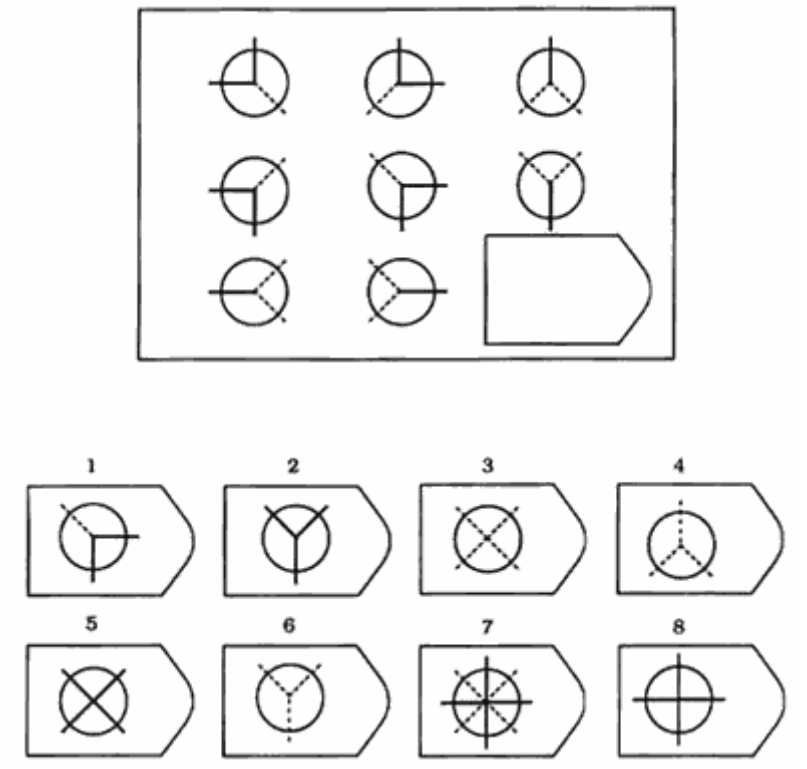
Raven F9.



Raven F10.



Raven F11.



Raven F12.