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„ Truly Implicit, Implicit Theories of Intelligence – The Mediating Role of State Anxiety between Growth Mindset and Learning“

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Contents

Truly Implicit, Implicit Theories of Intelligence – The Mediating Role of State Anxiety between Growth Mindset and Learning

Everyone experiences failure in their academic life. For some it is a bad grade on an exam, for others, it is failing the exam completely. But at some point, failure is inevitable. However, people differ in how they respond to failure. This difference is partly explained by the *implicit theories of intelligence (*Dweck & Leggett, 1988*)*. The implicit theories of intelligence differentiate in the way people think about intelligence and whether it can be developed.

On the one hand, individuals might believe that intelligence can be improved and therefore be more willing to learn after a failed attempt. This assumption about the malleability of personal qualities is called a *growth mindset.* In literature it is also often referred to as *incremental theory*. On the other hand, people might believe that intelligence or personal qualities in general are not changeable. This is referred to as a *fixed mindset*, often also called *entity theory* (Dweck & Yeager, 2019).
The implicit theories of intelligence have a variety of implications, ranging from an improvement in grades (Blackwell et al., 2007) to higher well-being (Zeng et al., 2016) in favor of people with a growth mindset compared to people with a fixed mindset.

Such implications made the theory popular and at this point it is promoted in various forms (e.g.: Moore & Glasgow, 2007; Maichin, 2019). Therefore, it can be assumed that growth mindset is seen as more desirable to have. This, however, presents a problem as growth and fixed mindset have so far been measured using questionnaires like the German intelligence mindset inventory (Spinath & Schöne, 2003). Respondents are asked how they would self-assess their belief about growth or fixed mindsets. Such questionnaires are prone to misreporting due to social desirability (Fischer et al., 2020). Considering the popularity of the concept of growth mindset, participants might tend to indicate having more of a growth mindset than what they actually think. This could lead to such tests being susceptible to misreporting and could paint a false picture of the given distribution of growth mindset and its effects.

It is assumed that such misreporting might be avoided by *implicit measurements* (Steffens, 2004). Consequently, the newly developed method, the *mousetracking Propositional Evaluation Paradigm* (MT-PEP), by Cummins and De

Houwer (2021) was used for this experiment. Since it is a novelty to use such an implicit measurement for the implicit theories of intelligence, it has the potential to provide valuable new insight into the connection of having tendencies of growth and fixed mindsets and learning.

After the initial implicit measurement, the procedure of this experiment consisted of presenting IQ tasks of different difficulty levels to the participants. The first block was initially presented as an easy introduction to the more difficult main block that would follow. However, the initial twelve IQ items were actually very difficult to solve in the given time, so it was expected that participants would experience failure. Thereafter, the opportunity existed to learn the tasks and their concepts to perform better in the following main block, which actually consisted of twelve easy IQ items. Throughout the experiment, psychophysiological effort was measured in order to assess the participants' learning behavior. In addition, various questionnaires were given throughout the experiment.

The concept of learning was measured in this experiment primarily by the *heart pre-ejection period* (*PEP*). PEP measures the level of effort and the amount of resources mobilized (Obrist, 1981). Therefore, this experiment more precisely measures the psychophysiological mental effort during the learning phase. Although there is an important distinction in the specifics, for practical reasons the psychophysiological mental effort during the learning phase will in this paper also be referred to as learning.

In addition, this new and expectedly more reliable implicit measurement allows for an attempt to replicate or refute previously assumed connections between growth mindset with learning (e.g., Bai & Wang, 2020; Bedford, 2017; Dweck, 2014). The present paper further examines the relationship between the implicit theories of intelligence and *state anxiety*. Previous research has indicated that state anxiety is negatively correlated with learning and academic achievement in general (King et al., 1976; Rosenfeld, 1978; Tanaka et al. 2006). Furthermore, Frondozo et al (2020) found that growth mindset negatively correlates with anxiety. On top of that, Dweck and Leggett (1988) were able to show a mediating effect of anxiety on learning. Building on this foundation, it is theorized in this paper that state anxiety mediates the effect of growth mindset on learning.

Theory and Hypotheses

Motivation has long been a central focus of psychology. It addresses the question of how motivation arises and under what conditions it sustains (Kruglanski et al., 2015). An important point in this regard is how people react to failure, as this can be a demotivating experience for many (Kaivanpanah & Ghasemi, 2011). The focal point is that individuals differ in their reaction to failure (Dweck, 2017). E.g., a student who fails an exam may not be motivated to learn. Here the implicit theories of intelligence come into play. After all, students react differently, if they attribute a lack of ability as the reason for their failure compared to a student who ascribes it to something which is possible to change (Dweck, 2017). This changeable attribution could be as simple as the amount of sleep the individual had the night before. The implicit theories of intelligence distinguish between those two approaches, naming them growth mindset and fixed mindset (Dweck & Yeager, 2019).

Description of the Implicit Theories of Intelligence

The idea of individuals having different beliefs of how intelligence works was first addressed by Dweck and Leggett (1988) at the end of the behavioristic era. Dweck first attempted to integrate the early work on *learned helplessness* with the *attribution theory* (Dweck & Yeager, 2019). As part of this research, she was able to confirm that children's attributions can in fact predict a "*helpless*-" or "*mastery-oriented*" response to setbacks, despite equal abilities on a task (Dweck & Reppucci, 1973; Diener & Dweck, 1978). It was later shown that differences in achievement goals can explain parts of this phenomenon (Elliott & Dweck, 1988). Accordingly, a distinction was made between the wish to prove or to improve. Along this differentiation, it was recognized that the wish to prove seems like a deep-seated, fixed attribute of the self. The wish to improve makes it seem like a dynamic quality, which can be developed. This was eventually the final step to the implicit theories of intelligence and the differentiation between a growth and a fixed mindset. The concept was named "implicit" because people are not aware of it and „theories" because they are potentially falsifiable ideas that people hold (Dweck & Yeager, 2019).

The difference between growth and fixed mindset becomes particularly clear in the reaction to failed tasks. Having failed in a situation, e.g., an intellectual task, people with more of a fixed mindset might tend to think that this failure happened

because of missing intellect or them being unable to understand the task (Dweck et al., 1995). When tending to have a growth mindset, another possibility is to attribute the failure to more controllable factors, such as lack of concentration or inadequate preparation. This can be viewed as a major differentiation between growth and fixed mindsets.

Furthermore, it is argued by Dweck and Yeager (2019) that some ideas are not isolated but represent a set of variables such as goals, beliefs and behaviors. These variables can be referred to as *meaning systems*. Growth and fixed mindsets serve as such meaning systems. Accordingly, these variables differ depending on people holding a fixed or growth mindset. One implication of this might be that individuals who believe intelligence and abilities can be changed are more likely to aim to improve their abilities by overcoming challenges (Dweck & Yeager, 2019). Effort could be viewed as behavior necessary for the process of improvement, while failure can more easily be seen as part of the learning process. This would encourage the willingness to respond to failure with further learning. In the case that a person believes intelligence to be fixed however, it would be the other way around. The person would have higher chances of viewing it as necessary to validate his or her intelligence. This individual might consider more effort as an indicator of less intelligence and failure as an indicator of lack of intelligence (Dweck & Yeager, 2019). These examples demonstrate how the variables goals, beliefs and behaviors function as one meaning system.

This in mind, it leads to various implications, already shown in various studies. One is that growth and fixed mindsets differ in goal setting (Yeager & Dweck, 2012). Students with a tendency to a fixed mindset lean towards conceiving various situations as a measurement of their abilities and intellect, such as academic performance and challenges. In contrast, students with a growth mindset tend to view academics in terms of learning, growing, and developing. They might interpret setbacks, challenges and effort as effective approaches to improving their skills and intelligence.

Another implication is an improvement in grades due to intervention teachings of growth mindset (Blackwell et al., 2007). Plaks (2017) was able to show that people scoring higher in the general belief of the malleability of personal qualities tend to exhibit less person judgements and group stereotypes.

Zeng et al. (2016) found growth mindset correlating with higher well-being, school engagement and resilience for students. That paper argues that resilience acts in part as a mediator between the other outcomes. Accordingly, students with a growth mindset are more likely to bounce back after academic failure and, in turn, become more engaged. This serves as a protective factor in the highly competitive school environment, which in return leads to greater well-being.

Furthermore, differences in lifelong learning have been documented for medical students by Babenko et al. (2019). The reasoning of the authors is that students, approaching academic situations with a growth mindset, use more adaptive goals and thus experience less psychological distress. This is theorized to lead to a greater commitment to lifelong learning.

However, it is important to point out that just believing in intelligence to be malleable does not lead to every task being equally achievable for every individual (Blackwell et al. 2007). Additionally, such findings from correlational and experimental research indicating that a growth mindset can predict outcomes, which are viewed as positive in society do not mean that a growth mindset is always positive. Sometimes personal attributes just cannot be changed and persistence without progress can be challenged (Dweck & Yeager, 2019).

Development

On the topic of how these two mindsets develop, the first assumption would be that role models like parents and teachers pass on their mindset to children. However, that is not the case and the issue is a bit more complex (Haimovitz & Dweck, 2017). Hooper et al. (2016) showed that there is no link between the mindset of math teachers and their students. This implies that just teaching about a mindset or being a role model with a certain mindset is not enough to induce it. In contrast to that Mueller & Dweck (1998) showed that it is more important how parents react to the behavior of their children. According to this study, after success being praised for intelligence (*person praise*) is more likely to lead to a fixed mindset than being praised for effort (*process praise*). This implies that how others react to one's success and failure plays a crucial role in acquiring a certain mindset. Haimovitz and Dweck (2017) further elaborate that focusing on the process of learning instead of the outcome induces more of a growth mindset. In addition to that finding, Sun (2015) was able to show in a study that mathematics teachers were successful in

promoting growth mindset. This success is assumed to be the case because the teachers focused their teachings on the learning process of their students rather than their abilities.

Furthermore, Hong et al. (1999) argues that the two different mindsets could be viewed as basic modes of thought. One of the two theories is more familiar to a person and after failure, the person leans into the already stronger represented mode. It is argued by Hong et al. (1999) that it is possible to push a particular implicit theory, which increases the likelihood that a person will adopt it. According to this line of thought, an induction of a mindset is possible and with that it should be possible to influence how participants respond to failure. Consistent with this idea, Blackwell et al. (2007) were able to demonstrate that seventh graders who received a growth mindset induction were more likely to attribute setbacks to changeable causes such as a lack of learning, instead of a lack of e.g., abilities. Consequently, it can be assumed that children learn mindsets through reactions to their behavior (Mueller & Dweck, 1998; Sun, 2015) and, moreover, that it can be further induced (Hong et al., 1999; Blackwell et al., 2007).

Popularity of the Theory and its Problem

Due to the many demonstrated implications of the implicit theories of intelligence discussed above, it gained popularity. Growth mindset continues to be taught, discussed, and promoted in various fields to this day (e.g., Moore & Glasgow, 2007; Maichin, 2019). Its popularity has reached such an extent that the OECD report for a PISA test showed a majority endorsing growth mindset (Gouëdard, 2021). In itself, this would not present an issue. However, it is problematic when it comes to measuring growth and fixed mindsets. As mentioned above, it is still measured through self-reported scales like the *Theories of Intelligence Questionnaire* (Dweck, 2000). However, on the one hand, individuals are typically unaware of this belief system (Dweck & Yeager, 2019). On the other hand, self-reported scales are susceptible to biased responses (Fischer et al., 2020), especially since it is generally desirable to state a tendency towards growth mindset. That is assumed to be the case, because a majority endorses it (Gouëdard, 2021). This potentially falsifies the results and paints a false picture of the distributions of the mindsets. Moreover, this falsifiability could lead to false connections being drawn between growth mindset and other constructs, such as well-being and life-long

learning. Thus, it is crucial to look for new ways to assess growth and fixed mindsets, to differentiate them more precisely and to examine previously found connections in new ways. Measuring different belief systems is not a new challenge and one approach is implicit measurement (Steffens, 2004).

Implicit Measurement

Implicit measurement is a form of testing that attempts to avoid e.g., social desirability biases of participants, as well as participants attempting to falsify questionnaires. The first example of such a test was the *Implicit Association Test* (IAT) by Greenwald et al. (1998). The idea behind it is to present participants with different pairs of two concepts, of which some have stronger and some have less strong associations. “Flower” and “beautiful” being an example for a strong association. In contrast to that would be a pair like “injury” and “beautiful”. In theory, participants should react faster to two concepts whose associations are stronger, as it is for the first pair compared to the second (Greenwald et al., 1998).

MT-PEP

Recently, Cummins and De Houwer (2021) developed a new implicit measurement procedure, the mousetracking Propositional Evaluation Paradigm (MT-PEP). As the name implies, it tracks the movement of the mouse while participants are required to perform a response task under time pressure. The basic idea of the propositional evaluation paradigm is that propositions form the core of attitudes and beliefs. Therefore, the MT-PEP distinguishes itself considerably from the Implicit Association Test of Greenwald et al (1998), as propositions differ from associations in crucial ways (De Houwer, 2009). De Houwer (2009) argues that an association only describes the existence of a state of affairs. This implies that associations can not be true or false, but are simply there. In contrast, propositions are described as statements about a state of affairs in the world that can differ in the extent to which they are considered accurate. Moreover, propositions can also refer to the way concepts are related. An example from De Houwer (2009) is the distinction between “cue A is a cause of outcome O” and “cue A is an effect of the outcome O”. This illustrates how propositions can differentiate in the nature of the relation, which is not possible with associations and the IAT.

The original Propositional Evaluation Paradigm (PEP) (Müller & Rothermund, 2019) has already shown evidence of its validity for measuring implicit belief systems. It measures the response time taken to answer specific questions. Furthermore, as the MT-PEP tracks the continuous movement of the hand, it visualizes decision processes and computes the microstructure of decisions at millisecond resolution. It is measured by deviation from regular mouse-movement (Cummins & De Houwer, 2021). For the current experiment “probe trials” and “catch trials” were used in the MT-PEP. On the probe trials people have to respond according to whether words of a sentence are spelled correctly or not. If it is spelled correctly, participants have to click “true”, if not “false”. These sentences address a specific topic. On the catch trial participants have to click “true” or “false” depending on whether the sentence is seen as true or false. It is theorized that the mouse movement can be used to measure whether people implicitly agree or disagree with the content of the sentence.

The MT-PEP showed a Cronbach´s α = .90 for measuring anti-immigrant beliefs in the truth-evaluation variant (Cummins & De Houwer, 2021). This represents a desirable internal consistency (Bland & Altman, 1997). The reliability for measuring the implicit theories of intelligence with probe and catch trials will be shown with the analysis of the current experiment. The MT-PEP was shown to be effective in capturing group-level beliefs across domains and to have potential for capturing relational information. The MT-PEP may be considered implicit in that it captures fast and unaware responses. Nonetheless, the MT-PEP still appears to be intentionally controllable and thus falsifiable to some extent (Cummins & De Houwer, 2021).

By applying this new method to the implicit theories of intelligence, this study hopes to gain new insight. Furthermore, since this paper focuses on the relation between growth mindset and its positive effect on learning, it was hoped to replicate previously found effects of growth mindset on learning using this new method.

Learning

Learning has been a focus of psychology for almost as long as it has existed (e.g., Ebbinghaus, 1885/1962; Thorndike, 1911). Since then, there has been a discussion of how learning is defined and what terms determine learning success. De Houwer et al (2013) define learning as an ontogenetic adaptation. This refers to

changes in the behavior of an organism that result from regularities in the environment of the organism. The implicit theories of intelligence are just another theory that addresses aspects of learning. Namely, it investigates how a certain mindset influences an individual's approach to learning (Dweck et al., 1995). The relationship of growth mindset and academic motivation is already well established (Bedford, 2017; Grant & Dweck, 2003; Dweck, 2008). Dweck (2014) for example, has shown that mindsets can predict achievements in science over time, just as interventions to strengthen growth mindset can improve academic achievement. Furthermore, Cavanagh et al., (2018) was able to demonstrate an effect of growth mindset on students' commitment to and engagement in active learning.

Another aspect is that research also indicates that growth mindset might be a good tool to avoid the negative effects of negative feedback on an individual's motivation to learn (Hong et al., 1999). It has already been shown that academic setbacks, for example, can have a negative impact on an individual's motivation to learn (Van Dijk & Kluger, 2011). This is particularly important because in life, and especially in academic life, it is inevitable to receive negative feedback. Along these lines, Hong et al. (1999) showed that people with a growth mindset were more likely to take corrective action after receiving negative feedback. This may be an indication of growth mindset protecting a person's motivation to learn from negative feedback.

Following these results, it was hypothesized in the current paper that growth mindset would have an impact on the participants' effort to learn during the experiment. This would be shown after the participants received negative feedback for the task of absolving difficult IQ items. In the current study, learning was measured using pre-ejection period values (PEP) to capture psychophysiological mental effort during the learning phase. The connection of PEP with learning is elaborated in the chapter Psychophysiological Measurement. In this experiment, however, only the mechanical part of learning is addressed, specifically the active part of the process. This active part of learning can be measured by PEP. The aspect of changes in the behavior of an organism is omitted, which according to De Houwer et al. (2013) is part of learning. This is the case because such change would have been difficult to measure in the current study design. Accordingly, when this paper refers to the learning, experimentally observed, it is referring to the psychophysiological mental effort during the learning phase. Thus, it is important to keep in mind that this arousal is not necessarily entirely equivalent to learning.

Psychophysiological Measurement

This research addresses the idea that growth and fixed mindset influence the way one responds to failures in learning. It was assumed that the relationship between growth mindset and learning can be seen by observing psychophysiological mental effort during the learning phase. Thus, it was attempted to show through psychophysiological measurement (heart rate, systolic, diastolic and mean arterial blood pressure and pre-ejection period) during the difficult IQ tasks and the learning block.

The systolic blood pressure (SBP) is the highest arterial blood pressure following a heartbeat and increases with task difficulty (Richter et al., 2008). Diastolic blood pressure (DBP) is the lowest arterial blood pressure following a heartbeat and mean arterial blood pressure (MAP) is the average blood pressure. The heart pre-ejection period (PEP) is the time interval between the onset of electrical stimulation of the left ventricle and the opening of the aortic valve (Lanfranchi et al., 1999). When the heart needs to sustain a behavior or keep up with a task, the contractile force of the heart increases. The level of effort and the amount of resources mobilized can then be measured by PEP. PEP is influenced by sympathetic nervous system activity via beta-adrenergic receptors. Beta-adrenergic influences on the heart and vascular system vary with effort in response to a performance challenge (Obrist, 1981). Such a performance challenge could be, for example, maintaining the energy level for a learning task, as it was the case in the current experiment.

The pre-ejection period represents a time interval (Obrist, 1981). This means, the shorter the interval, the more the heart collapses and expels more blood, mobilizing more glucose and more resources to accomplish a task. Therefore, lower PEP values signify more effort. All mentioned values were measured in this experiment. However, PEP is believed to be a more sophisticated measurement and is used as the gold standard. Blood pressure was measured to support the results.

Accordingly, it is assumed that decreasing PEP values, which means higher effort, are related to holding a growth mindset.

Self-Efficacy

Self-efficacy is another concept having a meaningful impact on learning (Schunk, 1985). Bandura and Wessels (1994) defined perceived self-efficacy as

people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives.

Self-efficacy in learning has been shown to correlate positively with motivation to learn and motivation to acquire knowledge and skills (Schunk, 1985). Liem et al. (2008) showed the positive correlation of self-efficacy with the use of cognitive strategies for learning. In line with this, a meta-analysis of 19 studies proved the effect of self-efficacy on students self-regulated learning (Panadero et al., 2017). Finally, Bai and Wang (2020) were able to demonstrate that growth mindset, just like self-efficacy, predicts the use of self-regulation strategies while learning. This in turn predicted English test scores of the participants. Such results demonstrate that self-efficacy and growth mindset can influence the same variables.

Correspondingly, self-efficacy is used as a control variable for the correlation analysis between growth mindset and learning. This implantation allows for the differentiation of the effects of growth mindset and self-efficacy on learning. Self-efficacy was measured by a seven item self-efficacy questionnaire (Pintrich & de Groot, 1990).

It is notable that this experiment was conducted in collaboration with other master and PhD students of the University of Vienna. Accordingly, the design, procedure, and measures of the experiment as well as the following hypotheses H1 and H1a are similar in regard to content to those of Linke (2023).

The presented theory forms the basis for the first hypotheses. The previously found effect of growth mindset on learning (e.g., Bai & Wang, 2020; Bedford, 2017; Dweck, 2014) was tried to be replicated using the implicit measurement MT-PEP (Cummins & De Houwer, 2021). This is the case because questionnaires like the German intelligence mindset inventory (Spinath & Schöne, 2003) are prone to misreporting (Fischer et al., 2020). The idea is that individuals with a growth mindset view challenges as opportunities to learn and grow, rather than to showcase their abilities. Therefore, persistence to learn can be sustained even after failing at the difficult IQ tasks used in the experiment (Raven & Raven, 2003). Learning was measured through the pre-ejection period (PEP).

Accordingly, the first hypothesis, shared with Linke (2023), is as followed:

H1: The implicit score of growth mindset is predictive for the psychophysiological mental effort during the learning phase.

To support the theoretical considerations from this paper and for exploratory reasons, additional analyses were conducted in accordance with Linke (2023), using the explicit rather than the implicit growth mindset score. Results are expected to vary depending on whether implicit or explicit growth mindset scores are used. It is hoped in this context that implicitly measured values have a higher sensitivity for capturing growth mindset. Accordingly, the following hypothesis emerges:

H1a: The explicit score of growth mindset is predictive for the psychophysiological mental effort during the learning phase.

Implicit Theories of Intelligence and State Anxiety

Another focus of this paper is the role state anxiety plays in the connection between growth mindset and learning. State anxiety reflects the psychological and physiological transient reactions directly related to adverse situations in a specific moment (Leal et al., 2017). It is differentiated from trait anxiety, which describes a personality trait. The distinction between these two concepts was first done by Spielberger et al (1970).

State anxiety has been shown to have a negative effect on learning and academic achievement in general (e.g., King et al., 1976; Rosenfeld, 1978; Tanaka et al. 2006). At the same time Frondozo et al. (2020) found that growth mindset negatively correlates with anxiety.

The underlying idea is that people with a growth mindset view their learning abilities as malleable and perceive learning tasks as opportunities to improve their skills. This circumstance may lead them to perceive less anxiety in the face of a task. Therefore, people might be able to engage and focus more on learning. In contrast, individuals with a less pronounced growth mindset (a tendency towards a fixed mindset) tend to believe that their ability is not malleable. Theoretically, this would imply for a person that if a task is not initially mastered, he or she will assume to not be able to acquire the skills necessary to master it at all. This further increases the pressure to master a task on the first try. Following this line of thought, it potentially leads to a higher tendency to experience state anxiety. This in turn negatively affects learning and academic performance (King et al., 1976; Rosenfeld, 1978; Tanaka et al. 2006).

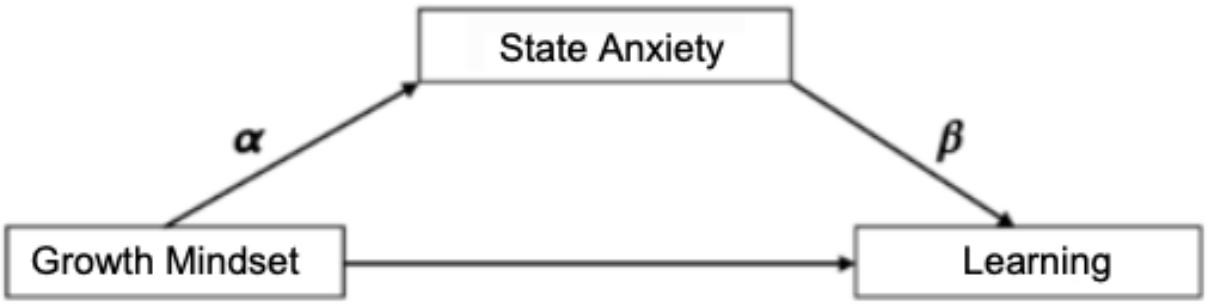
The consideration of state anxiety having a mediating role has already been presented by Dweck and Legget (1988). The authors refer to a study (Diener &

Dweck, 1980) in which children with a fixed mindset who experienced failure expressed stronger feelings of anxiety about their performance than children with a growth mindset. This effect would in turn have a negative impact on the learning process (King et al., 1976; Rosenfeld, 1978; Tanaka et al. 2006). In addition, Samuel and Warner (2021) showed a significant impact of a growth mindset-based intervention on math anxiety in first-year students. Such effects are consistent with the ideas of this paper.

Consistent with this notion of how anxiety is involved in the connection between growth mindset and learning, this paper assumes it to have a mediating role. Accordingly, growth mindset is considered as the independent variable and the psychophysiological mental effort during the learning phase as the dependent variable. This is also being referred to as learning. The score of state anxiety is considered as the mediator. Figure 1 shows a visualization of the theorized connection.

Figure 1

Model for the Expected Mediation of Growth Mindset and Learning by State Anxiety.



Note. This figure demonstrates the theorized connection between the variable's growth mindset, learning and state anxiety, which poses a mediator.

In the study already conducted, this would be as follows. The implicitly assessed score of growth mindset correlates with the psychophysiological assessed effort during the learning phase, which is mediated via the score of state anxiety, being assessed through a questionnaire. Accordingly, it was assumed that state anxiety would correlate positively with PEP values. This is the case, as PEP represents a time interval. The more the heart collapses, the shorter the time interval

and the more effort is exerted. In line with this, PEP values are presumably negatively correlated with holding a growth mindset.

Based on this, the following hypothesis arises:

H2: The relation between the implicit score of growth mindset and the psychophysiological mental effort during the learning phase is mediated by the score of state anxiety.

Again, the explicit measurement of growth mindset is investigated as well and whether it shows differences to implicitly measured growth mindset:

H2a: The relation between the explicit score of growth mindset and the psychophysiological mental effort during the learning phase is mediated by the score of state anxiety.

Methods

As this experiment was conducted in collaboration with colleagues, the following design, procedure and measures are the same in content for this paper and the paper of Linke (2023).

Participants and Design

For obtaining the necessary information for testing the hypothesis, participants were invited to take part in the study. The experiment was conducted in the Motivation Science Lab at the University of Vienna. Participants received six credit points as compensation. Such credit points are necessary for the completion of the psychology bachelor's degree at the University of Vienna. The survey was in German and was conducted between March and May 2022. Just as in Linke (2023), a total of 188 psychology bachelor students were recruited. Ten observations had missing values. This was partly due to defective electrodes. Five participants reported having a heart disease, which disqualified them from taking part in the experiment. Finally, three participants accidently closed the program in the middle of the experiment, which resulted in losing the data. This provided a data set of 170 final participants. (M_{Age} = 22.12, SD_{AGE} = 3.46, 58% female, 40% male, 0.6% diverse) ranging in age from 18 to 49 years. Implicit data were used for only 152 participants because 16 participants did not meet the specified 80% correct criteria for the implicit task and data was not saved for two participants. In six cases an

interruption occurred to reattach loosened electrodes. For these instances a score for the PEP measure was calculated for the time period without contact.

The data was matched with the timestamps of Qualtrics - the program used for the survey. This was done to know when participants started and finished the “solutions” and “difficult IQ” part. For the start and end of the baseline block timestamps were used, which were done manually by the instructors of the experiment. For three participants no baseline markers were recorded. For these cases a given manual file was used to determine the time stamps.

The design of this experiment is a correlational study. The dependent variable is the psychophysiological mental effort during the learning phase. More specifically it is the difference of the measured baseline PEP values and the PEP values during the learning block. The implicit score for growth mindset is the independent variable. State anxiety was used as a mediator. In the linear regression self-efficacy was used as a control variable.

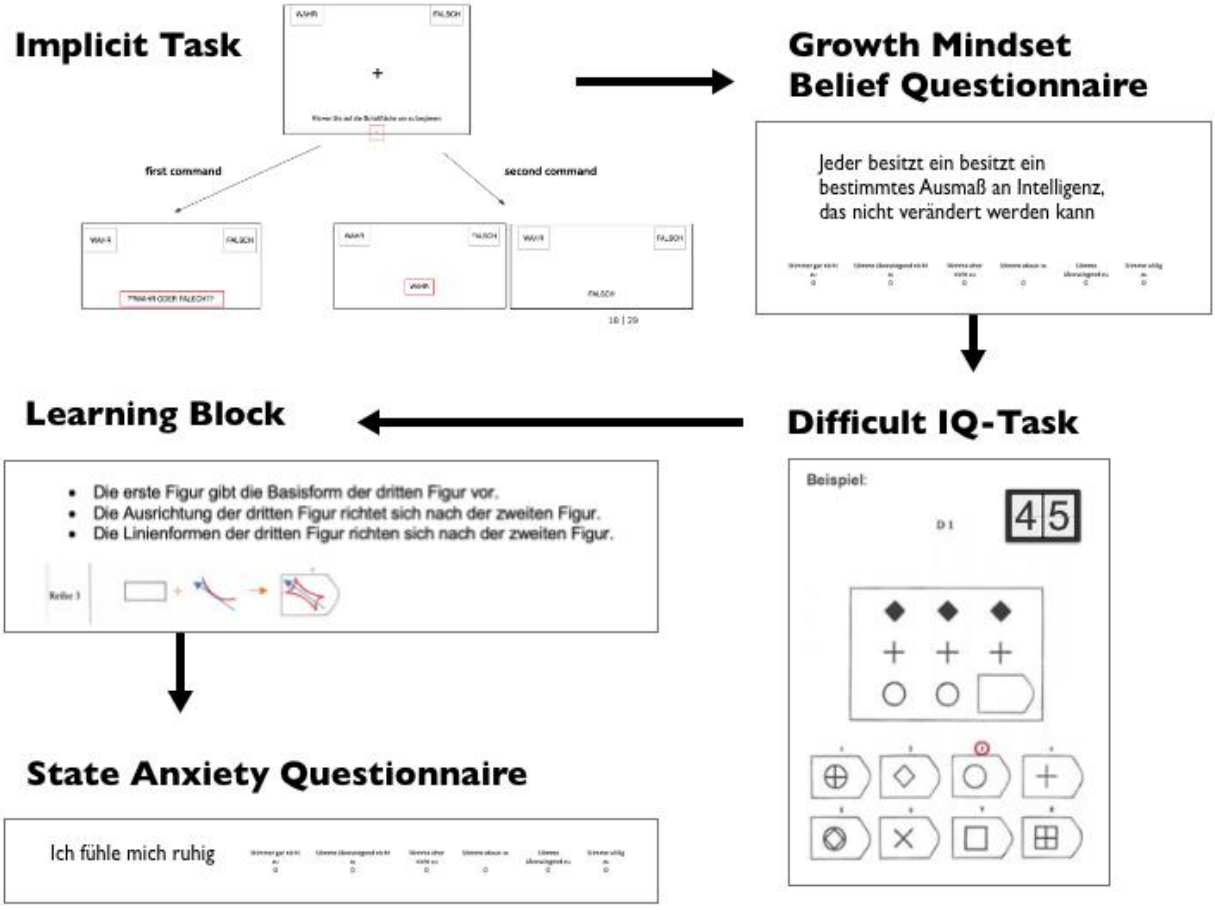
Procedure

The following procedure is the same in content as in Linke (2023). At the beginning participants were seated and had to read information provided to them about the experiment, as well as sign an informed consent that allowed the use of their data. Furthermore, they had to provide information about their physical health. They were then connected to an electrocardiogram (ECG) and a blood pressure monitor. The four electrodes were attached to the upper lateral chest area and the posterior neck area. The blood pressure cuff was attached to the nondominant arm. These recorded systolic blood pressure (SPB), diastolic blood pressure (DBP), mean arterial blood pressure (MAP) and pre-ejection period (PEP).

Because the PEP-baseline is different for each person, a baseline measurement was needed, lasting six minutes and being measured for two minutes. During that, participants were able to relax and listen to music. The following sequence of tasks for participants is approximated in Figure 2.

Figure 2

Sequence of the Experiment



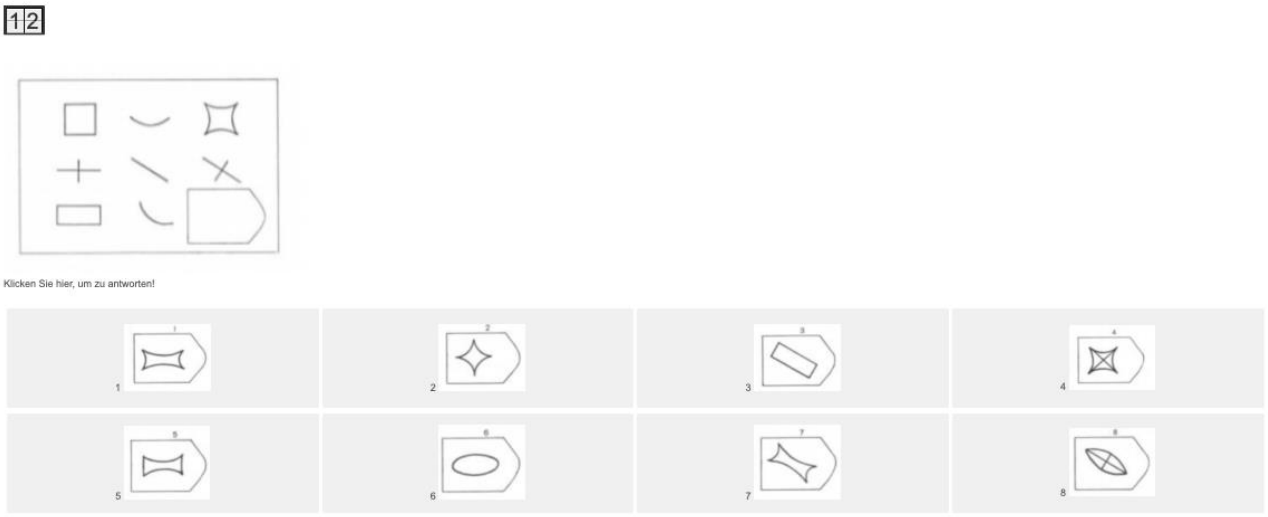
Note. This figure shows parts of the experiment and its sequence. Participants began with the implicit measurement task, after the initial questions and baseline measurement. This was followed by the explicit Growth Mindset Belief Questionnaire (Spinath & Schöne, 2003). Subsequently, participants had to complete 12 difficult IQ tasks within 45 seconds per item. Afterwards, the learning block began. Next, participants had to fill in the State Anxiety Questionnaire (Marteau & Bekker, 1992). Finally, the easy IQ items and several other questionnaires were conducted.

After the baseline testing the implicit task began (Cummins & De Houwer, 2021). It assessed the individuals´ implicit intelligence mindset beliefs through mouse tracking. Next, a six items self-report scale (Spinath & Schöne, 2003) was used to explicitly assess the participants´ mindset about intelligence. In addition, a seven item self-efficacy questionnaire (Pintrich & de Groot, 1990) was given.

Then twelve difficult IQ tasks (Raven & Raven, 2003) were presented. The participants had a time limit of 45 seconds for solving each of those items. An example item was shown and explained to the participants in the instructions, see Figure 3.

Figure 3

Example of the used Difficult IQ-tasks



Note. This figure demonstrates a difficult Item used for the “practice”. Eight figures which followed a certain logic were given. Participants had to figure out which of the eight possible options was supposed to be in the missing field. To solve it 45 seconds were given. It was anticipated that participants would experience failure, as it was expected that only a few items were to be solved in such a short time.

This was followed by the learning block, in which the items, the solutions and the logic behind them were shown to the participants. Again, participants had 45 seconds to solve each item. After finishing the learning block, participants had to complete the six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (Marteau & Bekker, 1992). Next, the so-called main block began, which consisted of twelve easy IQ-tasks (Raven & Raven, 2003). To solve these items unlimited time was given. Finally, it should be noted that participants were required to answer various additional questionnaires and provide demographic information between and after the various tasks.

Measures

The measures were used in accordance with Linke (2023). The first measure was the MT-PEP by Cummins and De Houwer (2021). In this implicit test, various sentences were shown to the participants. Their reactions had to be fast and they had to click “true” or “false”. This depended on whether a response to a misspelling of a word (probe trials) or agreement with a sentence was required (catch trials). The shown sentences were about the belief about intelligence. The idea behind this was that participants’ intuitive responses would reveal implicit agreement.

A six-item self-report scale from Spinath & Schöne (2003) (α = .85) was used to explicitly measure beliefs about growth and fixed mindsets. An example is “Everybody has a certain amount of intelligence which cannot be changed”. For this, a six-points Likert scale was given, ranging from 1 (strongly disagree) to 6 (strongly agree).

In addition, a seven item self-efficacy questionnaire (Pintrich & de Groot, 1990) (α = .8) was given. An exemplary item is “Compared to other study participants, I expect to do well“. Again, it was rated on a six-points Likert scale.

The twelve difficult IQ tasks (Raven & Raven, 2003) were introduced as practice for the main block of IQ tasks that followed later. However, these were more difficult, and it was assumed that most people would only be able to solve a few of them in the given 45 seconds per item. Participants received performance feedback in form of how many of the twelve items they were able to answer correctly. Because the items were difficult to solve, it was expected that participants would experience failure.

The learning block was implemented to measure the effort of participants to learn a task they had just failed in. To be able to learn, the solutions of the items and the logic behind them were shown. An example of a learning item can be seen in Figure 4.

Figure 4

Example of the Learning Block

Note. This figure shows one of twelve learning items of the learning block. It showed the correct answer and explained the thought process behind it. The participants had 45 seconds to look at it and potentially to learn from it. During this block effort was measured by the increased PEP compared baseline value.

Effort during this part was measured by the difference of PEP values compared to the previously measured individual baseline value. This difference was used to estimate how much more effort was mobilized for learning. Decreasing PEP values were assumed to be related to a growth mindset.

In the six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (Marteau & Bekker, 1992) (α = .82), statements are rated on a six-point Likert scale from “do not agree at all” to “agree totally”. Examples would be “I feel relaxed” and “I feel worried”.

The so-called main block again consisted of twelve IQ-tasks (Raven & Raven, 2003), but this time they were easy and participants had unlimited time to complete the task. Accordingly, participants were expected to solve more tasks.

The participants had to answer further questionnaires, which were for exploratory reasons and other papers being worked on. The questionnaires included an effort enjoyment scale (Sik & Job, in preparation) and a task enjoyment scale (Sik & Job, in preparation), the lay theories of the world scale (Dweck et al, 1995), a questionnaire for self-transcendent motives for learning (Yeager et al., 2014), a questionnaire regarding self-perceived talent (Bauer et al., under review), a questionnaire regarding effort approach and effort avoidance goals (Sik & Job, in preparation) and one regarding trait anxiety (Poythress et al., 2008).

Statistical Analysis

An a priori sample size calculation was performed for the different hypotheses. For hypothesis H1, an effect size of growth mindset on learning of β = .16 was found in a previous exploratory study. It was necessary to control for self-efficacy with β = .18. The required sample size was calculated using the program G*Power 3.1 for a linear multiple regression. A power = 80% and α = .05 were used, which resulted in 160 required participants. To forestall nonattendance and missing data, 214 participants were targeted. The targeted number of participants was ultimately not reached. 152 students ended up completing the experiment successfully.

For the mediation of hypothesis H2, the rule of thumb according to Fritz & MacKinnon (2007) was applied. For the alpha-path between state anxiety and growth mindset, Frondozo et al (2020) found an effect size of β = -.15. For the beta path between state anxiety and learning Bhoja et al. (2020) found an effect size of β = .12. One-third of these two values were subtracted in case of variation. This resulted in a required sample size of 558 participants according to Fritz & MacKinnon (2007). However, such a high number of participants was not feasible for this experiment.

The statistical analysis was performed using IBM SPSS Statistics 27 software for iOS using linear regression, Eta correlations and mediation analysis. The significance level was set at .05 for all analyses. Additionally, mean centering was carried out for the relevant variables. To control for heteroskedasticity, the Breusch-

Pagan test was performed. Since this was not significant, homoscedasticity was assumed. For the simple linear regression analysis of the H1 and H1a, 5 000 bootstraps were used. In addition, self-efficacy was used as a control variable. For the variable learning the difference between the baseline measurement and the measurement during the learning phase was used.

Diagrams were generated to examine the distribution of the various variables. The variables “State Anxiety”, “Learning” and the implicitly measured “Growth Mindset” are all normally distributed according to the diagrams. The explicitly measured growth mindset is not normally distributed. The Shapiro-Wilk test was additionally performed to confirm it.

For exploratory reasons, the correlation between implicit and explicit growth mindset was examined. For this purpose, an Eta correlation was performed since the variables are nominal and metric (Walther, 2021).

In addition, the split-half reliability for the implicit measure was analyzed to examine the internal consistency of the test.

To calculate a mediation analysis for H2 and H2a, PROCESS macro for SPSS by Hayes (2018) was used. For this purpose, 10 000 bootstraps were used.

For exploratory reasons and to investigate a possible correlation, a simple linear regression analysis was performed for implicit growth mindset and state anxiety as well as for explicit growth mindset and state anxiety. In addition, a linear regression analysis was performed for state anxiety and the effort during the learning phase.

Results

The Impact of Implicit Growth Mindset on Learning

To see the impact of implicitly measured growth mindset on learning a simple linear regression analysis, with self-efficacy as a control variable was performed. The results can be seen in Table 1. However, no significant effect of implicitly measured growth mindset on learning was shown in this experiment (F (2,149) = 1.24, p = .32), with an R^2 of .01. Implicitly measured growth mindset did not predict the psychophysiological mental effort during the learning phase significantly (β = .08, p = .32). Consequently hypothesis 1 was rejected.

Table 1

Linear Regression with Learning as Dependent Variable and Self Efficacy as Control Variable

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-5.561	3.857		-1.442	.151
	implicit GM	3.474	3.541	.081	.981	.328
	self_efficacy	1.459	1.053	.114	1.386	.168

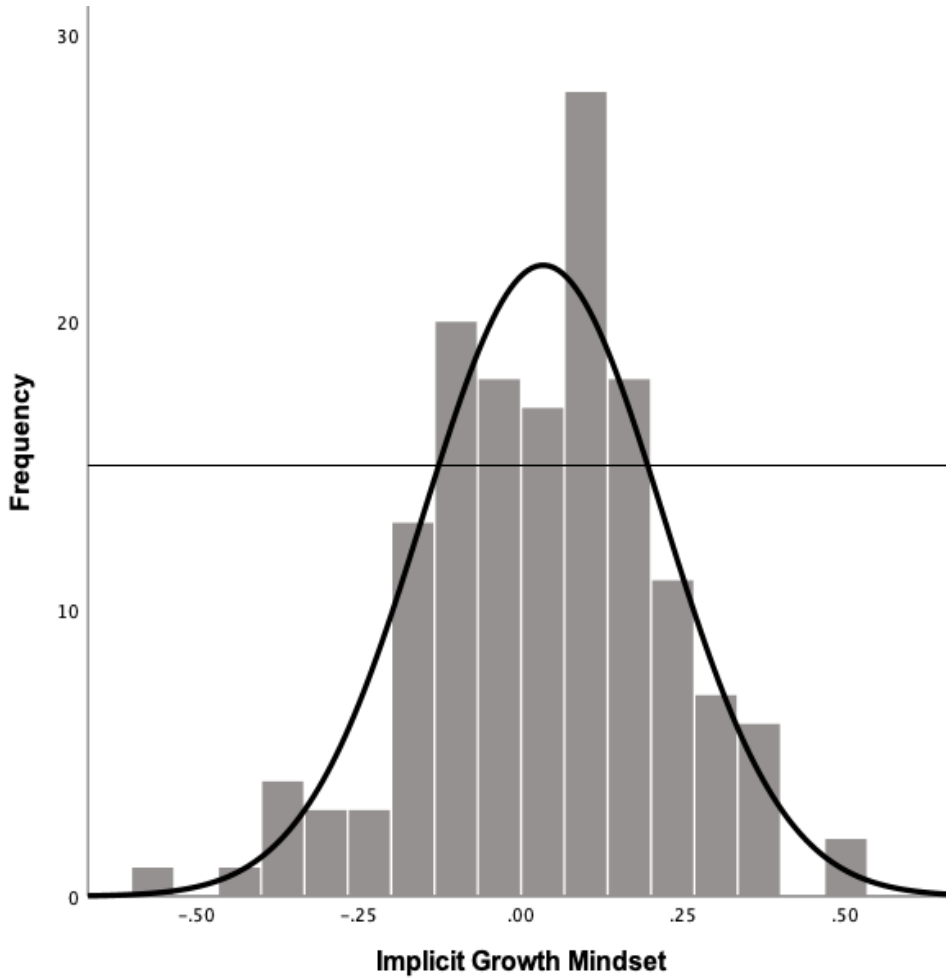
a. Dependent Variable: learning

Note. GM = Growth mindset, N = 152, $p > .05$

As seen in Figure 5 the implicitly measured Growth Mindset has a normal distribution, although there is a weak skewness to the left and kurtosis upwards.

Figure 5

Normal Distribution of Implicitly measured Growth Mindset



Note. Implicitly measured growth mindset is shown to be normally distributed. It showcases a weak skewness to the left and upward kurtosis. N = 152, M = .03, SD = .18

It was furthermore examined with the Shapiro-Wilk test and was not rejected. This implies that a normal distribution is indeed given.

The Impact of Explicit Growth Mindset on Learning

Another simple linear regression was conducted with explicitly measured growth mindset as an independent variable. Physiologically measured learning was the dependent variable and self-efficacy the control variable. The results, as seen in Table 2, showed no significant effects (F (2, 167) = 1.00, p = .68) with an R^2 of .01. It could not be shown that the explicit score of growth mindset predicted the psychophysiological mental effort during the learning phase significantly (β = .03, p = .68). This is similar to the analysis using the implicitly measured growth mindset. Therefore, hypothesis 1a was rejected. It did not show that the explicit score of

growth mindset predicted the psychophysiological mental effort during the learning phase.

Table 2

Linear Regression with Learning as Dependent Variable and Self Efficacy as Control Variable

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.607	4.125		-1.359	.176
	explicit GM	.253	.614	.032	.412	.681
	self_efficacy	1.256	.987	.099	1.273	.205

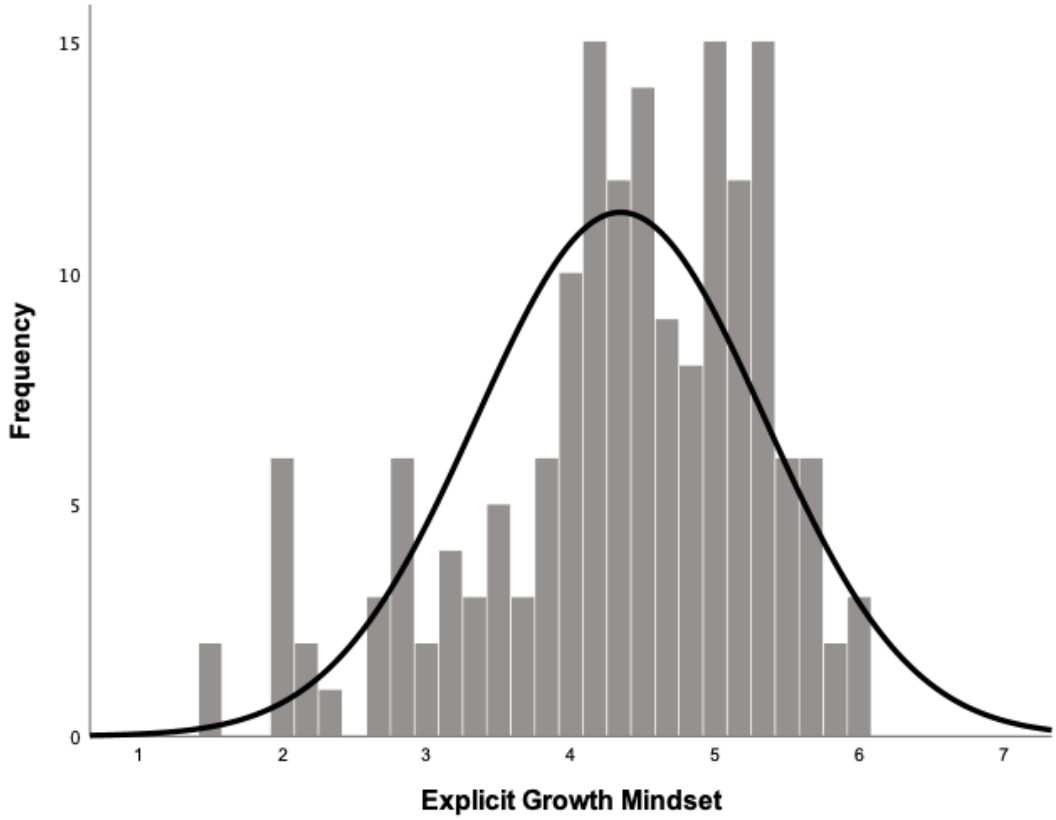
a. Dependent Variable: Learning

Note. GM = Growth mindset, N = 152, $p > .05$

The histogram for the distribution of explicitly measured growth mindset shows that it is not normally distributed, as it can be seen in Figure 6. It displays some skewness to the left. This represents a difference from the normal distribution of the implicitly measured growth mindset.

Figure 6

Distribution of Implicitly measured Growth Mindset



Note. Explicitly measured growth mindset is shown in the histogram as not normally distributed. It has some skewness to the left. N = 152, M = 4.34, SD = .99

Again, a Shapiro-Wilk test was additionally performed, and this time rejected. According to this, a normal distribution can not be assumed for the explicit growth mindset.

The split-half reliability of the implicit measurement was also investigated. The split-half estimates for the implicit measurement of growth mindset by the MT-PEP is r = -0.47, 95% CI [-1.03; -0.07]. Such a result implies that the test lacks internal consistency.

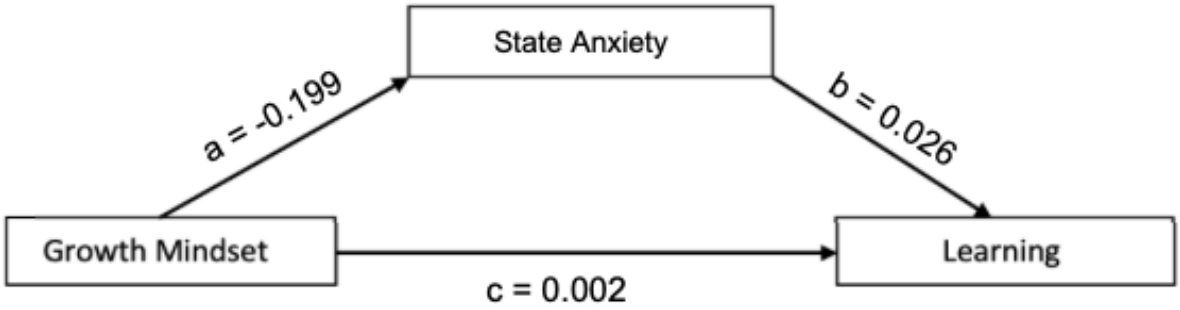
State Anxiety as Mediator

To examine whether growth mindset predicts learning and whether the direct path is mediated by state anxiety, a simple mediation analysis was conducted using PROCESS macro for SPSS by Hayes (2018). Figure 7 illustrates the results. The analysis shows no significant effect of implicitly measured growth mindset on the psychophysiological mental effort during the learning phase via state anxiety, β = -.0005, 95% CI [-.0017, .0003]. The direct effect of growth mindset on learning

remained non-significant even after controlling for the mediator state anxiety, β = .002, 95% CI [-.0019, .0058]. Accordingly, hypothesis 2, that state anxiety mediates the effect of growth mindset on learning, was rejected in this experiment.

Figure 7

Mediation Analysis Model with Learning as Dependent Variable and State Anxiety as Mediator



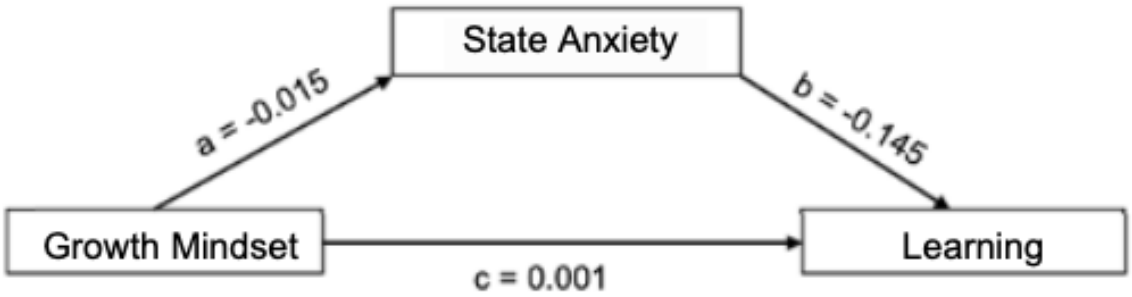
Note. Direct effect*:* β = 0.002, 95% CI [-.002, .006], indirect effect*:* β = -.0005, 95% CI [-.002, .0003], total effect: β = .0014, 95% CI [-.002, .005]. All the effects are non-significant with $p > .05$.

Mediation using Explicit Growth Mindset

Again, a mediation analysis was conducted using the psychophysiological mental effort during the learning phase as the dependent variable, the explicitly measured growth mindset as the independent variable and state anxiety as the mediator. Figure 8 illustrates the results. The analysis shows no significant effect of explicitly measured growth mindset on the arousal during the learning phase via state anxiety, β = .002, 95% CI [-.001, .007]. The direct effect of growth mindset on learning remained non-significant after controlling for the mediator state anxiety, β = .0017, 95% CI [-.017, .021]. Therefore, hypothesis 2a could not be accepted. It could not be shown in this experiment that state anxiety mediates the effect of explicitly measured growth mindset on learning.

Figure 8

Mediation Analysis Model with Learning as Dependent Variable, Explicitly measured Growth Mindset as Independent Variable and State Anxiety as Mediator



Note. Direct effect: β = .0017, 95% CI [-.018, .021], indirect effect: β = .002, 95% CI [-.001, .007], total effect: β = .004, 95% CI [-.015, .023]. All the effects are non-significant with $p > .05$.

To further investigate the ideas of state anxiety mediating the effect of growth mindset on learning, additional analyses were carried out. There was no significant effect of implicit growth mindset on state anxiety. However, a significant negative effect of explicitly measured growth mindset on state anxiety was found (F (1, 167) = 4, p = .46) with an R^2 of .024. Explicit growth mindset was shown to significantly predict the score of state anxiety (β = -.15, p = .46), as can be seen in Table 3. This translates to individuals with more of an explicitly measured growth mindset being more likely to report less state anxiety.

Table 3

Linear Regression with State Anxiety as Dependent Variable

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.221	.289		14.586	.000
	explicit GM	-.130	.065	-.154	-2.008	.046

a. Dependent Variable: State-Anxiety

Note. N = 152, $p < .05$

Furthermore, a significant negative effect of state anxiety on learning (F (1, 167) = 4.8, $p < .05$) with an R^2 of .028 could be shown. State anxiety significantly predicted the psychophysiological mental effort during the learning phase (β = -.16, p

= .03), as seen in Table 4. This means that for individuals who report more state anxiety, it is more likely to observe less effort during the learning phase.

Table 4

Simple Linear Regression with the Psychophysiological Mental Effort during the Learning Phase as Dependent Variable and State Anxiety as Independent Variable

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	5.680	2.657		2.138	.034
	State-Anxiety	-1.550	.708	-.167	-2.190	.030

a. Dependent Variable: Learning

Note. N = 152, $p < 0.5$

Discussion

This study was an attempt to fill current research gaps. It tried to do so by examining growth and fixed mindset using the MT-PEP measurement procedure, which was initially expected to be more reliable than paper-pencil tests. In doing so, it was hoped to replicate previous findings on growth mindset and its effect on learning and demonstrate its mediation by state anxiety. This was not achieved in this experiment.

It was not shown that the implicit score of growth mindset was predictive for the psychophysiological mental effort during the learning phase. This was also the case for the same analyses conducted with the explicit score of growth mindset. When measuring growth mindset in this paper, the implicit and explicit measures showed no significant relationship with each other.

Furthermore, a mediating function of state anxiety was not demonstrated. It is debatable whether this is due to the lack of participants, a flaw in the study design, or a flaw in the underlying theory. It might seem like a plausible assumption that an individual’s view on intelligence affects the state anxiety while learning. If someone might think that intelligence is something fixed and the test establishes the individual's unchanging intelligence, it might create a lot of pressure. This pressure

then could induce state anxiety, and state anxiety might have a negative effect on learning behavior.

Significant effects

An indication for such mediation might have been shown in the exploratory analyses conducted. There, it was shown that the explicitly measured growth mindset had a weak but significant effect on state anxiety (see Table 3). This means that the higher a person's explicit growth mindset score was stated, the lower the experienced state anxiety was. Similarly, did Frondozo et al. (2020) already show a significant negative effect of growth mindset on anxiety.

In addition, state anxiety had a negative significant effect on learning (see Table 4), i.e., the higher the reported state anxiety, the lower the physiological mental effort during the learning phase. Such a negative effect of anxiety on learning behavior was already shown in several other studies (e.g., King et al., 1976; Rosenfeld, 1978; Tanaka et al. 2006). These results of the simple linear regressions are consistent with the already elaborated idea of the connection between growth mindset, state anxiety and learning. Accordingly, it questions the origin of the non-significant mediation results of this experiment and indicates that state anxiety could indeed be a mediator of the effect of growth mindset on learning. This connection was already implied by Dweck and Legget (1988). Moreover, these results strongly suggest that further research on state anxiety as a mediator of the effect of growth mindset on learning is still needed.

It is important to note that a significant effect of implicitly measured growth mindset on state anxiety was not demonstrated. Such difference in effects calls into question whether implicit measurement is a more valid instrument for measuring growth mindset, or, whether growth mindset actually has an effect on anxiety. This question is discussed in detail in the following chapter Distribution and Implicit and Explicit Differences.

Distribution and Implicit and Explicit Differences

Despite the many non-significant results, it was still possible to gain further insight into the distributions of the explicitly and implicitly measured growth mindset. Unlike the explicitly measured growth mindset, the implicit growth mindset exhibits a normal distribution (see Figure 5 and Figure 6). Moreover, the explicit distribution

exhibits some skewness to the left. In addition, a significant effect of explicitly measured growth mindset on state anxiety was shown (see Table 3), which was not the case for implicitly measured growth mindset. Therefore, it is questionable which measure is more valid and relevant to look at and which one might be the better instrument for measuring growth mindset. The origin of such differences of the distributions but also of the differences of the effects of growth mindset on state anxiety can be explained in different ways. Depending on the origin of this difference, different implications arise for the importance of the respective measurements as well.

The difference in distribution and effects could be due to the explicit measurement of growth mindset being flawed and with this not reflecting the actual distribution of mindset. A possible explanation might be that this difference may be due to the self-assessment by the participants and a social desirability of believing more in a growth mindset. An indication for that might be the distribution's skewness to the left, which can be seen in Figure 6. Such social desirability has a tendency for biased responses (Fischer et al., 2020). Accordingly, it might imply that the true distribution of growth mindset is a normal distribution, since the implicit measurement avoids, among others, social desirability biases of participants, as well as attempts to falsify questionnaires (Greenwald et al., 1998). This might lead to the assumption that implicitly measured results are more valid and could be taken as a strong indication that the actual distribution of growth mindset is normal.

In contrast to that, another explanation for the difference in distribution and effects may lie in the split-half reliability (r = -0.47, 95% CI [-1.03; -0.069]) for the implicit measure method MT-PEP in assessing growth mindset. This finding suggests that the test lacks internal consistency, and that not all parts of it contribute equally to the measurement of growth mindset. Given this lack of quality standard for testing, the use of MT-PEP as a measure of growth mindset is questionable. This might be one reason for finding no effect of implicitly measured growth mindset. However, it is important to note that this limitation does not necessarily indicate that the construct of growth mindset cannot be measured implicitly. It rather indicates that the current measure used, the MT-PEP, was not an appropriate tool for doing so.

One other reason for it might lay in the nature of the two different measurements. Bargh (1994) elaborates that explicit measures, such as self-report questionnaires, rely on participants directly reporting their attitudes and beliefs.

Explicit responses are controllable, intended, made with awareness, and require cognitive resources. In contrast, implicit measures, such as the MT-PEP, assess attitudes and beliefs without requiring participants to report them directly. Implicit responses exhibit at least one of the characteristics: reduced controllability, lack of intention, reduced awareness of the origins, or high efficiency of processing. Nosek and Smyth (2007) analyzed explicitly and implicitly measured data for various constructs and showed that although the strength of the correlations varied widely, both measures indicated distinct but related constructs. There are several explanations for this phenomenon. One conjecture is that implicit measures are influenced by cultural - extrapersonal - knowledge and differ from attitudes (Karpinski & Hilton, 2001). Another possible explanation is that implicit measures generally reflect the results of automatic processing, whereas explicit measures generally reflect the result of conscious processing (DeCoster et al., 2006).

Considering the theoretical conception of DeCoster et al. (2006), the implication is that the different measurements assess different expressions of growth mindset rather than one measurement being more relevant. The implicit growth mindset measurement would assess the automatic, internalized process of an individual’s growth mindset. This would include a person's initial reaction to failure, as it is shaped by the implicit growth mindset. In contrast, the explicit measurement would accordingly assess a person’s conscious and rationalized perspective on growth mindset. Following this line of thought, it would imply that the results of the two measurements could exist in legitimate contrast to each other. One might implicitly assume that intelligence is not changeable. After consciously processing the situation being confronted with, however, it might be rationalized that the task is solvable and that the necessary skill is improvable. Therefore, implicitly, this person would be more inclined to a fixed mindset, but explicitly, more inclined to a growth mindset.

When considering the distribution of the differently measured mindsets, it is important to keep in mind that this experiment involved a very specific cohort. Since only psychology students from the University of Vienna were recruited, it was predominantly a young, white, academic, Austrian and German cohort. Claro and Loeb (2019) showed a differential effect of Growth Mindset for different subgroups when testing for implicit intelligence theories with a survey. Accordingly, the question arises whether the distribution could vary for different groups. However, the paper of

Claro and Loeb (2019), did not test for a normal distribution. Thus, there is no acute indication of reasons why the distribution itself might vary for different subgroups.

In this context, it is also noteworthy that for such a cohort of psychology students, many have likely already been exposed to their belief system about intelligence. It is also to be reasonably expected that people in academia might tend to rationalize their beliefs about intelligence as improvable. This might be assumed because many students regularly face exams and academic challenges that are initially difficult to overcome. This could be a potential reason for the skewness in favor of a growth mindset in the explicit distribution (see figure 6). Moreover, the implicitly measured belief about growth mindset might not be easily changeable. For this reason, the implicit measure might show the expected normal distribution. This could be an explanation for the demonstrated difference in distributions.

Learning and Effort

For the measurement of learning, the use of the pre-ejection period may introduce some inherent problems. To recapitulate the assumption of this paper: When the heart needs to sustain a behavior or keep up with a task, the contractile force of the heart increases. The degree of effort and the amount of resources mobilized is measured by PEP (Obrist, 1981). Accordingly, decreasing PEP values indicate higher effort. In this paper, it is now assumed that decreasing PEP values are related to a growth mindset. However, it should be considered that in such an experiment, higher observed effort does not necessarily mean that the subject is trying to learn more or harder. This is especially the case, since the learning block is a segment in which the solution and the correct path is shown to the participant for a certain amount of time. The participant does not necessarily need to actively participate in the learning block as there is no active task to be done, but to learn. Therefore, the participant could potentially focus on an entirely different topic, independent of the experiment. This implies that a participant could theoretically put effort towards something completely different than learning, but higher effort would still be shown.

This is also related to another issue that arises from the definition of learning. As already mentioned in the chapter Learning, De Houwer et al (2013) define learning as changes in the behavior of an organism that results from regularities in the environment of the organism. However, measuring learning with PEP

theoretically only measures the effort participants put into the active process of learning. This experimental design does not allow to assess if actual changes in the behavior of an organism occurred. Therefore, this again raises the question, if participants really learned more when the PEP values are lower. In theory a participant could have put in more effort, without actually learning more.

Replication Crisis

In contrast to previous research (e.g., Dweck & Leggett, 1988), this study did not demonstrate a significant effect of growth mindset on learning, nor did it demonstrate state anxiety as a mediator. Since this is the case, it is important to consider other possibilities beyond the limitations of this paper. One more obvious option might be the theory itself. In psychology there is currently much discussion about the *replication crisis* (Chopik et al., 2018). This term refers to the circumstance that many studies often cannot be replicated. Among them are many important and influential findings. In an attempt by the Open Science Collaboration (2015) to replicate studies from three high-impact journals, only 36% were able to show significant findings, and the effect sizes in the replications were only about half the size of those in the original studies. This poses a severe issue for psychology as a science and leaves a door open to questioning many psychological phenomena.

For the results around the implicit theories of intelligence, however, it has been shown many times that there are significant effects (e.g., Bedford, 2017; Grant & Dweck, 2003; Claro et al., 2016). Nevertheless, there have been replication attempts in recent years that did not find the same effects. This makes it necessary to investigate the possibility that the effect of growth mindset might not be as strong as previously assumed.

An indication of this is Paunesku et al. (2015). In this paper a small significant effect of mindset on grades was only found when the analysis was restricted to the bottom third of attendees. Similarly, Burgoyne et al. (2020) sought to examine several premises of the theory of implicit mindsets. An exemplary premise was that people with a growth mindset hold learning goals. No significant relationship was shown.

One paper that attempted to replicate the effects of growth mindset is Bahnik and Vranka (2017). This study tried to investigate the effects of growth mindset on people taking a GAP test for university admissions, with a sample size of N = 5653.

Only a very slight effect of growth mindset on test scores was found. This, however, was a negative effect, which is in contrast to previous results. Furthermore, no relationship was found between the number of test administrations and mindset. This is noteworthy in that it could have been theorized that people with a growth mindset would attempt to repeat the GAP test more often. This would have been the case since, in theory, people with a growth mindset should be more likely to believe in being able to improve their scores when repeating the test. This was not the case in the study by Bahnik and Vranka (2017).

Another replication attempt is Li and Bates (2019), in which four different studies were conducted. In the first study, children with growth mindsets were shown to perform significantly higher after failure. While this confirms earlier results from Mueller and Dweck (1998), the effect showed a substantially reduced magnitude than previously found. Study 2 failed to replicate significant effects of a mindset manipulation on moderately difficult or difficult items. Moreover, it even showed a negative relationship between holding a growth mindset and scores for difficult items. Similarly, no relationship was found between growth mindset and grades in study 4.

Furthermore, Macnamara & Burgoyne (2022) conducted a systematic review and meta-analysis of 63 studies on growth mindset interventions. This paper suggested major shortcomings in study design, analysis and reporting. Only a small overall effect of growth mindset interventions on students´ academic achievement was found. After correcting for a potential publication bias, this effect turned out to be non-significant. Similarly, no significant evidence was found that such interventions influence the mindsets of the participating students.

Such results strongly imply that previously found effects might not be as strong and, in some cases, not even given. With respect to these replication attempts, however, it is important to note that these studies have also been heavily criticized (Yeager & Dweck, 2020). For example, the study by Li and Bates (2019) has been critiqued by Dweck and Yeager (2019) as inadequate. The main criticism is an insufficiency of the methods used, e.g., that the power is too small for a replication study. According to Simonsohn (2015), the power of replication studies should be 2.5 times higher than the power of the original study. This was not the case. In addition, Dweck and Yeager (2019) re-analyzed the data of Li and Bates (2019) with other analyses argued to be more appropriate for the given power. This provided support for the original results of Mueller and Dweck (1998).

Yeager and Dweck (2020) furthermore reviewed numerous studies which indicate weaker to no effects of the implicit theories of intelligence. They elaborate various factors that might explain the differences in outcomes from previous studies (Bedford, 2017; Grant & Dweck, 2003; Dweck, 2008). Among others, they point to cultural differences, the quality of measurement and the differences in used concepts (Yeager & Dweck, 2020). This controversy can be viewed as another development of the current replication crisis in psychology and open questions still remain.

The present paper is among those that have failed to find significant results despite the use of an implicit measurement, which initially was expected to be more reliable. This does not necessarily imply that the underlying theory of implicit intelligence and its hypothesized relationship to learning and state anxiety is flawed. Rather, it might be indicative of the severity of the limitations to which this study is subject. Reflecting on the exact limitations of this paper, it is still possible to draw further implications from this study and learn how future studies might be able to conduct such experiments in a better way.

Of particular note, however, is that this paper was still able to find significant effects of explicitly measured growth mindset on state anxiety and of state anxiety on learning.

Limitations

In addition to some of the aspects already addressed in the chapter Discussion, this study has several other limitations that must be considered to put the non-significant results into perspective.

One clear limitation is the material used. Some of the employed electrodes frequently lost contact to the participants. Attempts were made to avoid this by using adhesive tape, but this was also insufficient in occasional cases. Eventually, the probe of electrodes was replaced with better performing electrodes. Nevertheless, several participants were affected. In particular, when an electrode fell off and participants tried to reattach it themselves or even hold it in place. The inefficiency of the electrodes may have had a distracting and irritating effect on several participants, even if they did not report it or no missing data showed up on screen. This has the potential to influence the outcome of this study. However, it is not possible to determine the exact number of subjects who were affected by this or to determine how strongly they were affected by it. It was tried to exclude

participants who were affected too much by this problem. Concluding, these insufficient electrodes resulted in a smaller sample size and potentially distracted subjects. This is especially severe in a study which already had difficulties recruiting enough participants.

Another limitation of this study was using a blood pressure measurement and electrodes in general. These devices had to be placed and fixated on the subjects. The electrodes impaired the ability to move around, and the blood pressure device was distracting as it inflated loudly from time to time. Furthermore, the measuring devices were also noisy. This could be distracting itself. Further, participants might have felt strongly surveilled in a setup where they are connected to different measurement devices while completing performance tasks, such as the difficult IQ items. These issues with the measurement itself, may have caused participants to be distracted, but also more agitated, or more anxious. This is particularly problematic as this might have had a particular effect on the mediation variable state anxiety. This might be the case as it is unclear whether there are differences in responses to such distractions between individuals with a growth mindset and a fixed mindset.

Similarly, some participants may have experienced frustration during the implicit block, partly because the mouse pad was set at high sensitivity, which increased the likelihood that they might fail the required implicit task. The implicit task was about clicking fast on a very small box under certain circumstances. The high sensitivity made it more difficult. This frustration was not intentional and could have had a negative effect on the effort they expended on subsequent tasks. Again, however, it is not known whether and how people with a growth mindset and a fixed mindset differ in this response. It furthermore might be an issue, because individuals were excluded if they did not reach the criterion of 80% correct answers in the implicit task. This in turn resulted in less data for the analyses.

Finally, the number of participants poses another serious limitation. The 152 probands whose data were usable are not sufficient for the mediation analysis according to the power analyses conducted. This is particularly evident when looking at the outcomes, which do not yield significant results. The lack of participants is drastic as with that, it is not possible to draw inference statistical conclusions.

Implications

One implication of this study can be drawn from the evidence of a normal distribution of implicitly measured growth mindset (see Figure 5). The explicit growth mindset also shows some skewness to the left. This implies that participants tended to state in the questionnaire to have more of a growth mindset. This is particularly intriguing because explicitly measured growth mindset is not normally distributed in this experiment (see Figure 6).

The differences in distributions and effects for implicit and explicit measurement again raises the question of which of the two is more valid. Implicit measurements are generally expected to showcase a higher validity and reliability of measuring constructs compared to questionnaires (Cummins & De Houwer, 2021). This was not the case in this experiment, as evidenced by the split-half reliability of the MT-PEP for measuring growth mindset. This implies that the MT-PEP may not be an appropriate instrument to measure growth mindset. Accordingly, more intensive research is needed on how best to measure growth mindset implicitly. However, it could also imply the possibility of measuring two different processes of growth mindset (DeCoster et al., 2006). This is elaborated in-depth in the chapter Distribution and Implicit and Explicit Differences.

Of particular note is additionally the finding of a significant, negative effect of explicitly measured growth mindset on state anxiety. This was not the case for implicitly measured growth mindset. Furthermore, an effect of state anxiety on psychophysiological mental effort during the learning phase was shown. These constitute interesting effects that may suggest that the assumption of state anxiety as a mediator of the effect of growth mindset on learning may have merit.

Still, many anticipated effects could not be demonstrated. Growth mindset, neither implicitly nor explicitly measured, was shown to have an effect on the psychophysiological mental effort during the learning phase. Further, state anxiety was not shown to act as a mediator of the effect of growth mindset on learning. This might be considered a consequence of the limitations already elaborated, as previous studies have shown effects of growth mindset on learning (e.g., Bedford, 2017; Grant & Dweck, 2003; Dweck, 2008).

However, given this lack of effects, it is important to consider the implication that the effect of implicit intelligence theories may not be as strong as previously

thought. This fits into the existing broader replication crisis, having arrived in the field of the implicit theories of intelligence. Several studies on growth mindset have shown either no significant effect or an effect of smaller magnitude than previous studies (e.g., Burgoyne et al., 2020; Li & Bates, 2019; Macnamara & Burgoyne, 2022). This implies the importance of conducting more replication studies but also more research in general on the implicit theories of intelligence.

Future Research

In view of the previously stated considerations there is still a lot to be done. This study did not show significant results for the effect of growth mindset on learning. Accordingly, it was not able to replicate the findings on the implicit theories of intelligence and how it influences learning. Just as it did not show any link between implicitly measured growth mindset and state anxiety.

Accordingly, it is particularly important to conduct further replication attempts of previous studies. It is important to do so within the gold standards of the replication process (Shrout & Rodgers, 2018). For this, more sophisticated power analyses and full disclosure of statistically nonsignificant and significant results are recommended to provide more clarity about true effects. In addition, there needs to be an open and transparent discussion about it. Such improvements could include adopting the open science conventions of preregistration and full disclosure, as well as ensuring that replication efforts are based on multiple studies rather than a single replication attempt (Shrout & Rodgers, 2018). This needs to be the case to gain clarity on the impact of growth mindset and the effectiveness of growth mindset interventions. But further, it is important to find similar effects using different methods. This would further increase the credibility of the implicit theories of intelligence. Accordingly, it is seen as crucial for future studies to try to replicate the findings on the implicit theories of intelligence, learning and state anxiety, using an implicit measurement.

Beyond that, the exploratory analyses demonstrated that explicitly measured growth mindset significantly predicted state anxiety. In addition, it was shown that state anxiety significantly predicted the psychophysiological mental effort during the learning phase. This suggests the possibility of state anxiety actually being a mediator of the effect of growth mindset on learning. Accordingly, it is crucial to repeat and improve such an experiment to gain further insight.

An improvement of this study could be achieved by conducting an experiment with more participants, as this was a major limitation of the mediation analyses. Furthermore, future studies should pay attention to the selection of instruments for the experiment. This might either be more reliable electrodes, or even trying to find a way of measuring learning reliably by using different methods at all. This is suggested as blood pressure machines or electrodes distract participants and potentially induces state anxiety. This should be avoided as it is not clear if people with growth and fixed mindset react differently to such settings. Moreover, it still needs to be investigated if another implicit measurement is to be used, as the MT-PEP turned out to have a very low split-half reliability for measuring growth mindset.

A concrete follow-up study would be to look further into the difference of implicit and explicit measurement for growth mindset. The idea is to create an experiment in which people´s implicit theory of intelligence is measured both implicitly and explicitly at the outset. Then a growth mindset intervention takes place. Finally, growth mindset again is measured implicitly and explicitly. The idea is to investigate the change of the measured growth mindset. One assumption would be that the explicitly measured score of growth mindset increases significantly through the intervention. Further the assumption would be that no effect for the implicit measure would be demonstrated.

In addition, it could be investigated whether a change of explicitly measured growth mindset is associated with a change in behavior, such as increased learning after failure. This could imply various aspects. In the case of success, it would imply that the implicit belief in growth mindset is a more robust construct that is not easily influenced by an intervention. In addition, it would imply that the explicit belief in growth mindset is manipulable and might be cognitively reflectable. It would further imply that the implicitly and explicitly measured distributions for growth mindset in this paper (see Figure 5 and Figure 6) just show different processes of growth mindset.

Finally, it could provide further insights into the significance of the different testing methods. One possibility is that such an experiment could show significant change in behavior going along with a significant increase in explicitly measured growth mindset. This might be the case even if there is no increase in implicitly measured growth mindset. This would imply that the explicit measurement of growth mindset might be the more relevant one for research. It would imply that it is measuring more

validly how people act according to their mindset. Such theoretical results would have strong implications for the research around the implicit theories of intelligence and would provide further insight. So far this is only a theory, and future studies still have to conduct more research.

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Figure Captions and Notes

Figure 1. Model for the Expected Mediation of Growth Mindset and Learning by State Anxiety.

Note. This figure demonstrates the theorized connection between the variable's growth mindset, learning and state anxiety, which poses a mediator.

Figure 2. Sequence of the Experiment

Note. This figure shows parts of the experiment and its sequence. Participants began with the implicit measurement task, after the initial questions and baseline measurement. This was followed by the explicit Growth Mindset Belief Questionnaire (Spinath & Schöne, 2003). Subsequently, participants had to complete 12 difficult IQ tasks within 45 seconds per item. Afterwards, the learning block began. Next, participants had to fill in the State Anxiety Questionnaire (Marteau & Bekker, 1992). Finally, the easy IQ items and several other questionnaires were to be conducted.

Figure 3. Example of the used Difficult IQ-tasks**.**

Note. This figure demonstrates a difficult Item used for the "practice". Eight figures which followed a certain logic were given. Participants had to figure out which of the eight possible options was supposed to be in the missing field. To solve it 45 seconds were given. It was anticipated that participants experience failure, as it was expected that only a few items were to be solved in such a short time.

Figure 4. Example of the Learning Block

Note. This figure shows one of twelve learning items of the learning block. It showed the right answer and explained the thought process behind it. The participants had 45 seconds to look at it and potentially to learn from it. During this block effort was measured by the increased PEP compared baseline value.

Figure 5. Normal Distribution of Implicitly measured Growth Mindset

Note. Implicitly measured growth mindset is shown to be normally distributed. It possesses a weak skewness to the left and upward kurtosis. N = 152, M = .03, SD = .18

Figure 6. Distribution of Implicitly measured Growth Mindset

Note. Explicitly measured growth mindset is shown in the histogram as not normally distributed. It has some skewness to the left. N = 152, M = 4.34, SD = .99

Figure 7. Mediation Analysis Model with Learning as Dependent Variable and State Anxiety as Mediator

Note. Direct effect*:* β = 0.002, 95% CI [-.002, .006], indirect effect*:* β = -.0005, 95% CI [-.002, .0003], total effect: β = .0014, 95% CI [-.002, .005]. All the effects are non-significant with $p > .05$.

Figure 8. Mediation Analysis Model with Learning as Dependent Variable, Explicitly measured Growth Mindset as Independent Variable and State Anxiety as Mediator

Note. Direct effect: β = .0017, 95% CI [-.018, .021], indirect effect*:* β = .0023, 95% CI [-.001, .007], total effect: β = .004, 95% CI [-.015, .023]. All the effects are non-significant with $p > .05$.

Table Captions and Notes

Table 1. Linear Regression with Learning as Dependent Variable and Self Efficacy as Control Variable

Note. GM = Growth mindset, N = 152, p > .05

Table 2. Linear Regression with Learning as Dependent Variable and Self Efficacy as Control Variable

Note. GM = Growth mindset, N = 152, p > .05

Table 3. Linear Regression with State Anxiety as Dependent Variable

Note. N = 152, p < .05

Table 4. Simple Linear Regression with the Psychophysiological Mental Effort during the Learning Phase as Dependent Variable and State Anxiety as Independent Variable

Note. N = 152, p < 0.5

Appendix A – Abstracts

Abstract

Background: The implicit theories of intelligence assume that people hold one of two different theories of how intelligence works. A fixed mindset is the idea that intelligence is unchangeable. Growth mindset describes the idea of intelligence being changeable. This leads to attributing setbacks to either changeable or unchangeable causes. These mindsets can explain different approaches to learning. The theory has so far been measured using paper-pencil tests. Therefore, this paper attempted to replicate previous findings on the effect of growth mindset on learning using an implicit measurement. Furthermore, it tried to show that the connection between learning and growth mindset is mediated by state anxiety. Additional exploratory analyses were conducted.

Method: 152 psychology students completed the implicit test MT-PEP to measure their mindset. Next, difficult IQ tests had to be performed, designed to induce failure. Afterwards, it was observed how much effort participants used in the learning block, by observing the pre-ejection period. Finally, they had to complete several questionnaires.

Results: The study showed no significant difference in effort during learning between people with growth and fixed mindset. Neither did it show state anxiety as a mediator. However, implicitly measured growth mindset was shown to be distributed normally in contrast to explicitly measured one. In addition, a negative effect of explicitly measured growth mindset on state anxiety was shown. Furthermore, a negative effect of state anxiety on learning was observed. More research must be conducted to deepen the knowledge about the effect of growth mindset on state anxiety and learning.

Key words: Implicit Theories of Intelligence, Growth Mindset, Implicit Testing, MT-PEP, Pre-ejection period

Zusammenfassung

Hintergrund: Die Idee hinter den impliziten Theorien von Intelligenz ist, dass Menschen eine von zwei Theorien über die Funktionsweise von Intelligenz vertreten. Ein „fixed“ Mindset ist die Vorstellung, dass Intelligenz unveränderbar ist. „Growth“ Mindset beschreibt die Vorstellung, dass Intelligenz veränderbar ist. Das führt dazu, dass Rückschläge entweder auf veränderbare oder unveränderbare Ursachen zurückgeführt werden. Auch können unterschiedliche Lernansätze durch diese Denkweisen erklärt werden. Diese Mindsets wurden bisher mit „Paper & Pencil“ Tests gemessen. Daher wurde in dieser Arbeit versucht vorherige Erkenntnisse über die Auswirkungen von „growth“ Mindset“ auf Lernen durch implizite Messungen zu replizieren. Darüber hinaus wurde versucht eine Mediation vom Effekt von „growth“ Mindset auf Lernen durch Zustandsangst nachzuweisen. Weitere explorative Analysen wurden durchgeführt.

Methode: 152 Psychologiestudierende absolvierten den impliziten Test MT-PEP zur Messung vom Mindset. Anschließend kamen schwierige IQ-Items, die ein Scheitern provozieren sollten. Danach wurde durch die Präejektionsperiode (PEP) erfasst, wie viel Anstrengung Teilnehmer für das Lernen aufbrachten.

Ergebnisse: Die Studie zeigte keinen signifikanten Unterschied in der Anstrengung während des Lernens zwischen Personen mit „growth“ und „fixed“ Mindset. Ebenso konnte keine Mediation des Effekts von „growth“ Mindset durch Zustandsangst gezeigt werden. Es konnte jedoch gezeigt werden, dass implizit gemessenes „growth“ Mindset im Gegensatz zur explizit gemessenem eine Normalverteilung aufweist. Darüber hinaus zeigte sich ein negativer Effekt von explizit gemessenem „growth“ Mindset auf Zustandsangst. Außerdem wurde ein negativer Effekt von Zustandsangst auf Lernen beobachtet. Weitere Untersuchungen werden benötigt, um das Wissen über die Auswirkungen von „growth“ Mindset auf Zustandsangst und Lernen zu vertiefen.

Schlüsselwörter: Implicit Theories of Intelligence, Growth Mindset, Mindset, Implicit Testing, MT-PEP, Pre-ejection period

Appendix B – Materials

The following materials were used in collaboration with Linke (2023).

Consent and Instruction

Sehr geehrte Studieninteressentin, sehr geehrter Studieninteressent,

Welches Ziel verfolgt die Studie?

Mit dieser Umfrage möchten wir besser verstehen, wie Studierende unterschiedlicher Fakultäten Informationen integrieren und wie sie sich in ihren intellektuellen Fähigkeiten unterscheiden. Wir möchten auch herausfinden, ob bestimmte kardiovaskuläre Indikatoren mit der Bearbeitung von kognitiven Aufgaben in Verbindung stehen.

Welche Daten werden erhoben?

Sie werden eine computerbasierte Reaktionsaufgabe und einige Aufgaben aus einem Intelligenztest bearbeiten. Wir werden dabei Ihre Leistung erfassen. Außerdem werden Sie verschiedene Fragebögen bearbeiten, bei denen wir Ihre Antworten erfassen. Parallel dazu wird mittels eines Impedanzkardiographen die Präejektionsperiode (PEP; Kraft von Kontraktionen im linken Herz-Ventrikel) und mithilfe einer Manschette Ihr Blutdruck erfasst.

Wie läuft die Studie ab?

Die Studie dauert 90 Minuten in den Untersuchungsräumen des Motivation Sciences Lab an der Universität Wien. Im Anschluss an Ihre schriftliche Einwilligung beginnen wir mit einigen allgemeinen und soziodemografischen Fragen, gefolgt von Fragebögen zu Ihren Einstellungen und Ihrem Verhalten. Im Hauptteil der Studie werden Sie eine kognitive Aufgabe bearbeiten.

Kardiovaskuläre Erhebung

Bestimmte kardiovaskuläre Kennwerte spiegeln beta-adrenerge Aktivierung wider. Insbesondere die Kraft von Kontraktionen im linken Herz-Ventrikel ist ein bewährter Indikator sympathischer Aktivität. Der Fokus liegt dabei auf der Kontraktionsfähigkeit des Herzens in Bezug auf die Präejektionsperiode (PEP). Diese ist das Zeitintervall zwischen dem Einsetzen des QRS-Komplexes (d. h. dem Beginn der elektrischen

Stimulation des linken Ventrikels) und des Ausstoßens von Blut aus dem Herzen (d. h. dem Öffnen der Aortenklappe). Je höher die Kontraktilität des Herzens ist, desto kürzer ist die PEP.

Ein zweiter Indikator für beta-adrenergen Aktivierung ist der systolische Blutdruck (SBP). Es handelt sich dabei um den maximalen arteriellen Druck nach einem Herzschlag. Systolischer Blutdruck wird durch die Kraft der vorherigen Herzkontraktion zusammen mit dem gegenwärtig im Gefäßsystem verfügbaren Raum (d. h. Gefäßwiderstand) bestimmt. Je stärker die Kontraktionskraft und je weniger Platz zur Verfügung steht (je höher der Gefäßwiderstand), desto höher sollte der SBP sein. Eine Erhöhung der Herzkontraktilität sollte zu einer Erhöhung des SBP führen, wenn der Gefäßwiderstand konstant gehalten wird oder steigt. Techniken zur Messung von SBP und PEP werden seit über 70 Jahren zur Messung der beta-adrenergen Aktivität eingesetzt. Diese Maße gelten als risikoarm und werden weltweit routinemäßig angewendet. Sie sind nicht-invasiv und sollten, wenn überhaupt, nur minimale Beschwerden verursachen. Um eine gleichmäßige Messung zu gewährleisten, bitten wir Sie, während des gesamten Experiments in derselben Sitzposition mit gleicher Haltung zu bleiben.

Es gibt zwei Arten von Aufzeichnungsgeräten, die in dieser Studie verwendet werden. Im Folgenden finden Sie genauere Informationen zu beiden Erhebungsmethoden.

Elektro- und Impedanzkardiographie

Vier selbstklebende Elektroden werden an der rechten und linken Seite der Halsbasis sowie an der linken und rechten Seite Ihres Oberkörpers angebracht. An den Elektroden befestigte Kabel werden an ein Cardioscreen1000-System angeschlossen, das kontinuierlich die elektrische Stimulation des Herzens (EKG) und den elektrischen Widerstand des Herzens (ICG) misst.

Eine kurze Kalibrierungsperiode ist erforderlich und erfordert möglicherweise geringfügige Anpassungen der Elektrodenplatzierung. Sobald jedoch ein sauberes Signal empfangen wird, bleiben die Elektroden für die Dauer des Experiments angeschlossen.

Blutdruckmessung

Eine Manschette wird über der Ellbogenbeuge an Ihrem nicht dominanten Arm platziert. An der Manschette befestigte Gummischläuche werden an einen Monitor angeschlossen. Der Monitor verwendet ballonähnliche Sensoren, mit denen Blutdruck und Herzfrequenz nichtinvasiv und schmerzfrei gemessen werden können. Eine kurze Kalibrierungsperiode ist erforderlich und erfordert möglicherweise geringfügige Anpassungen an der Platzierung der Manschette. Sobald jedoch ein sauberes Signal empfangen wird, bleibt de Manschette für die Dauer des Experiments angebracht. Leichte Kleidung kann unter dem Armband getragen werden, schwerere Kleidungsstücke müssen jedoch vor dem Anbringen des Armbands entfernt oder aufgerollt werden.

Welche Risiken sind mit der Teilnahme verbunden?

Obwohl die heute verwendeten Erfassungstechniken als Routineverfahren mit geringem Risiko angesehen werden, können minimale Beschwerden auftreten. Es ist denkbar, dass Sie Unwohlsein verspüren, wenn die Manschette aufgepumpt ist. Das Unwohlsein sollte jedoch gering sein, wenn es überhaupt vorhanden ist und nicht länger als einige Sekunden anhalten. Es ist auch denkbar, dass Sie ein gewisses Maß an Müdigkeit und Stress erleben, aber mit ziemlicher Sicherheit nicht mehr als an einem typischen Tag.

Versicherungsschutz

Während der Teilnahme an dem Experiment besteht für Sie seitens der Universität Wien kein gesonderter Haftpflicht-, Unfall-, oder Wegeunfallversicherungsschutz.

Freiwilligkeit/Rücktritt

Die Teilnahme an der Studie erfolgt freiwillig. Falls Sie teilnehmen möchten, bitten wir Sie, die beiliegende Einwilligungserklärung zu unterschreiben. Sie können diese Einwilligung jederzeit ohne Angabe von Gründen widerrufen, ohne dass Ihnen dadurch Nachteile entstehen. Die Rechtmäßigkeit der bis zum Widerruf erfolgten Nutzung der Daten bleibt davon jedoch unberührt. Bitte beachten Sie die zusätzlichen Hinweise in den Informationen zum Datenschutz unten. Wenn Sie Ihre Einwilligung widerrufen möchten, wenden Sie sich bitte an das Studienpersonal. Auch Studienmitarbeiter/innen können nach ihrem Ermessen die Durchführung der Studie jederzeit unterbrechen oder beenden.

Entstehen mir durch die Teilnahme Kosten? Erhalte ich eine Aufwandsentschädigung?

Die Studienteilnahme ist für Sie kostenlos. Als Entschädigung für die Studienteilnahme erhalten Sie 6 Credits.

Daten

Alle Ihre Daten werden anonym erfasst und nur auf Gruppenebene ausgewertet.

Mit der Bearbeitung dieses Fragebogens erklären Sie sich damit einverstanden, dass wir Ihre Angaben im Rahmen unserer Forschungsarbeit verwenden dürfen.

Ihre anonymisierten Daten können später anderen Wissenschaftlerinnen und Wissenschaftlern für weitere Analysen zur Verfügung gestellt werden (Publikation in einer Online-Datenbank z.B. Open Science Framework).

Appendix C – Measures

Six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (Marteau & Bekker, 1992)

	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 fühle mich ruhig (1)	○	○	○	○	○	○
Ich fühle mich angespannt (4)	○	○	○	○	○	○
Ich fühle mich betrübt (5)	○	○	○	○	○	○
Ich fühle mich entspannt (6)	○	○	○	○	○	○
Ich fühle mich zufrieden (7)	○	○	○	○	○	○
Ich fühle mich besorgt (8)	○	○	○	○	○	○

The following questionnaires were used in collaboration with Linke (2023)

Explicit questionnaire - German intelligence mindset inventory (Spinath & Schöne, 2003)

	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)	○	○	○	○	○	○

Seven item self-efficacy questionnaire (Pintrich & de Groot, 1990)

	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)	○	○	○	○	○	○