

GRIT AND MINDSET – UNRELATED TO PERFORMANCE IN A MOTOR
LEARNING TASK

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Abstract

CAN LEARNING A NEW SKILL INCREASE GRIT AND GROWTH MINDSET?

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Objective Research has shown grit and mindset can be improved, but no known research has investigated the effect of learning a new skill on grit and growth mindset. While grit and mindset seem to predict success in education and success, it is also not clear if initial grit or mindset have an effect on motor skill acquisition. The purposes of this research is to investigate if grit and growth mindset are predictors of learning a new skill and if learning a new skill leads to improvement in grit and growth mindset. **Methods** 14 students enrolled in a motor learning course participated in a six week intervention where they practiced juggling during class via Zoom. Concepts discussed in class as part of the course were incorporated into practice sessions by the teaching associate/researcher. Grit and growth mindset were measured using the short grit (Grit-S) scale and Dweck Mindset Instrument (DMI) respectively and compared in individuals before and after four weeks practicing juggling. The highest number of successful catches by each subject was recorded after each week of practice. The correlation of improvement in successful ball catches and initial grit and growth mindset were analyzed. A pre/post analysis was done using a dependent T-test and correlation between number of juggling catches and initial grit and growth mindset were analyzed. All data was collected virtually over Zoom and Google Sheets. **Results:** A negative, moderate relationship was found between initial grit and percent improvement to week 4 ($R = -.517$; $p=.029$) and no significant relationship

between mindset and percent improvement to week 4 was found ($R = .172$, $p = .279$).

There was no difference in mean between grit pre and post ($p = .067$) or mindset pre and post ($p = .581$). **Discussion:** This intervention may have not found a significant correlation between grit and growth mindset and improvement because of the absence of mandatory practice and explicit education. While previous research suggests that grit and growth mindset can be improved through intervention, this study suggests that an effective intervention may need to incorporate specific aspects in order to obtain results. This may include things such as mandatory practice and explicit education on mindset and grit. **Conclusion:** Future research should continue to explore factors that are effective in improving grit and growth mindset, and specifically how these concepts relate to motor learning.

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Introduction

In the current pandemic environment, one of the most popular ways of coping with stress is to learn a new skill (Riefe, 2020). Because of this, research in motor learning and human performance can play a significant role in everyday life, particularly research that investigates into an environment where individuals may have more limited access to teaching and coaching and must rely more on self-motivation. Understanding different aspects of psychology behind learning is a vital part of making individuals as effective as possible in learning a new skill. Specifically, looking at the components which may affect an individual's motivation may be helpful in predicting effective learning. *Grit* and *mindset* are two of the key components into which motivation can be broken. Grit can be described as the personality trait of a tendency for “perseverance and passion for long-term goals” (Duckworth, Peterson, Matthews, & Kelly, 2007), while mindset refers to the belief in the malleability of human attributes (Dweck, 2008). Together, these two factors can be a major indicator of consistency and success in learning and performance (Dweck, 2008; Duckworth 2007), perhaps particularly in an environment with less access to coaches and teachers.

The objective of this research is to better understand the inter-relationship among grit, mindset, and learning a new motor skill over the course of an online motor learning university course. Our first hypothesis is that improvements in motor learning will be positively correlated with higher initial levels of grit and growth mindset. Our secondary hypothesis is that improvements in motor learning will lead to improvements in grit and growth mindset.

Review of Literature

Factors That Affect Motor Learning

Research in motor learning has discovered which elements tend to lead to successful outcomes. Practice schedules and feedback are two main components which can be controlled in order to enhance learning (Schmidt & Lee, 2005). When individuals are given autonomy over their own practice, progress in learning seems to be strengthened. For example, Wulf & Toole (1999) found that when subjects were given autonomy over the use of a physical assistance device (poles with a ski simulator) retention in motor learning was significantly greater. It is plausible that one's own personal drive to be successful could be directly linked to their adherence to a practice schedule, and therefore the personality trait of grit may be directly applicable to improvements in motor learning, specifically when an individual is experiencing setbacks and adversity. This is important because errors are part of the process of learning a new skill and one's attitude toward these errors is a strong determinant of successful learning (Wulf & Lewthwaite, 2016) Grit has specifically been associated with practice adherence in sport (Tedesqui & Young, 2017). Since adhering to regular practice is one of the main factors affecting motor learning, being able to be persistent with practice, even in the face of adversity, is important.

Feedback is another key factor that has a great impact on successful motor learning (Wulf & Lewthwaite, 2016) and while there are many forms of feedback, one thing that often seems to remain consistent in research is that positive feedback seems to be the most ideal form of feedback, regardless of what type. For example, research has

demonstrated that feedback on a positive performance is more effective than feedback on a negative performance (Badami, VaezMousavi, Wulf, & Namazizadeh, 2012; Chiviacowsky & Wulf, 2007; Chiviacowsky, Wulf, Wally, & Borges, 2009). This suggests that improving an individual's mindset may be an effective way to improve learning, because one's mindset can affect whether they view a particular type of feedback as positive or negative (Dweck 2008).

A great example of how this could work was found in an experiment by Cimpian, Arce, Markman, & Dweck (2007). In this study, children who received praise implying an identity ("you are a good drawer"), as opposed to a non-generic compliment ("you did a good job drawing"), exhibit more hopeless behavior when confronted with criticism or mistakes. This could imply that suggesting an established sense of identity could create a fixed mindset in these children, because it implies that their capabilities have already been pre-established. In other words, Children in this study with a fixed mindset tend to blame their own inadequacy for their failures, which often discourages further effort. This is likely also the case in adults who experience similar judgements on their own identity.

Understanding how human motivation plays into these factors of motor learning is a critical aspect of teaching and understanding human behavior. Wulf & Lewthwaite (2016) assert that motivation (one form being intrinsic motivation) plays an important role in their OPTIMAL theory of motor learning. Wulf and Lewthwaite (2016) describe how conceptions of ability affect performance, or more specifically, how an individual "will act when future prospects provide a sense that positive outcomes will occur, and perhaps particularly when we believe we will be the agents who bring these positive

outcomes to fruition”. In this review, mindset is defined as one of the key motivational factors that can influence an individual in learning and performance. Research suggests that an individual’s mindset in their confidence of their own abilities is strongly related to phenomena of choking (Beilock, 2011) and flow state (Csikszentmihalyi, 1990), either of which can be the defining factor of whether an individual succeeds or fails in a task. Grit can also act as a component of maintaining motivation over time, and could therefore result in better learning outcomes (Duckworth et. al, 2007).

Growth Mindset

Mindset refers to the inherent belief of the particular nature of human attributes, and is often used in reference to things such as intelligence or competency (Ortiz Alvarado, Rodríguez Ontiveros, & Ayala Gaytán, 2019). Mindset is understood as a spectrum opposing traits of a *growth mindset* or *fixed mindset*. A fixed mindset refers to an individual who believes that a characteristic such as talent or intelligence is unchangeable, while an individual with a growth mindset thinks of positive qualities as malleable and that success is achieved through effort (Dweck 2008; Ortiz Alvarado, et. al, 2019). Growth mindset has been attributed to improved learning and performance capabilities across many contexts including things such as sport, education, business, and relationships (Dweck, 2008). Evidence exists suggesting that one’s mindset can change based on experience and experimental intervention. For example, Lewis, Williams, & Dawson (2020) found that mindset improved in nursing students after an informative intervention focusing on neuroplasticity and how behavior can change an individual’s capabilities. Schleider & Weisz (2018) found similar results using a similar protocol

which taught positive research on mindset and encouragement to adolescent girls. Our research aims to investigate if learning a new skill along with an informative intervention may also contribute to improving an individual's mindset.

Existing research has also investigated how mindset can affect performance. Cury, Da Fonseca, Zahn, & Elliot (2008) found that having a fixed belief about one's own intelligence can have a significantly negative effect on performance and time spent practicing for an IQ test. Conversely, a growth mindset may lead to improved performance and effort. For example, Cumtusu & Lou (2020) found that those who have a growth mindset and seek critical feedback (a behavior suggesting growth mindset) performed better in an online graphic design game. In essence, when individuals have seen their own errors as a learning opportunity and not a statement on their own worthiness or capabilities, we tend to see progress in learning and performance. When tracking junior high school students over a two-year period, it was found that mindset was a significant determinant of whether student's grades suffered or improved over this time (Dweck, 2008). Similarly, Ortiz Alvarado, Rodríguez Ontiveros, & Ayala Gaytán, (2019) found a correlation between growth mindset and well-being and school performance - where higher levels of a growth mindset led to better well-being and school performance. This research suggests that mindset can be a significant predictor of positive performance.

Dweck (2008) describes how the difference between thinking "I failed" or "I am a failure" is a significant indicator of mindset and predictor of future effort and performance. Specific to motor learning, the research by Cimpian, Arce, Markman, &

Dweck (2007) where children were praised either generically or non-generically on their drawing performance, shows how the difference between these two thoughts can play a role in progress and adherence to a task. Children who were praised generically were less likely to continue putting in effort and making progress on their drawing skills.

It is important to look at what experimental methods have been effective in improving mindset. Lewis, Williams, & Dawson (2020) studied an intervention involving nursing students who participated in a one-hour educational session including self-identifying your own mindset, and presentations on neuroplasticity and learning how successful people overcome failure, and about the behaviors associated with growth mindset. Participants scored significantly higher in growth mindset analyzed after completing the intervention. This evidence suggests that there are effective interventions to improve mindset, and this may be an effective way at improving human performance. Further research on the specific types of interventions with potential to change an individual's mindset in a positive way can be an important factor in teaching and learning.

Grit

Grit refers to a characteristic of perseverance and passion toward long term goals (Duckworth et. al, 2007) and can enable individuals to work hard and stick to long term goals (Perkins-Gough, 2013). Duckworth and colleagues (2007) further describe grit to be characterized by maintaining effort and interest through adversity. One may think of it as maintaining stamina of effort over time, despite hardships and setbacks.

The characteristic of grit may be associated with improved learning, because being more persistent with challenges could lead to more frequent success rates. Duckworth, Peterson, Matthews, and Kelly (2007) found grit to significantly affect a variety of success outcomes including: educational attainment, grade point average among Ivy League undergraduates, retention in classes at the United States Military Academy, and ranking in the National spelling bee.

There seem to be numerous mechanisms whereby grit improves performance. Grit has been associated with experience of flow. Smith, Marty-Dugas, Ralph, & Smilek (2020) measured grit and flow using questionnaire scales and found that, even when the personality trait of conscientiousness was controlled for, grit is strongly associated with experience of the flow state. This is highly suggestive of grit being directly linked to performance optimization. Grit has been correlated with success of achieving long-term goals because individuals who exhibit grit tend to break these long-term goals down into manageable short-term goals (Duckworth & Gross, 2014). Lee (2017) found that there is research to suggest that grit and stress have a negative relationship by comparing

responses to grit and stress scales. In the case of motor learning, grit may be a helpful characteristic in adhering to a practice schedule. Tedesqui & Young (2017) found grit to be a predictor of practice adherence and breaking down complex motor skills into partial movements which are practiced individually in a sport setting by comparing self-reported practice and grit characteristics. We can conclude that grit is very likely to be a broad predictor of successful performance.

Duckworth et. al (2007) discovered how, when education is controlled for, grit increases significantly with age, and when age is controlled for, grit increases with higher education. This research may suggest that while grit seems to be partially determined by genetic or developmental factors, it is not limited to these. In other words, grit may be developed through experience rather than something that is predetermined. Potentially, the confidence that comes from achievement has a significant impact on the grit in one's personality. This is an important distinction to make, as Flanagan & Einarson (2017) found that as confidence in math increases, the distinct positive effect of grit in learning and performance in math may decrease. It is important for research to distinguish between these two concepts and therefore, a study which considers both the impact of grit on performance, and the impact of performance on grit could give insight on exactly how the relationship between grit and performance functions.

Improving Growth Mindset and Grit

Mindset and Grit are important to analyze together, because of the influence that these traits have on one another. Park, Tsukayama, Yu, & Duckworth (2020) studied how intelligence, growth mindset and grit influenced one another over time. They collected

information from 1667 adolescents and their teachers on four different occasions over 2 academic years. Data for grit and growth mindset were collected using the original Grit scale (Duckworth et. al, 2007) and Dweck's (1999) scale, respectively. It was concluded that the development of grit and growth mindset characteristics were "distinct but mutually reinforcing" meaning that one characteristic seems to suggest the presence of the other. It is suggested for future research to also explore what other factors lead to improved mindset and grit in an individual. Because of this we can assert that conducting research which accounts for both of these characteristics may give good insight on their relationship to each other.

In addition to the research of Park et. al (2020) on grit during adolescence, Greco (2018) also points out that when looking at the change in traits, one's initial belief about the malleability of their own traits (growth mindset) may have a distinct reinforcing effect on how these traits are influenced. In other words, high grit may lead to improved grit (when improving grit is the goal) and high growth mindset may lead to improved mindset (when improving mindset is the goal). We may even expect to see a bigger change in those who already score high in growth mindset in a pre/post intervention study for this reason.

Further evidence that these characteristics can be developed comes from Lewis, Williams, and Dawson (2020), who found an effective improvement in growth mindset in a group of nursing students. They found growth mindset scores to increase after an intervention which involved specific education on what growth mindset is and how it can potentially be improved. This study suggests that these personality characteristics can be

malleable, and further research on potential ways of improving characteristics will be very useful in creating interventions geared toward personal development. Research should continue to ask what exactly has the potential to improve growth mindset.

This research aims to answer if motor learning, and specifically becoming proficient in a new skill, has a direct relationship to grit and growth mindset. Because learning is relevant to all success outcomes assessed by much of the research, it may play an important role in the relationship between these success outcomes and grit and growth mindset. Also, because failure is a key aspect of learning something new, learning a new skill also provides the opportunity to confront failure. In doing so, this provides the opportunity to learn how to respond to failure better, which seems to play a critical role in grit and growth mindset based on previous research.

This research provides a great understanding of the significant relationship between grit, mindset and success and how these factors have the potential for change. New research should investigate the relationship between these factors; for example, does higher levels of grit or growth mindset lead to higher achievement in motor learning, or does higher achievement in motor learning lead to an increase in grit and mindset in individuals. Learning about this could help us better ways to improve performance and well-being. A study investigating grit and mindset before and after the achievement of learning a new skill may help to provide insight to these questions, and this research aims to do that job.

Method

Participants

39 participants were recruited to participate in this study, 14 of which were chosen for statistical analysis based on meeting all inclusion criteria. Participants included university students who completed this study as part of a kinesiology motor learning course in Fall 2020. This study was approved by the Institutional Review Board at Humboldt State University and all participants signed an informed consent form prior to participating in this study. Inclusion criteria include enrollment in the course, to be physically capable of learning how to juggling, and answering all required questionnaires.

Procedure

This study was conducted as an experimental design without randomization. Data collection took place over six weeks - between the weeks of September 9, 2020 and October 28, 2020. All participants completed the Dweck Mindset Instrument (DMI) (Dweck, 2000), and Short Grit Scale (GRIT-S) (Duckworth & Quinn, 2009) before week 1 of practice. Participants practiced juggling in small groups via Zoom for 30 minutes, two times a week, for four weeks over the four-week period between September 14th, and October 5th, 2020, directly after their weekly lectures in their motor learning course. Attending this practice time at the end of class was encouraged, though optional. Practicing outside of these sessions was also encouraged. During this time, subjects practiced over Zoom individually with supervision and help from researchers. Juggling

equipment used by individuals varied and included things such as rolled socks, apples, and balls. Concepts from the motor learning course were incorporated into these practice sessions, including the significance of practice schedules, feedback types, autonomy, motivation, and attention. Each week, participants reported time spent practicing and the average number of successful 3-ball catches out of 10 trials into a password-protected Google Form. Retention of juggling skills were assessed at week 6, (October 19th, 2020) two weeks after the end of the practice intervention. After week 6, the participants also completed the DMI and GRIT-S scales and completed an exit survey.

Data Analysis

Subjects were analyzed based on completion of all questionnaires. Although pre-intervention data was collected from 39 subjects, 25 did not respond to all questionnaires post-intervention and were therefore not included in our data analysis. Differences in average performance between week 1 and week 4 and week 1 and retention were tested using a dependent T-Test. We first tested our primary hypothesis is that higher initial levels of grit and growth mindset will lead to greater changes in motor learning. The percentage improvement from week one to week four and week one to retention were compared to initial grit and mindset using a correlation. Data contained no outliers, was linear, and normally distributed.

To test the secondary hypothesis, that we would see a significant increase in both grit and growth mindset after successfully learning a new skill, pre- and post- grit and mindset scores were compared using an Dependent T-Test to test for a change in grit and mindset after going through the intervention. We also measured how level of success affected change in grit and mindset by placing subjects into two groups based on their level of success in learning. Change in grit and mindset in subjects who made an improvement in number of catches greater than 50% in week four compared to week one were compared with those who made an improvement less than 50% in this timeframe. This data contained no outliers, normality was determined by a Kolmogorov-Smirnov test, and equality of variance was determined by a Levene's statistic.

Results

Fourteen participants completed all questionnaires for analysis as shown in *Table 1*. In general, all participants showed improvements in juggling performance over the four weeks of practice, with the average percent improvement of 60.5%. Changes in juggling performance over the four week practice period and retention trial are shown in Figure 1. A significant difference between means was found between performance at week 1 and week 4 ($p < .000$) and week 1 and retention ($p < .000$) suggesting significance in improvement as a result of this intervention.

With respect to hypothesis one, a negative, moderate relationship was found between initial grit and percent improvement to week 4 ($R = -.517$; $p = .029$), meaning that people with lower initial grit had significantly better gains in juggling performance. There was no significant relationship between mindset and percent improvement to week 4 ($R = .172$, $p = .279$), suggesting that mindset did not function as a predictor of percent improvement.

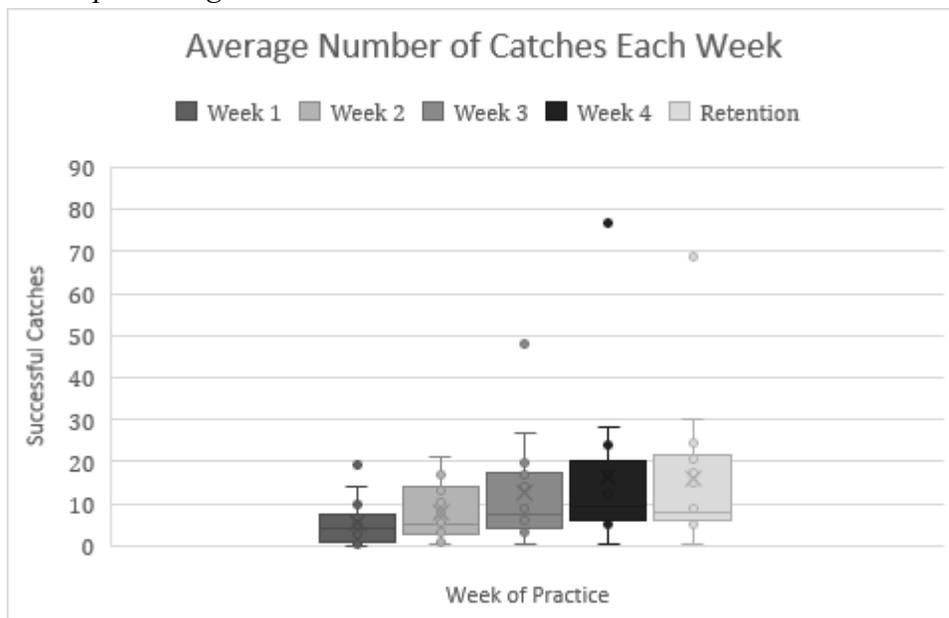
We also investigated the relationship between DMI & GRIT-I and improvement in juggling performance to retention. The average number of balls caught at the end of practice was 16.59 and the average number during retention was 15.88. This indicates that juggling performance in retention decreased compared to at the end of practice. However, the average improvement in juggling performance from week 1 to retention was 10.41, showing a net improvement in juggling performance. No significant relationship was found between pre-grit and improvement to retention ($R = -.430$, $p = .063$), or pre-mindset and percent improvement to retention ($R = .171$, $p = .279$).

With respect to hypothesis two, it does not appear that the motor learning intervention affected grit or mindset. After going through the intervention, there was no difference in mean between grit pre and post ($p = .067$) or mindset pre and post ($p = .581$). There was no significant difference in means of change in grit between those with an improvement greater than 50% and those with an improvement less than 50% ($p = .862$) or change in mindset in these two groupings ($p = .902$).

Table 1*Participant Data*

Subject	Grit Pre	Grit Post	Mind Pre	Mind Post	Juggling Improvement (Week 1-Week 4)	Improvement %	Sessions Attended
1	3.1	3.05	4.69	4.81	5.9	88.06	~6 times (~3/4 of the time)
2	3.6	3.55	3.88	3.88	0.1	20	~6 times (~3/4 of the time)
3	4.2	3.4	5.25	6	6	50	~4 times (~1/2 of the time)
4	3.6	3.4	4.94	5.31	20	83.33	~6 times (~3/4 of the time)
5	3.7	3.95	4.78	5	2.5	48.08	Every Monday and Wednesday in class!
6	3.9	3.2	3.25	2.69	57.3	74.61	1-2 times (~1/4 of the time)
7	4.1	3.8	4	3.81	4.9	26.06	Never
8	4.4	4.3	3.81	3.53	7	41.18	~4 times (~1/2 of the time)
9	4	3.8	4.25	4.81	21.7	76.95	~4 times (~1/2 of the time)
10	3.3	2.9	6	5.75	3.3	53.23	~6 times (~3/4 of the time)
11	1.7	2	5.5	5.34	5.2	91.23	Never
12	3.6	3.4	5.13	4.28	6.8	100	~6 times (~3/4 of the time)

13	3.1	3.1	3.31	3.38	13.7	75.69	~4 times (~1/2 of the time)
14	4	4.1	5.5	4.69	1.2	19.35	1-2 times (~1/4 of the time)
Average	3.59	3.42	4.59	5.42	11.11	60.55	

Figure 1*Participant Progress*

Discussion

The purpose of the current research was to investigate if learning a new skill improves grit and growth mindset, and to study the effectiveness of grit and growth mindset as predictors for learning success. We found no significant connection between initial grit and mindset as predictors for success in learning how to juggle. Our results also show that learning to juggle over 4 weeks in a virtual environment did not seem to be effective at increasing our participant's scores in the GRIT-S and DMI.

Juggling Improvements

All subjects experienced some improvement in juggling performance over the four week training period. There are likely too many confounding factors to make any significant conclusions on why some performed better than others. Some specific factors that likely have played a strong role are how efficiently practice time was used and what obligations these students faced over the four-week practice period. While this was a four-week intervention, structured practice time only made up 30 minutes of each week, and students likely lived very different lives outside of this time which either allowed or prevented them from getting sufficient practice time. It is important to note too that it is likely that not all students may have experienced the same amount of intrinsic motivation to practice juggling.

Mindset

Mindset did not function as an effective predictor of performance in this intervention. We also did not find a significant improvement in DMI as a result of this intervention. While it still seems likely when considering previous research that grit and

mindset can be used as a predictor of success and can be improved, this particular intervention was not effective at demonstrating these concepts. Lewis, Williams, and Dawson (2020) conducted an intervention that created a significant increase in growth mindset in nursing students. This intervention included several hours of different lessons which directly pertained to what growth mindset is and how it can be improved. One difference between this intervention and ours is that the participants in Lewis, Williams, and Dawson's (2020) study were explicitly educated in mindset and how it can be improved, whereas our participants were briefly exposed to the idea of mindset and then performed an intervention which was mainly focused on juggling. Based on this, it may also be possible that grit is more likely to improve with an intervention focused explicitly on grit as well. Another important note is that this study used a modified version of the DMI (WILS tool) to measure and categorize mindset.

Grit

We did not find significant improvement in responses to the Grit-S scale as a result of this intervention. Conversely, we found a negative moderate relationship between initial grit and improvement, suggesting that a low grit level may have functioned as a predictor of success in this study. Previous research has actually suggested no relationship between grit and talent, as defined as one's "natural" ability (Perkins-Gough, 2013). In other words, having an innate ability to quickly become skilled or proficient something can sometimes suggest that it requires less effort. Our findings may represent this idea, especially considering that, regardless of an individual's

Grit-S score, this optional intervention may not have been the first priority for a lot of subjects' lives at the time.

It is also important to consider and compare the grit scores which we found in this study to other studies that used the Grit-S scale. For example, research done by Lee (2020) found a negative relationship between stress and grit in a sample of 345 students working toward an associates degree. The average grit found in this study 3.05, a number that is comparable to the 3.59 average initial grit that we found in our subjects. Since the grit found in our subjects averaged relatively higher than this study with a much larger sample size, it is possible that our sample had a grit level that was already above average and essentially could have had less “room for growth”. Future studies may be able to account for this question by using a larger sample size.

Grit, Mindset and Motor Learning

While we predicted that grit and mindset would increase after learning a new skill, we obtained no significant evidence that this was the case. It may be likely that this, again, relates to the fact that this intervention may have just not been significant enough to create a long-term change in grit and growth mindset. While it seems unlikely that these traits would be completely unaffected by motor learning based on previous research, this study may have not incorporated a long enough intervention to find a measurable difference. An intervention which ensures that all subjects achieve a mastery of a new skill may find different results than this study.

Other research focused on both grit and growth mindset as likely predictors of success outcomes in things such as academics and sport. (Duckworth, Peterson,

Matthew, & Kelly, 2007; Dweck, 2008; Lee 2017; Wulf, Chiviacowsky, & Lewthwaite, 2012). One reason that we may have not found this in juggling, specifically, is that these studies tend to look at large life outcomes, or in other words, things that were likely a main focus in the lives of the subjects being analyzed. This generally includes significant events such as successfully obtaining a college degree or being successful in a sport which the subject has dedicated a large part of their life to. The reality of this study is that juggling practice just may have not been a priority for many of these subjects and more important things may have taken precedence over this intervention, such as work and school.

We considered a number of confounding variables that may have contributed to our research not finding these results. For example, all of our participants were college students who were simultaneously adjusting to taking virtual courses as a result of the coronavirus pandemic. The fact that this intervention was taught virtually may have provided a barrier to it reaching its full effectiveness. Participants also reported other variables unrelated to grit and growth mindset which may have interrupted their progress.

We collected qualitative data to get an idea of what may have caused our particular results. All participants were asked what they felt to be the biggest obstacle to improvement. Four participants mentioned that they did not have the amount of time to practice that they wish they had. Five said that they experienced a lack of resources such as proper materials and space to practice. As mentioned previously, time spent practicing has been shown to be a crucial component in predicting success (Wulf & Lewthwaite, 2016). Regardless of one's score on the GRIT-s and DMI scales, not having ample

practice time will interfere with successful outcomes. One participant mentioned that a lack of direct in-person feedback was their biggest obstacle to improvement. All of these responses suggest that performing this intervention in-person rather than virtually may have resulted in more effective learning.

Limitations

Because practice during class was optional, many participants did not participate in all sessions and two participants reported never attending a single practice session. This may be another example where an in-person intervention could have been more effective, as the temptation to leave an online class could potentially be greater, particularly with college students who are likely to have busy schedules and work to keep up with that would take priority over juggling practice for this study. In fact, only one participant reported that they attended all eight sessions, while five reported attending six sessions, four reported four sessions, and two reported attending only one or two sessions. A more effective intervention may be one that requires all participants to attend the same amount of practice sessions in order for their data to be analyzed.

It could also be likely that our study did not contain enough subjects to find significant results. Many of the similar studies we have discussed analyzed more subjects than the present study. For example, Lewis, Williams, and Dawson (2020) analyzed 35 participants in their similar study examining the effectiveness of a mindset intervention on nursing students.

Future Directions

The virtual setting of this experiment may have contributed to its lack of effectiveness. An in-person class could have potentially provided a more motivating environment with better teaching and feedback. Because one goal of this experiment was to see how this intervention could be effective in a virtual environment, future studies may want to learn how to better emulate the benefits of an in-person environment virtually. For example, one-on-one or even group practice sessions could provide individuals with more personalized feedback for improvement.

As mentioned previously, an experiment requiring participants to attend all practice sessions could prove to be more effective at enhancing improvement and motivation in this task. Future studies may consider recruiting more participants as well in order to ensure a large enough sample is analyzed. Additionally, it may be worthwhile to include more explicit education on grit and growth mindset, and how they can be improved, as part of a future intervention.

Conclusion

This experiment suggests that participating in an online motor skill learning intervention may not be enough to improve grit and growth mindset. In this particular study, scores on the Grit-S scale and DMI did not serve as predictors of success. While previous research demonstrates that interventions can be effective in changing grit and growth mindset and these can be effective predictors of performance, future research should continue to explore what is and is not effective in changing grit and mindset. We recommend future studies use more subjects and involve mandatory practice sessions in order to create a more standardized approach to addressing these questions. Factors such as mandatory participation, feedback, and the use of a virtual environment should be explored and controlled for when researching what may and may not be effective in improving grit and mindset.

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Appendix

Short Grit Scale (Duckworth & Quinn, 2009)

Directions for taking the Grit Scale: Please respond to the following 8 items.

Be honest – there are

no right or wrong answers!

1. New ideas and projects sometimes distract me from previous ones.*

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

2. Setbacks don't discourage me.

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

3. I have been obsessed with a certain idea or project for a short time but later lost interest.*

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

4. I am a hard worker.

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

5. I often set a goal but later choose to pursue a different one.*

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

6. I have difficulty maintaining my focus on projects that take more than a few months to complete.*

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

7. I finish whatever I begin.

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

8. I am diligent.

Very much like me

Mostly like me

Somewhat like me

Not much like me

Not like me at all

Scoring:

1. For questions 2, 4, 7 and 8 assign the following points:

5 = Very much like me

4 = Mostly like me

3 = Somewhat like me

2 = Not much like me

1 = Not like me at all

2. For questions 1, 3, 5 and 6 assign the following points:

1 = Very much like me

2 = Mostly like me

3 = Somewhat like me

4 = Not much like me

5 = Not like me at all

Add up all the points and divide by 8. The maximum score on this scale is 5

(extremely gritty), and

the lowest score on this scale is 1 (not at all gritty).

Dweck Mindset Instrument (Dweck, 2000)

DWECK MINDSET INSTRUMENT

Directions: Read each sentence below and then mark the corresponding box that shows how much you agree with each sentence. There are no right or wrong answers.

	1	2	3	4	5	6
	Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree
1) You have a certain amount of intelligence, and you really can't do much to change it.						
2) Your intelligence is something about you that you can't change very much.						
3) No matter who you are, you can significantly change your intelligence level.						
4) To be honest, you can't really change how intelligent you are.						
5) You can always substantially change how intelligent you are.						
6) You can learn new things, but you can't really change your basic intelligence.						
7) No matter how much intelligence you have, you can always change it quite a bit.						
8) You can change even your basic intelligence level considerably.						

	1	2	3	4	5	6
	Strongly Agree	Agree	Mostly Agree	Mostly Disagree	Disagree	Strongly Disagree
9) You have a certain amount of talent, and you can't really do much to change it.						
10) Your talent in an area is something about you that you can't change very much.						
11) No matter who you are, you can significantly change your level of talent.						
12) To be honest, you can't really change how much talent you have.						
13) You can always substantially change how much talent you have.						
14) You can learn new things, but you can't really change your basic level of talent.						
15) No matter how much talent you have, you can always change it quite a bit.						
16) You can change even your basic level of talent considerably.						

Motivation Questionnaire (Wulf, Chiviacowsky, & Lewthwaite, 2012)**Task-related Responses**

How motivated were you to learn this task?

How much did you enjoy practicing this task?

Ability-related Responses

How satisfied were you with your performance?

How concerned were you about your performance?

How much did your thoughts concern your ability on this task?

Nervousness-related Responses

How nervous were you before the start of each trial?

How nervous were you while balancing on the platform?

How nervous were you while waiting for the feedback?