THE RELATION BETWEEN EXECUTIVE FUNCTIONS AND ACADEMIC PERFORMANCE IN HIGH SCHOOL STUDENTS

By

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Abstract

Prior research has demonstrated that executive functions are related to academic achievement in preschool and middle school children (Blair & Razza, 2007; Espy, Kaufmann, McDiarmid, & Glisky, 1999). Research is limited, however, in adolescents. The current study will address this gap in the literature by examining the relations between executive functions and academic performance in high school students. Students ages 15-18 (M=16, approximately 50% male and majority White) were surveyed at Benton High School in St. Joseph, MO. The results of this study indicated that attention was a significant predictor of both teacher reported general academic performance and student GPA. Emotion regulation also predicted GPA, but it was not as strong of a predictor as attention. Emotion regulation did not predict general academic performance.
Introduction

Background Issues and Concerns

Understanding the mechanisms that promote academic success for students is critical for structuring classrooms and education systems in ways that support student learning and success. One such mechanism that has been examined in the literature is executive functions. Executive functions are defined as higher order cognitions that require effort and allow for more effective cognitive processing (Bull, Espy, & Weibe, 2008). Executive functions include things like attention, working memory, and cognitive self-regulation. These cognitive functions are important for social interaction and academic performance because they allow the individual to attend to the necessary material and successfully navigate their responsibility as a student (Bull, Espy, & Weibe, 2008). Prior research has demonstrated that executive functions are related to academic achievement in preschool and middle school children (Blair & Razza, 2007; Espy, Kaufmann, McDiarmid, & Glisky, 1999). Research also suggests that executive functions are flexible and can be improved with practice (Diamond, Barnett, Thomas, & Munro, 2007). It is imperative that educators understand what can be done to improve students’ academic performance and help them be as successful as possible.

Practice Under Investigation

The current literature is unclear as to how executive functions impact academic performance in high school. Based on previous literature with younger children, however, it seems that activities that foster executive functions are very important for growth and development that will lead to better academic performance. This research will inform
Policy regarding exercises in the classroom through high school that foster and support executive functions.

*School Policy to be informed by Study*

The current project will add to the literature and inform school policy regarding activities specifically focused on executive development as a part of the curriculum. If executive functions are important for academic performance in high school, the activities that support these functions should be a part of the typical school day so each child has a chance to reach their full potential and become successful academically. This study will also inform policy makers and school officials that early emphasis on executive functioning is important because poor executive functions may negatively predict academic performance throughout the educational experience.

*Conceptual Underpinning*

This project arose from the cognitive developmental theory. This theory suggests that brain development is a continuous process that occurs throughout development. The environment and experiences that occur in one’s life shape development and the functions of the brain. If adolescents are trained in the classroom to strengthen their executive functions, they may become more academically successful.

*Statement of the Problem*

Previous research suggests that throughout childhood, executive functions are related to better academic performance. Research is limited, however, in adolescents. The current study will address this gap in the literature by examining the relations between executive functions and academic performance in high school students.
Research Questions

RQ1: Are executive functions related to academic performance in high school students?

RQ2: Can executive functions predict academic success?

Null Hypotheses

Ho1: Executive functions are not related to academic performance in high school students.

Ho2: Executive functions cannot predict academic success.

Anticipated Benefits of the Study

This study will inform the literature and lead to a better understanding of the influence of executive functions on academic performance in high school. It is important to better understand the unique contributions of specific aspects of executive functions to academic performance as well. Research has demonstrated that specific measures of attention, control, and memory predict academic outcomes in unique and different ways (Bull & Scherif, 2010). The current study will examine the relation between specific aspects of executive functions, attention and regulation, and academic performance in a sample of high school students.

Definition of Terms

Executive functions: regulation and attention. These two acts require conscious control of cognitions and an effort in order for them to be effective. Attention is measured by teacher report, and regulation is measured by student, self-report. Academic performance is measured by both teacher report and student GPA.
Summary

The current study will extend the literature by examining the impact of executive functions on academic performance in a high school sample. Previous research has suggested that executive functions predict academic performance in childhood, but is it unclear whether these relations are consistent in adolescents.
Review of Literature

The study by Miyake, Friedman, Emerson, Witzki, & Howarter (2000) examined specific aspects of the executive function construct and their role in complex tasks. The participants, who were college students, completed three tasks examining distinct aspects of executive functioning. Shifting was assessed using a card-sorting task. Memory tasks assessed working memory. The Stroop Task, a common task that requires reading color names off of a computer screen, was used to assess inhibition of responses. The results demonstrated that the tasks were moderately correlated with each other. They also uniquely predicted the complex executive tasks (Miyake et al., 2000). These results suggest the importance of considering unique aspects of executive functions and how they uniquely predict performance. This is important to consider when examining academic achievement because particular executive functions are working together to produce academic outcomes.

A study by Blair and Razza (2007) examined executive functioning and later academic achievement in preschool children over a two-year period. Participants in this study were children from low-income European American families. Children were assessed on multiple aspects of executive functioning, including inhibition, attention, and false belief understanding in preschool. In kindergarten, children’s math and literacy abilities were examined. The results demonstrated that self-regulation was related to later academic achievement, regardless of intelligence. Inhibition was also related to both math and literacy performance in kindergarten (Blair & Razza, 2007). These results support the hypothesis that executive functions are related to academic achievement in early childhood.
Bull, Espy, & Wiebe (2008) examined the relation between executive functions in preschool and academic achievement in the third grade. Participants were examined in preschool on their working memory, short-term memory, and multiple other cognitive and executive functioning measures. In the third grade, they were again examined on the same constructs. The results demonstrated that visual-spatial short-term memory predicted later mathematical performance. Executive function also predicted general learning ability over time (Bull et al., 2008). These results support the hypothesis that executive functions are important for learning and academic performance. Research with preschool children seems to suggest that executive functions are important for developing academic competencies, but the research with typically developing adolescents is limited. There is some research that has been conducted with adolescents, but often these samples are clinical.

Regulation is another aspect of executive functions that has been examined in the literature. A study by Pintrich & De Groot (1990) examined the relations between self-regulation and academic achievement in math and science. Participants were in the seventh grade and filled out measures of self-regulation and learning strategies. Examining homework assignments and test scores assessed class performance. Results demonstrated that self-regulation predicted academic performance. These results suggest that self-regulation, which is a component of executive function, is an important predictor of academic performance for students in middle school.

A study by Beiderman et al. (2004) examined the relation between executive function deficits and academic achievement in children and adolescents who were diagnosed with a diagnosis of Attention-Deficit Hyperactivity Disorder (ADHD).
Participants were ages 6-17 and were followed for four years. Participants were assessed on their cognitive functioning, their intelligence, their social skills, and their academic performance. The results demonstrated that ADHD and lower cognitive functioning were related to an increased risk for grade retention and lower academic achievement (Biederman et al., 2004).

St. Claire-Thomas and Gathercole (2006) examined the relation between the executive functions, shifting, updating, inhibition, and working memory, and academic achievement in 11 and 12 year old students in England. The results demonstrated that working memory was related to achievement in both Math and English. Inhibition was associated with achievement in English, Math, and Science. These results suggest that the executive functions, working memory and inhibition, are related to success in multiple academic domains (St. Claire-Thomas & Gathercole, 2006). It is important to expand the literature on executive functions and academic outcomes with older adolescents so the developmental framework for understanding how executive functions impact academic outcomes can be better understood.

These results suggest that executive functions are consistently related to academic performance throughout development; however, the research with older adolescents is limited. It is necessary to examine whether or not these processes remain differentiated in high school, or if the variability in executive functions declines so that it no longer is an adequate predictor of academic achievement.
Research Methods

Research Design

The current study was cross-sectional. Students were Freshman through Seniors in High School. Data was collected using teacher surveys and self-report measures. The independent variables in this study are attention and emotion regulation. The dependent variable is academic performance.

Study Group Description

Students ages 15-18, M=16, approximately 50% male and majority White, were surveyed at Benton High School in St. Joseph, MO. The majority of students were from low-middle socioeconomic status and lived in the same area of town.

Data Collection and Implementation

The students completed a demographic measure including their overall GPA, (M=2.53, which is a high C average) which was used as a measure of academic performance. Students also completed a self-report measure of their emotion regulation skills, which was used as part of the executive function construct (Gratz & Roemer, 2003; see appendix 1). Teachers were surveyed as well regarding the student’s general attention in their classes, the other part of executive function, as well as their academic performance in the class. These questions and response scales can be viewed in Appendix 2. Descriptive statistics are reported in Appendix 3.

Statistical Analysis Methods

Multiple Stepwise Regression analyses were conducted to examine the predictive power of executive functions on academic performance in high school. The unique
predictive power of attention and emotion regulation was examined through regression analyses.
Findings

The results demonstrated that attention significantly predicted GPA, $b=.62$, $t(47)=4.84$, $p<.001$. Emotion regulation, however, was only a marginally significant predictor of GPA, $b=.24$, $t(47)=1.89$, $p=.07$. Attention was also a stronger predictor than emotion regulation, $b=-.05$, $t(47)=-.63$, $p=.54$, of teacher reported academic performance in the classroom, $b=.82$, $t(47)=9.69$, $p<.001$.

Table 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>gender</td>
<td>49</td>
<td>1</td>
<td>4</td>
<td>1.31</td>
<td>.585</td>
</tr>
<tr>
<td>attention</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>3.43</td>
<td>1.080</td>
</tr>
<tr>
<td>performance</td>
<td>49</td>
<td>1</td>
<td>5</td>
<td>3.47</td>
<td>1.101</td>
</tr>
<tr>
<td>GPA</td>
<td>49</td>
<td>0</td>
<td>4</td>
<td>2.53</td>
<td>1.174</td>
</tr>
<tr>
<td>emotion</td>
<td>48</td>
<td>1.00</td>
<td>3.46</td>
<td>2.0256</td>
<td>.71253</td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results shown in the table above demonstrate that student teacher reported attention significantly positively predicted GPA. As shown in Table 1, simple linear regression was calculated predicting subject’s GPA score based on self-report. A significant regression equation was found $F = 11.76, p = < .001$, with an $R^2$ of 0.34. Subjects’ GPA increased 0.62 points for an increase of one unit of reported attention score with an SEE of +/- 0.97. R squared (0.34) indicates a practical model that accounts for about 34% of the variance between the two variables. Standard Error of the Estimate (SEE) finding suggests that the predicted GPA is accurate +/- 0.97 points at one sd. It can be concluded that the model has moderate good power and accuracy. $F (11.76)$ has moderate relative value when compared to zero. This indicates that there is little change that a Type One Error would be made if the null hypothesis was rejected. The SLR model is significant. It can be concluded that the model null hypothesis can be rejected with great confidence. It can be concluded that teacher reported attention can predict GPA scores. SLR Model can be constructed from the beta coefficient results.
The results shown in the table above demonstrate that student emotion regulation only marginally positively predicts GPA. Emotion regulation is not as strong of a predictor of GPA as attention. As shown in Table 1, simple linear regression was calculated predicting subject’s GPA score based on their emotion regulation score. A significant regression equation was found $F = 11.76, p < .001$, with an $R^2$ of 0.34. Subjects’ average GPA increased .40 points for an increase of one emotion regulation score with an $SEE = \pm .97$. $R$ squared (0.34) indicates a practical model that accounts for about 34% of the variance between the two variables. Standard Error of the Estimate ($SEE$) finding suggests that the predicted GPA is accurate $\pm .97$ points at one sd. It can be concluded that the model has moderate good power and accuracy. $F$ (11.76) has moderate relative value when compared to zero. This indicates that there is little change that a Type One Error would be made if the null hypothesis was rejected. The SLR model is significant. It can be concluded that the model null hypothesis can be rejected with great confidence. It can be concluded that emotion regulation scores can predict GPA scores. SLR Model can be constructed from the beta coefficient results.
### Table 3: Emotion regulation and academic performance

<table>
<thead>
<tr>
<th>Source</th>
<th>Beta Coef.</th>
<th>$R^2$</th>
<th>SEE</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotion regulation</td>
<td>-.05</td>
<td>.71</td>
<td>.61</td>
<td>55.80</td>
<td>.54</td>
</tr>
</tbody>
</table>

Alpha = $< 0.05$

The above table demonstrates that attention is a stronger predictor than emotion regulation of teacher reported academic performance. As shown in Table 1, simple linear regression was calculated predicting subject’s academic performance score based on their emotion regulation score. A nonsignificant regression equation was found $F = 55.80$, $p = .54$, with an $R^2$ of .71. Subjects’ average increased performance rating decreased .05 points for an increase of one emotion regulation score with an SEE of +/- .61. R squared (0.71) indicates a practical model that accounts for about 71% of the variance between the two variables. Standard Error of the Estimate (SEE) finding suggests that the predicted performance is accurate +/- .61 points at one sd. It can be concluded that the model has good power and accuracy. $F (55.80)$ has high relative value when compared to zero. This indicates that there is little change that a Type One Error would be made if the null hypothesis was rejected. The SLR model is not significant. It can be concluded that the model null hypothesis can be retained with great confidence. It can be concluded that emotion regulation does not predict academic performance.
Table 4: Regression Analysis for Attention and academic performance

<table>
<thead>
<tr>
<th>Source</th>
<th>Beta Coef.</th>
<th>$R^2$</th>
<th>SEE</th>
<th>F</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>.84</td>
<td>.71</td>
<td>.61</td>
<td>55.80</td>
<td>.001</td>
</tr>
</tbody>
</table>

Alpha = < 0.05

As shown in Table 1, simple linear regression was calculated predicting subject’s teacher-reported academic performance based on their attention. A significant regression equation was found $F = 55.80, p < .001$, with an $R^2$ of .71. Subjects’ average performance score increased .84 points for an increase of one attention score with an SEE of +/- .61. $R^2$ squared (0.71) indicates a practical model that accounts for about 71% of the variance between the two variables. Standard Error of the Estimate (SEE) finding suggests that the predicted CBaseE is accurate +/- .61 points at one sd. It can be concluded that the model has moderate good power and accuracy. $F$ (55.80) has high relative value when compared to zero. This indicates that there is little change that a Type One Error would be made if the null hypothesis was rejected. The SLR model is significant. It can be concluded that the model null hypothesis can be rejected with great confidence. It can be concluded that attention scores can predict academic performance. SLR Model can be constructed from the beta coefficient results.
Conclusions and Recommendations

The results of this study indicated that attention was a significant predictor of both teacher reported general academic performance and student GPA. Emotion regulation also predicted GPA, but it was not as strong of a predictor as attention. Emotion regulation did not predict general academic performance. These results suggest that student attention in high school is still an important element that is necessary for academic success. Emotion regulation, which is another aspect of executive function, is also important, but maybe not as much so as attention. These results are consistent with previous research that suggests that executive functions predict academic performance in younger children. Executive functions seem to still be important and predictive for high school students.

There were several limitations in the present study that should be addressed in future research. This sample was predominantly white and middle to low socio-economic status (SES). Future research should examine the relations between executive functions and academic performance in other groups as well to examine generalizability. Also, the same teacher reported on overall academic performance and attention. There could have been response bias that accounted for the high association between these two items. In the future, better measures of overall academic performance and multiple responders should be used to eliminate as much bias as possible. Future research should also examine other potential aspects of executive function such as memory and how that predicts academic performance.
It is important to further understand how executive functions predict academic performance and the malleability of these functions so that steps can be taken to ensure that students have the support that they need to be academically successful.
References


Appendix 1: Differences in Emotion Regulation Scale Questions

1  2  3  4  5
Not like me  Completely like me

When I am upset, I lose control of my behaviors.
When I am upset, I believe that I will end up feeling very depressed.
When I am upset, I have difficulty controlling my behaviors.
When I am upset, I believe that I will remain that way for a long time.
  When I am upset, I become out of control.
When I am upset, I believe that wallowing in it is all I can do.
When I am upset, I feel out of control.
When I am upset, it takes me a long time to feel better.
I experience my emotions as overwhelming and out of control.
When I am upset, I know I can find a way to eventually feel better.
When I am upset, I feel that I can keep control of my behaviors.
When I am upset, my emotions feel overwhelming.
When I am upset, I start to feel very bad about myself.
Appendix 2: Teacher Reports of Academic Performance and Attention

Based on your interactions with student number ____________, please rate the participant’s average attention level.

1=Very poor
2=Slightly poor
3=Average
4=Good
5=Great

How would you rate this student’s overall academic performance?

1=Very poor
2=Slightly poor
3=Average
4=Good
5=Great