

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

EVALUATION OF AN INTERPRETATION BIAS MODIFICATION PROGRAM  
TARGETING INTERNALIZING SYMPTOMS IN SECONDARY SCHOOL STUDENTS

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Doctor of Philosophy

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by

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INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

EVALUATION OF AN INTERPRETATION BIAS MODIFICATION PROGRAM  
TARGETING INTERNALIZING SYMPTOMS IN SECONDARY SCHOOL STUDENTS

presented by Michael Van Wie

a candidate for the degree of Doctor of Philosophy of school psychology, and hereby certify that, in their opinion, it is worthy of acceptance.



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# INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

## DEDICATION

I would like to dedicate this work to my family. I thank Lindsay for always being supportive and sharing her enthusiasm for the pleasure of finding things out. For my children, Henry and Kate, every professional decision I make is guided by wanting to be the best father I can be for you. I would also like to thank my brother, Andrew, who provided essential guidance and support in the development and programming of the THINK intervention app.

# INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

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**TABLE OF CONTENTS**

**CHAPTER 1: INTRODUCTION..... 1**

**Background..... 1**

**Statement of the Problem ..... 3**

**Purpose of the Current Study ..... 5**

**Research Questions ..... 5**

**CHAPTER II: LITERATURE REVIEW ..... 6**

**Internalizing Problems ..... 6**

**Definition of Internalizing Problems ..... 6**

**Etiology of Internalizing Problems ..... 6**

**Internalizing Problems on a Continuum..... 7**

**Prevalence of Internalizing Problems..... 8**

**Impact of Internalizing Problems ..... 9**

**Evidence-based Internalizing Interventions ..... 10**

**Treatment as Usual for Internalizing Cases (CBT)..... 10**

**Limitations of Community and Clinical Therapeutic Interventions ..... 11**

**Need for Interventions in Schools Settings ..... 12**

**Overview of MTSS Framework ..... 13**

**Need for Efficient and Effective Tier 3 Interventions ..... 13**

**Information Processing Theory and Internalizing Disorders ..... 14**

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

**Theory Background**..... 14

**Interpretation Biases in Internalizing Disorders**..... 16

**Information Processing Biases in Children and Adolescents** ..... 16

**CBM for Internalizing Disorders**..... 17

**Word-Sentence Association Paradigm** ..... 19

**Cognitive Bias Modification Programs in Schools**..... 21

**Small number of school-based research studies** ..... 21

**Evidence of Gap for CBM-I**..... 21

**CHAPTER III: METHODS** ..... **22**

**Research Design**..... 22

**Power Analysis**..... 22

**Participants**..... 22

**Measures** ..... 24

**Behavior Risk Screeners** ..... 24

**Intervention**..... 26

**Procedures**..... 31

**Recruitment and Screening** ..... 31

**Performance-Based Data** ..... 33

**Process Analyses** ..... 34

**Data Analysis** ..... 34

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

**Benign/Threat-Endorsement/Rejection** ..... 34

**Reaction Time** ..... 34

**Linear Regression** ..... 34

**Latent Profile Analysis** ..... 35

**Growth Mixture Modeling (changes in reaction time as a function of training period)**35

**CHAPTER 4: RESULTS** ..... 36

**Analyses** ..... 36

**Demographic and Clinical Properties** .....Error! Bookmark not defined.

**Tests of Randomization** ..... 36

**Data Missingness**..... 37

**Assumption Testing** ..... 37

**Preliminary Analyses** ..... 38

**Latent Profile Analyses** ..... 40

**Process Analyses**..... 42

**Primary Outcome Analyses** ..... 43

**Secondary Outcome Analyses**..... 49

**Tertiary Outcome Analyses** ..... 52

**Qualitative Acceptance of Intervention** ..... 54

**CHAPTER 5: DISCUSSION** ..... 55

**Primary Findings**..... 55



# INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

<b>Secondary Findings</b> .....	56
<b>Tertiary Findings</b> .....	57
<b>Qualitative Perceptions</b> .....	57
<b>Limitations</b> .....	58
<b>Future Directions</b> .....	60
<b>Conclusions</b> .....	64

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

LIST OF FIGURES AND TABLES

Table 1. Demographic Characteristics of the N = 101 participants ..... 23

Table 2. Treatment Frequency and Setting ..... 38

Table 3. Baseline Questionnaire Correlations ..... 39

Table 4. Internalizing Symptom Pre-Post Measures..... 40

Table 5. Model Fit Indices for 1-5 Class Solutions of Baseline Youth Internalizing Indicators... 41

Table 6. Model Fit Indices for 1-5 Class Solutions of Post-Intervention Youth Internalizing Indicators..... 42

Table 7. Estimates of Covariance Parameters for Positive Endorsement Time Growth Curve ... 46

Table 8. Estimates of Covariance Parameters for Negative Endorsement Time Growth Curve.. 47

Table 9. Graph of the change in response latencies for positive and negative interpretations. ... 47

Table 10. Estimates of Covariance Parameters for Positive Endorsement Rate Growth Curve .. 48

Table 11. Estimates of Covariance Parameters for Positive Negative Rate Growth Curve ..... 49

Table 12. Paired Samples t-test for Baseline and Post-Intervention Measures ..... 50

Table 13. Estimates of Covariance Parameters for DBR Unhappy Growth Curve ..... 51

Table 14. Estimates of Fixed Effects – DBR Unhappy Scale Predicted by LPA Class and Negative Endorsement ..... 53

Table 15. Qualitative Feedback from Participants Regarding Their Training Experience..... 54

# INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

## ABSTRACT

The current study evaluated an intervention that supports secondary school students with internalizing symptoms through a computerized Interpretation Bias Modification program. The program is defined by multiple training sessions that reinforce the adoption of more positive interpretations of ambiguous social scenarios. The program's goal is to increase the accuracy and speed with which students can judge the threat-based nature of events they are likely to encounter in their day-to-day lives. As students' progress through the training program, measurements were made regarding their 'online' and 'offline' processing biases and the association to cognitive and behavioral internalizing symptoms known to maintain depressive and anxious conditions.

The randomized waitlist control trial design was conducted with students ages 11-18, drawn from school and community samples. The researchers compared internalizing behavior of the treatment group (N = 56) to the participant outcomes in the waitlist control group (N = 45). The variables of interest were measures of anxiety, depression, and patterns of negative thought that embody both conditions. Variables related to

Primary findings from t-tests, ANCOVA, growth curve analysis, and linear mixed-effects model regressions indicated significant differences between the training conditions and within the training condition as a function of training. Researchers identified a medium effects size on reductions in depressive symptoms within the treatment group. There were positive findings regarding the acceptability of the interpretation bias training intervention. Limitations and future directions for this area of research are discussed.

## CHAPTER 1: INTRODUCTION

### Background

Of the roughly 75 million children in the United States, an estimated 17 million have or have had a psychiatric disorder (Merikangas, 2010). The 13% of American youth represented in this category amount to more children with cancer, diabetes, and AIDS combined (Center for Disease Control, 2020). The onset of half of all psychiatric illnesses occurs before the age of 14, and 75% occur by age 24. Approximately half of the children experiencing a mental health illness meet the criteria for an internalizing disorder such as anxiety or depression. There is a clear need for interventions designed to address children's current challenges and prevent future emotional, social, and physical stress associated with internalizing concerns (Schleider & Weisz, 2017).

Past research has reviewed the evidence base for a myriad of empirically supported treatments for youth internalizing problems (Weisz, 2004). Treatments for anxious and depressed youth often focus on mechanisms of change such as modeling approach behavior, relaxation training, in-vivo exposure, social skills training, or a modular treatment approach utilizing many combinations of the methods mentioned above (Weisz, 2015). One treatment mechanism that has received substantially less attention in the internalizing research literature is cognitive restructuring. Until recently, there have been few methods to train anxious and depressed youth away from threat-based thoughts without the help of behavioral techniques (Andrews, 1971; Saigh, 1984; Dewis, 2001). While selecting several treatment mechanisms to focus on, behavioral modeling and in-vivo exposure can increase the amount of time spent in therapy. Treatments for internalizing children and adolescents are often restricted to the outpatient clinic setting. Despite increased interest in pursuing treatments outside of the clinic setting, few

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

research studies have focused on pursuing internalizing intervention research in community settings such as public schools (Herman et al., 2009; Kilgus, Reinke, & Jimerson, 2015).

Within the context of mental health concerns, schools are emerging as a meaningful access point to intervene in and prevent youth internalizing problems (Herman et al., 2004). Within a tiered service delivery model, many students within a given school will benefit from school-wide interventions or even services delivered on a semi-regular basis to small groups of students who share a common concern. However, a few students will continue to require ongoing assistance to manage their internalizing issues. The services that these students need are often time and resource-intensive. Unfortunately, there is a clear gap in the number of children with internalizing concerns and those who receive services. Of the students identified as having internalizing problems, one estimate finds that while 65% of students receive mental health services, only 40% receive special education services for those problems (Bradshaw et al., 2008). Due to the less visible nature of internalizing disorders compared to externalizing disorders, students susceptible to depression and anxiety may be left ‘treading water.’ In contrast, other students with more visible disruptive behavior are linked to the care they need.

Moving beyond assessment issues for internalizing disorders, there are also school-based treatment matters that warrant more attention. Based on data sourced from the U.S. Department of Education, most states are not meeting the recommended school psychologist-to-student ratio of 1:700. The national average lags behind the recommendation with a ratio of 1:1382 school psychologists to students. Missouri represents one of the states with the most concerning proportion, 1:4867 school psychologists to students. Student-to-counselor and student-to-social worker ratios are similarly troubling, with both the national and Missouri state averages drastically underrepresented (ACLU, 2020). The shortage in school-based mental health

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

professionals is likely related to the missed opportunities to connect students with ongoing internalizing concerns to the services they could likely benefit from. Lastly, few studies have considered a cost-benefit ratio between the positive effects of out-of-class therapy services compared to continued in-class academic-oriented time losses.

### **Statement of the Problem**

Based on the prevalence of internalizing disorders in youth, there is a need to address both the short-term and long-term implications that anxiety and depression can have in one's life. Schools offer a crucial access point to youth mental health intervention, as many students spend most of their supervised time at schools and receive a host of other supports (Paternite, 2005, Weist & Murray, 2008). Schools are the most significant public sector setting for service delivery, with 70-80% of youth mental health care provided by school-based mental health professionals. Compared to student externalizing concerns, few evidence-based interventions are explicitly designed for internalizing students requiring tier 2 & 3 support (Allen, Kilgus & Eklund, 2018; Cook et al., 2010). Others have argued that existing interventions inadequately address the scope of internalizing problems (Herman et al., 2009). These issues, paired with the lack of mental health professionals to provide such intervention (Evans and Wesit, 2004), justify further research related to efficient and effective interventions designed for students with internalizing concerns.

Few studies have addressed the efficiency of school-facilitated interventions for internalizing concerns. Recent research has identified that school-based services demonstrate a small-to-medium effect in decreasing mental health problems with large effects found for targeted intervention (Hedges  $g = 0.76$ ) compared to universal prevention (Hedges  $g = 0.29$ ). Additionally, mental health services integrated into students' academic instruction showed strong

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

effects (Sanchez et al., 2018). These often require substantial time and resources to ensure the high levels of fidelity needed to make the interventions effective. Students are often pulled away from academic instruction to participate in small group interventions or one-on-one counseling with a school-based mental health professional (Beidas, 2012). Teachers and school mental health professionals will spend a significant amount of time preparing for, delivering, and monitoring the intervention. School psychologists, counselors, and social workers routinely work to manage many responsibilities. A reduction of competing commitments is an undoubtedly important factor in the availability to deliver evidence-based interventions for students with internalizing concerns.

Of the evidence-based internalizing interventions designed for school use, few focus on the cognitive restructuring of threatening ideas, instead opting to focus on changing maintaining mechanisms related to social skills and overt, observable behavior. Recent research developed from the information processing theory suggests that youth at increased risk of developing anxiety and depressive disorders display a negative information processing bias (Beard, 2004). According to this cognitive theory, individuals who possess such maladaptive cognitive patterns are vulnerable to internalizing concerns because they tend to engage in negatively toned information processing about themselves and their experiences when they encounter stressful events (Alloy et al., 1997). Within the past ten years, novel interventions designed to address information processing biases have been developed and show evidence of reductions in internalizing symptoms (Beard, 2004; Beard, 2009; LeMoult, 2017). Cognitive Bias Modification programs offer a unique potential for school-based use. They operate under a simple cognitive premise, are time-efficient, require little service-delivery effort, and have

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

medium effect sizes comparable to the treatment as usual approaches for typical tier 3 internalizing interventions.

### **Purpose of the Current Study**

The current study evaluated an internalizing intervention developed for secondary school students, which uses a computerized Interpretation Bias Modification program designed to reduce symptoms of anxiety and depression. The program is defined by training sessions that reinforce the adoption of more positive interpretations of ambiguous social scenarios. The program's goal is to increase the accuracy and speed with which students make judgments about the threat-based nature of events they are likely to encounter in their day-to-day lives. As students' progress through the training program, measurements were made regarding their 'online' and 'offline' processing biases and the association to cognitive and behavioral internalizing symptoms known to maintain depressive and anxious conditions. This study used a multi-method design to identify the effectiveness of a computer-based cognitive-bias modification program designed for students struggling with various internalizing concerns. The research questions for the current study were as follows:

### **Research Questions**

1. Does the Interpretation Bias Modification program effectively train participants by increasing interpretation measures (e.g., endorsement rate and response time)?
2. What is the effect of the Cognitive Bias Modification program on students' internalizing concerns as reported by student self-reports compared to a waitlist control group?
3. To what extent can the severity of internalizing concerns predict treatment success in the Cognitive Bias Modification Program?



## CHAPTER II: LITERATURE REVIEW

### Internalizing Problems

#### Definition of Internalizing Problems

The spectrum of internalizing problems is typified by a variety of over-inhibited or internally-focused symptoms, including anxiety, fear, sadness/depression, social withdrawal, somatic complaints, rumination, difficulties regulating emotions, and avoidance of specific stimuli or situations (Levitt & Miller, 2009; Willner et al., 2016). Compared to externalizing problems, which are typically viewed as under-controlled behaviors, internalizing problems are viewed as over-controlled behaviors (Levitt & Merrell, 2009). These over-controlled behaviors cause distress to oneself internally. Still, because of the less visible nature of many of these behaviors, internalizing disorders often go undetected compared to their externalizing counterparts (Friedman, 2009).

#### Etiology of Internalizing Problems

Several models allege different factors as influential factors that contribute to the development of internalizing disorders (Hammen et al., 2014; Higa-McMillan, 2014). These models view the onset of internalizing problems as the culmination of interacting genetic and environmental factors. Cognitive style, parental modeling, socialization experiences, interpersonal stressors, and early adverse experiences represent some of the ecological factors which may play a role in the development and maintenance of internalizing disorders (Hammen et al., 2014; Liu, 2011). Anxiety and depression share similar genetic influences, of which genetic influences share more significant overlap than environmental influences do (Cosgrove et al., 2011; Middeldorp et al., 2005). The correlation between genetic influences on MDD and generalized anxiety disorder (GAD) was high and ranged from .86 to 1.00 (Silberg et al.,

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

2005) also reported a common genetic factor influencing separation anxiety, overanxious disorder, depression, and eating disorders.

### **Internalizing Problems on a Continuum**

Mental health concerns, including internalizing problems, generally fall along a continuum from mental health to mental illness. The idea of a continuum is not new (Allport, 1937), but decades of research have supported the idea that mental health and mental illness represent two poles of a linear sequence that move as an individual moves through different developmental stages (Jahoda, 1958; Keyes, 2002; Travis, 1975). The World Health Organization (2017) defined mental health as “a state of well-being in which every individual reaches his or her potential, can cope with normal stresses of life, work productively and fruitfully, and contribute to his or her community.” We conceptualize the continuum as having three distinct points. The first point fully represents the definition of mental health. People within the healthy area are generally satisfied with their lives and live emotionally well-balanced, stable, goal-oriented lives. The mid-range of the continuum represents a problem point. Individuals in this spectrum section may show some distress or inability to cope but can perform daily life functions. The end of the continuum represents a range of disordered thoughts and behaviors. People falling under this span of the continuum cannot cope with stress and exhibit significantly distressful thoughts, feelings, and behaviors because of this.

As previously mentioned, the position of mental health and mental illness may vary as individuals mature. Childhood and adolescence represent a unique time in development when feeling anxious or sad in response to stressful situations are an average experience (Compas, 1987). For example, specific stimuli and experiences of fear change drastically over one’s life. Inborn fears are seen in children younger than two-years-old who display worries associated with

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

separation and strangers (Kagan et al., 1987; Field, 2010). Fears related to the dark and imaginary creatures permeate the minds of young children, whereas fears associated with failure and rejection appear in later childhood (Bauer, 1976; Schaefer et al., 2003; Wellman, 1990). With a developmental lens in mind, it is vital to understand when fear or sadness no longer serves an adaptive function and becomes maladaptive to the child or adolescent's social experience. When these maladaptive thoughts or behaviors impact a child or adolescent, that individual may be at-risk for an internalizing disorder (Higa\_McMillan et al., 2014; Zahn-Waxler et al., 2000). An internalizing disorder is defined by clinically significant levels of distress experienced by an individual which impairs important life activities, such as schoolwork, home life, or interactions with peers, in addition to a cluster of symptoms as defined by the Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition (DSM-V; American Psychiatric Association (APA), 2013; Higa-McMillan et al., 2014; Zahn-Waxler et al., 2000). Examples of diagnosable anxiety disorders include Generalized Anxiety Disorder (GAD), Social Phobia, Separation Anxiety Disorder, and Panic Disorder. Examples of mood or depressive disorders include Major Depressive Disorder (MDD), Persistent Depressive Disorder, and Bipolar disorders.

### **Prevalence of Internalizing Problems**

Research on prevalence rates of mental illness cites that one in 20-25% of children or adolescents has a mental disorder and that roughly 10% of children or adolescents have severe impairments due to a given mental illness (Levitt & Merrell, 2009; Merikangas et al., 2010). In a nationally representative sample of more than 10,000 adolescents ages 13 to 18, internalizing disorders were identified at prevalence rates (31.9% for anxiety disorders and 14.3% for mood disorders). Of the specified internalizing conditions, 22.2% of youth who met the criteria for a

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

mental illness experienced severe impairment and distress (Merikangas et al., 2010). Age of onset differs by disorder type, with the median age of onset for anxiety disorders identified at six and thirteen years of age for mood disorders.

### **Impact of Internalizing Problems**

Whether symptom severity is above or below clinical levels, internalizing concerns can negatively impact youth functioning. Children and adolescents with internalizing concerns will likely experience symptoms in multiple contexts. Anxiety and mood problems can inhibit school performance in several areas. Academic performance, social relationships with peers, and teacher interactions can all be impacted by internalizing issues (Mychailyszyn et al., 2010). Additional impairment may be experienced in children and adolescents' home lives. Interactions with family members and friends in the home environment may be negatively impacted. Youth at risk for internalizing issues may also remove themselves from specific experiences, so a full range of affairs may not even be captured for children and adolescents with anxiety and depression. Virtual interactions are a final consideration of where internalizing symptoms may interfere in young people's lives. Recent research has shown that digital interactions, specifically peer interactions facilitated by social media use, can increase and maintain internalizing behavior (Hoge et al., 2017).

Youth who experience internalizing disorders are also at a higher risk for impairments related to internalizing issues later in life (Pine et al., 1998). Anxiety and depressive symptoms which present in early life (i.e., childhood or adolescence) are associated with adverse proximal outcomes such as low academic achievement (Fergusson & Woodward, 2002; Lefkowitz & Tesiny, 1985) and poor peer relationships (Fombonne, Wostear, Cooper, Harrington, & Rutter, 2001; Grover, Ginsburg, & Ialongo, 2007) in addition to adverse distal outcomes such as adult

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

psychopathology (Fombonne et al., 2001; Grover et al., 2007), substance abuse (Fergusson & Woodward, 2002; Lewinsohn, Zinbarg, Seeley, Lewinsohn, & Sack, 1997), and suicidality (Cogle, Keough, Riccardi, & Sachs-Ericsson, 2009; Fergusson & Woodward, 2002; Fombonne et al., 2001; Perroud et al., 2009).

There are also steep societal costs to youth internalizing disorders. The monetary costs of children experiencing acute and especially chronic episodes of depression and anxiety are substantial. Past studies of adult occurrences of depression have estimated that a total cost of \$83.1 billion was spent on treating the disorder and accounting for resources lost to decreased productivity or premature death (Greenberg et al., 2003). Cohort analyses have found that children and adolescents today are experiencing internalizing disorders at higher rates than generations past (Twenge et al., 2014). A fixed-cost model would see the economy further burdened by depression and anxiety in the future as young people age and enter the workforce.

### **Evidence-based Internalizing Interventions**

#### ***Treatment as Usual for Internalizing Cases (CBT)***

A growing number of school-based studies have shown the effectiveness of internalizing specific interventions (Barrett, 2005; Gillham et al., 2007; Kilgus et al., 2018; Masia-Warner, 2005), yet the number of studies is comparatively fewer compared to clinic-based research. Of the various forms of psychotherapy offered in clinic and school-based studies for internalizing disorders, the vast majority fall under a Cognitive-Behavioral umbrella. Cognitive Behavioral Therapy (CBT) is often held as the gold standard form of therapy (David et al., 2018). Based on the research of Albert Ellis and Aaron T. Beck and colleagues, CBT focuses on the connections between thoughts, feelings, and behaviors in addressing dysfunctional cognitive distortions and maladaptive behaviors. Commonly used in therapy today, the theoretical mechanism of change is

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

founded on cognitive theory (Beck, 1973; Clark & Beck, 1990). Cognitive theory suggests that one's thoughts about a situation spur an emotional reaction.

An example would be a negative attribution in a specific situation that leads to feelings of hopelessness, which may increase the likelihood of maladaptive behavior (avoidant, inhibited, etc.). CBT focuses on identifying maladaptive thoughts as an access point in treatment guided by clinicians; patients work to recognize maladaptive thoughts and gradually shift their thinking style to a more positive and rational view. Cognitive shifts would then promote changes in emotion and behaviors through improved problem-solving.

A limited number of therapy sessions characterizes CBT compared to long-term psychotherapy approaches such as psychodynamic or interpersonal forms of therapy. To accomplish the swift therapy experience, manualized approaches to treating various internalizing concerns have been developed. Meta-analyses have revealed that manualized approaches commonly feature specific therapy skills such as psychoeducation, goal setting, behavioral activation, coping skills, relaxation training, cognitive restructuring, problem-solving skills, and graduated exposure (Hoffman et al., 2012).

### **Limitations of Community and Clinical Therapeutic Interventions**

Although evidence-based interventions designed specifically for treating children and adolescents with internalizing symptoms and delivered in the clinic setting have been beneficial, barriers prevent many youths from accessing these services. One estimate finds that of children and adolescents with mental health concerns, 75 to 80% do not receive treatment (Levitt & Merrell, 2009). A major barrier to receiving treatment is the difficulty in accessing clinics or service providers who offer evidence-based interventions. Families from low socio-economic status (SES) backgrounds may have trouble accessing interventions due to time or resource

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

constraints (Howell, 2004; Richardson, 2008). Youth in rural settings may simply lack access to quality services providers based on distance alone (Yoshikawa et al., 2012). The preceding reasons, combined with ongoing stigma related to mental health problems, offer just a few of many possible barriers to youth accessing the necessary treatment for their concerns.

Although children and adolescents are increasingly accessing community service providers to treat internalizing disorders, these avenues can be costly and prohibitively expensive for some families. More research is needed to determine the short- and long-term costs of internalizing disorders in childhood, specifically related to long-term savings associated with the prevention and treatment of the disorders. By default, schools offer a front-line position to observe and be impacted by children's emotional ordeals. Schools should be motivated to offer free services for students internalizing concerns if research shows that alleviating these symptoms increases student academic performance. This commitment to investment in mental health services will likely be contingent on research-based assurances of positive returns. School-based quick and cost-efficient interventions may provide a route for generating the positive returns necessary for those investments.

### **Need for Interventions in Schools Settings**

To address barriers that limit access to evidence-based interventions, recent research has reviewed the need to explore further interventions designed for real-world settings (Higa-McMillan et al., 2016). Researchers suggest that schools offer clinicians a unique access point to intervene in children's mental illnesses. To mitigate the negative impact of depression and internalizing symptoms amongst children and adolescents, researchers have suggested that schools may serve as a universal setting for mental health intervention (Herman, 2009; Weist & Murray, 2008).

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

### **Overview of MTSS Framework**

Increasingly, schools are choosing to address a wide range of student concerns through multi-tiered systems of support (MTSS). MTSS frameworks have been adapted from a public health model. The focus is on prevention and early intervention for most students, intending to prevent future problems from developing (McIntosh et al., 2014). Researchers have suggested that internalizing issues could be addressed through multi-tiered systems such as the School-Wide Positive Behavior Intervention Supports (PBIS) framework (McIntosh et al., 2014). Researchers have identified an identifiable dearth of evidence-based interventions and the need for more internalizing interventions than those created for externalizing problems (Herman et al., 2004).

### **Need for Efficient and Effective Tier 3 Interventions**

The third tier of the PBIS framework reflects supports and interventions required for severe behaviors to have not benefited from universal strategies or targeted interventions. Students with tier 3 behaviors may receive intensive one-on-one individualized instruction to address a student's specific needs. There are several individualized manualized CBT interventions designed to manage anxiety and depression that would be ideal within the third tier of support. ACTION and Coping Cat family of interventions are two treatments with substantial research support for treating depressive and anxious symptoms (Stark et al., 2005; Kendall, 1990). Although both treatments were designed for use in a clinic setting, each has been subject to school-based use. Both interventions are time-intensive for service providers and the students who receive them. ACTION comprises 20 hour-long sessions, whereas Coping Cat and the CAT project fit skills-based lessons into twelve 60-minute sessions. One estimate of the individualized cost of treatment programs such as ACTION or Coping Cat could be \$2,000. Schools may be



## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

unwilling or unable to spend the necessary money on training service providers and purchasing manuals and equipment, and time spent delivering the actual interventions. Given the previously mentioned lack of well-trained mental health service providers available to schools throughout the country, there is a clear need for efficient, effective, and inexpensive mental health interventions for children and adolescents in schools.

### **Information Processing Theory and Internalizing Disorders**

#### **Theory Background**

Two prominent theories suggest a strong association between cognitive biases and emotional vulnerability. The schema model (Beck, 1976) and the network model (Bower, 1973) differ in detail, but both predict the presence of pervasive automatic processing biases in clinically anxious and depressed patients. Beck believed that a depressed person would, often from childhood experiences, hold a negative self-schema (Beck, 1976). This schema may originate from negative early experiences, such as criticism, abuse, or bullying (Beck, 1994). The schema model suggests that people with negative self-schemata are liable to interpret information negatively presented to them, leading to the cognitive distortions outlined above. The pessimistic explanatory style, which describes how depressed or neurotic people react negatively to specific events, is an example of the effect of these schemata on self-image. This explanatory style involves blaming oneself for negative events outside of their control or the behavior of others (personalization), believing that such events will continue forever, and letting these events significantly affect their emotional wellbeing.

Bower proposed that concepts, events, and emotions can all be represented as nodes within a network. The type of network originally chosen by Anderson and Bower (1973) consisted only of labeled links; the nodes themselves had no semantic labels. Concepts, events,

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

and emotions are all represented as nodes within the network. Activation within the network depends on the proximity of nodes, the strength of the initial activation, and the time-lapse since activation. The network encodes events that cause proceeding events, allowing for the visualization of events responsible for emotions. Over time, nodes commonly activated in a temporal pattern develop shared associative connections, resulting in a cognitive priming effect. Bower argued that basic mood-congruent processing effects should be common to all people. However, the priming effect should be most pronounced in those who have developed unusually strong associative connections between a node of a particular negative emotion and associated memory nodes. With the previous prediction in mind, Bower suggests that this specific model predicts the degree to which a specific negative mood state elicits the emotion-congruent processing bias should be most significant among individuals with a high level of trait vulnerability to that emotion.

Although the assumed mechanisms differ, the theoretical models put forth by Beck and Bower arrive at a similar set of predictions. Each theoretical model predicts that cognitive biases that deal with emotionally congruent information processing should be evident in both anxiety and depression across both encoding and retrieval processes. Both predictions suggested that the biased processing effects would be triggered by an internalizing mood state and would be most prominent in individuals with high levels of trait vulnerability to a specific negative emotion (anxiety or depression). Finally, both Beck and Bower believed that these biased cognitions would operate automatically and would not be impacted by the individual's 'online' processing. Both theories mentioned above have catalyzed a great deal of research into the association between susceptibility to negative emotional states and clear patterns of biased cognition (Beard & Amir, 2011; MacLeod & Mathews, 1991).

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

### **Interpretation Biases in Internalizing Disorders**

Biased information processing is an important marker of negative mood and has contributed to the development of depression and anxiety disorders (Mathews & Macleod, 2005). Individuals with internalizing concerns tend to interpret ambiguity in a threatening way, a phenomenon that has been named *interpretation bias* (Field, 2010). Interpretation biases have been extensively studied in psychopathology, where they are argued to have a role in the onset of disorders such as anxiety and depression (e.g., Beck and Clarke, 1988; Mathews and Mackintosh, 2000; Clark, 2001; Hirsch and Mathews, 2012; Hirsch et al., 2016). Further research on cognitive models of depression and anxiety suggests that negative interpretation bias, a perpetual view of seeing one's glass as half empty rather than half full, is critical to the maintenance of depressed mood and anxious states via a cycle of safety-seeking behavior (Amir et al., 1998; Williams et al., 1997). Interpretation bias represents one of four identified cognitive biases (attention, memory, judgment, and interpretation)

### **Information Processing Biases in Children and Adolescents**

Cognitive biases that hinge on detecting and processing threat-related information are a significant feature of both adult (Bar-Haim et al., 2007) and developmental models of anxiety (Muris & Field, 2008). Given the increasing prevalence of internalizing conditions in recent decades, recent research has furthered our understanding of information processing biases in children and adolescents. Many situations that children and adolescents encounter in daily life are coded in ambiguity. A child's first day of school or butterflies in a teenager's stomach when learning to drive- could be interpreted as positive or benign. Yet, some children and adolescents might identify potential danger in these situations. Both anxious and depressed individuals tend to interpret ambiguity in a threatening way (Field, 2010). How young people perceive and

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

interpret these situations is important to how they later choose to deal with them. The behavioral consequences of these information processing biases are crucial to developing and using avoidant coping strategies. Using a prevention-science approach, researchers interested in treatments for youth with internalizing concerns should devote their time to creating strategies to curb information processing biases to reduce avoidant behavior. By reducing avoidant behavior, students will be less likely to fall into an avoidant cycle, which further strengthens existing information processing biases whether through selective attention, negative interpretation, or ruminating over negative events.

### **CBM for Internalizing Disorders**

Cognitive bias modification (CBM) was initially developed as a way for researchers to experimentally manipulate cognitive biases, permitting an empirical test of the causal role of these biases in anxiety and depression. Most current CBM paradigms were adapted from established paradigms in experimental cognitive psychology. In a typical CBM paradigm, participants are exposed to an experimental contingency between negative emotional stimuli and the target response. For example, in the dot-probe task (MacLeod et al., 1986), two stimuli appear simultaneously on a computer screen. One stimulus is threatening (e.g., an angry face), and one is positive or benign (e.g., a smiling or neutral face). Immediately following the offset of these stimuli, one or two dots (the “probe”) appear in the location of one of the stimuli. The participant must identify the number of dots (one or two) as quickly as possible. Faster responses to a probe that replaces a threatening stimulus suggest preferential attention toward threatening information. Attention biases can be trained using this paradigm by varying the frequency with which the probe replaces the threatening stimulus. In studies designed to reduce attention bias toward threat, the probe replaces the benign stimulus in 80%– 100% of trials. Over many trials,

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

participants are expected to implicitly learn the association between the benign stimulus and the target response and begin attending selectively to benign stimuli. Training success is assessed by removing the contingency between the stimulus and probe and examining whether participants who have undergone training continue to demonstrate the trained bias. Interpretation bias paradigms differ from attention bias paradigms in several respects. Whereas stimuli in attention modification paradigms are typically pictures or words, stimuli in interpretation bias paradigms generally are sentences or paragraphs.

Additionally, whereas attention bias paradigms usually require participants to respond to a stimulus by pressing a button, interpretation bias modification paradigms frequently require participants to be generative. For example, in a standard interpretation bias training paradigm, participants are presented with a series of ambiguous sentences. The valence of each sentence can be determined only from the last word of the sentence, which is presented as a word fragment that participants must solve (Mathews & Mackintosh, 2000). For instance, participants might be presented with the following ambiguous sentence: “As you get ready to go to a party, you think the new people you meet there will find you . . .” Participants in a positive training group are presented with a fragment that resolves the sentence positively (“fr\_e\_dly”), whereas participants in a negative training group are presented with a fragment that resolves the sentence negatively (“b\_r\_ng”). After completing each fragment, participants typically are asked a comprehension question that reinforces the interpretation (e.g., “Will you be liked by your new acquaintances?”). To assess training success, participants are presented with new sentences that remain ambiguous even after the word fragment is completed. For example, “As you give a speech at your friend’s wedding, you notice some people in the audience starting to . . .” is followed by the word fragment “l\_\_gh.” Participants are then asked to disambiguate these

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

sentences by selecting one of several different meanings. Participants who choose positively disambiguated sentences (e.g., “As you speak, people in the audience laugh appreciatively”) are considered to have developed a positive interpretation bias. In contrast, those who choose negatively disambiguated sentences (e.g., “As you speak, people in the audience find your efforts laughable”) are considered to have developed a negative interpretation bias.

### **Word-Sentence Association Paradigm**

Beard and Amir (2008; 2009) developed a measure of interpretation bias called the Word-Sentence Association Paradigm (WSAP), which includes offline and online components and assesses benign and negative interpretations separately. In the original version of the WSAP, each trial consists of four steps. First, a fixation cross is presented on a computer screen for 500 ms. This directs participants’ attention toward the screen to alert them that a trial is starting. Second, a word representing either a benign interpretation (e.g., “funny”) or a threat interpretation (e.g., “embarrassing”) appears on the screen for 500 ms. Third, an ambiguous sentence (e.g., “People laugh after something you said”) appears and remains on the screen until participants press the spacebar on the keyboard to indicate they have finished reading the sentence. Fourth, participants are prompted to press a key if they think the word and sentence were related or press a different key if they think the word and sentence were unrelated. The WSAP differs from other IB assessment instruments in that it provides two types of responses for analysis: endorsement or accuracy rates (i.e., relatively “offline”) and reaction time data (i.e., “online”). Expressly, the WSAP results in two primary indices of interpretation: (1) percentage of benign interpretations endorsed and (2) percentage of threat interpretations endorsed, and four reaction time variables: response latency to (1) endorse benign (2) reject benign (3) endorse threat (4) reject threat. Researchers sometimes combine these various WSAP indices to create

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

bias scores. In the initial WSAP validation study, undergraduates with high and low levels of social anxiety (SA) completed 110 trials of the WSAP (Beard & Amir, 2009). Results indicated that individuals high in SA were slower to reject and faster to endorse threatening interpretations of ambiguous social sentences than non-anxious controls.

Similarly, those high in SA were also quicker to reject and slower to endorse positive interpretations of social sentences. The endorsement indices revealed that the participants high in SA endorsed positive and threatening interpretations at similar rates, whereas the non-anxious controls strongly favored positive interpretations over threat interpretations. In a follow-up study utilizing the WSAP in a clinical sample of individuals diagnosed with SAD, Amir, Prouvost, and Kuckertz (2012) similarly found that the SAD group lacked a positive IB relative to non-anxious controls. In addition to its utility as an assessment instrument, the WSAP has been adapted for Cognitive Bias Modification for Interpretations (CBMI). CBM was initially designed to alter cognitive biases experimentally to test causal relationships between interpretation bias and emotional vulnerability. Whereas psychotherapy attempts to modify cognitive biases through explicit verbal processes (e.g., instructing patients how to challenge preconceptions), CBM relies on a more implicit, experiential approach. As described by Koster, Fox, and MacLeod (2009), CBM consists of two primary features: first, the direct target of change is a cognitive bias “known to characterize a clinical disorder, a clinically relevant symptom, or a personality trait associated with vulnerability to clinical dysfunction”; and second, the methodology of manipulating the target cognitive bias has not primarily utilized verbal instruction, but rather involved a process of repeated practice of a specific cognitive task.

### **Cognitive Bias Modification Programs in Schools**

#### **A small number of school-based research studies**

In many cases, school represents one of if not the primary social outlet for children and adolescents. Like any other environment, the social interactions within schools are comprised of ambiguous, negative, and positive cues. For example, a student is called to the principal's office of the public announcement system. Any given student may interpret the request to meet with the principal in a positive or negative light. A student may believe they are in trouble and will be reprimanded by the principal (threat interpretation). Alternatively, a student may feel that their efforts in class have not gone unnoticed and the principal has prepared an award for them. School-based interactions likely represent a range of social interactions that could be difficult for youth with internalizing problems. To date, very little research has focused on the school-based implementation of cognitive bias modification programs, and less than a handful have studied school-based interventions exclusively. This literature review has found no evidence of a targeted intervention for at-risk youth who may benefit from a cognitive bias modification program designed to address the broad negative cognitive biases common to students with both anxious and depressive symptoms.

#### **Evidence of Gap for CBM-I**

Previous research has found that attention-based CBM programs (ABM) do not have as much intervention success compared to interpretation-based cognitive bias modification programs (CBM-I) (Christea et al., 2018). One potential explanation for this is the use of unengaging attention tasks in ABM programs. To address the research gap and the need for evidence-based, cost-effective interventions available to students, the present study aims to create an engaging, user-friendly app-based intervention deliverable without needing any support



## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

from a mental health service provider on school grounds and in a third of the time required of traditional manualized interventions for child and adolescent internalizing problems.

### CHAPTER III: METHODS

#### Research Design

The current study employed a waitlist randomized controlled trial design to examine the effectiveness of a Cognitive Bias Modification (CBM) program across middle and high school students. Random assignment placed students into two conditions: treatment and waitlist control. Data collection occurred in pre-intervention and post-intervention for both groups. Participants in the intervention group received the active CBM training. In contrast, participants in the waitlist control group received no training until the active condition finished their training period. The active CBM training condition was offered to the control group following the completion of post-intervention data collection.

#### Power Analysis

The study utilized a waitlist control study design. Power analyses were conducted using the G\*Power software program. In the t-tests family, the Means: Difference between two independent means (two groups) was selected. A priori power analyses were selected. Input parameters were a two-tailed distribution with effect size  $d = .8$ . The type 1 error probability was set to 0.05, and the Power was set to 0.95. The output provided advised that to achieve a critical t value, the sample size of each group must be  $n = 42$ .

#### Participants

Participants were selected from the Midwest and Mid-Atlantic region communities of the United States. Students ranging in age from 11 to 18 and grades 6 through 12 were recruited for the study. The particular age and grade were targeted per prevalence rates for internalizing

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

symptoms, and previous efforts focusing on tier 3 interventions provided for internalizing concerns in the community (BCSMHC, 2019). Student demographic information was collected, including age, grade, race/ethnicity, gender, and socio-economic status. Inclusionary criteria for students to participate in the intervention included emotional or internalizing risk on a universal socio-emotional/behavioral risk screener and participation in the general education setting.

The treatment and waitlist control groups were similar in age (14.59 vs. 14.18 years and gender (53.5% vs. 46.7%). The group condition did have a more observable difference across race/ethnicity. Despite both samples being majority racial/ethnic minority, a greater proportion of White students was observed in the treatment group (35.7% vs. 22.2%). A larger proportion of Hispanic/Latino students was found in the Control group (19.6% vs. 40%).

*Table 1. Demographic Characteristics of the N = 101 participants*

	Group	
	Treatment (n = 56)	Control (n = 45)
	Mean(SD)/Count (%)	Mean/Count (%)
Age	14.59 years	14.18 years
Gender		
<i>Female</i>	30 (53.6%)	21 (46.7%)
<i>Male</i>	23 (42.9%)	23 (51.1%)
<i>Nonbinary</i>	2 (3.6%)	1 (2.2%)
Race		
<i>African American</i>	11 (19.6%)	10 (22.2%)
<i>Asian American</i>	8 (14.3%)	5 (11.1%)
<i>Biracial</i>	5 (8.9%)	1 (2.2%)
<i>Hispanic</i>	11 (19.6%)	18 (40%)
<i>Native American</i>	1 (1.8%)	1 (2.2%)
<i>White</i>	20 (35.7%)	10 (22.2%)

## Measures

### Behavior Risk Screeners

#### *Patient Health Questionnaire 9-Item (PHQ-9).*

The 9-item Patient Health Questionnaire (PHQ-9; Johnson, 2002) is a self-report measure assessing depression severity. Response anchors range temporally from 0 (not at all) to 3 (nearly every day). Higher scores indicate greater severity of symptoms.

#### *Automatic Thoughts Questionnaire-Revised (ATQ-R).*

The ATQ is a 30-item instrument that measures the frequency of automatic negative statements about the self. Such statements play an essential role in developing, maintaining, and treating various psychopathologies, including depression. The ATQ taps four aspects of automatic thoughts: personal maladjustment and desire for change (PMDC), negative self-concepts and negative expectations (NSNE), low self-esteem (LSE), and Helplessness. Items are rated on the frequency of occurrence from “not at all” to “all the time.” Total scores are the sum of all 30 items. A high total score indicates a high level of automatic negative self-statements. The instrument has excellent internal consistency with an alpha coefficient of .97. Items significantly discriminated depressed from non-depressed subjects, the ATQ-R has good concurrent validity, correlating with two measures of depression, the Beck Depression Inventory, and the MMPI Depression scale (Hollon and Kendall, 1980).

#### *Distress Intolerance Index (DII).*

The DII is a 10-item self-report measure designed to assess the inability to tolerate negative states. Items are rated from 0 (very little) to 4 (very much) and are summed for a total score, with higher scores indicating greater distress intolerance. The DII has demonstrated strong internal consistency, reliability, and convergent and discriminant validity and correlates with DI's

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

behavioral measures (McHugh & Otto, 2011, 2012b). Internal consistency was excellent in the current sample ( $\alpha = .93$ ).

### *Direct Behavior Rating (DBR).*

Standard Direct Behavior Rating Single-Item Scales (DBR-SIS; Chafouleas et al., 2009) consists of single items that provide measurements of academic engagement, respectful behavior, or disruptive behavior. Teachers typically complete standard DBR forms, giving their impression of the percent-based duration a particular student exhibits the behaviors mentioned above. Drawing from previous research (Kilgus et al., 2018), the DBR-SIS used in the current study will use the anchor, *unhappy*. This prompt and its behavioral definition were chosen to include components of negative affectivity and low positive affect (Watson et al., 1995). Low positive affect has been shown to differentiate depression from other internalizing problems (Watson, Clark, & Carey, 1988), and emphasizing some specific components of depression in comparison to other internalizing problems will the evidence for the utility of the CBM in differentially treating depressed versus anxious elements of individuals internalizing problems.

### *Penn State Worry Questionnaire.*

The PSWQ has 16 items, and each item is rated on a scale from 1 ('not at all typical of me') to 5 ('very typical of me'). Eleven items are worded in the direction of pathological worry, with higher numbers indicating more worry (e.g., 'Once I start worrying, I cannot stop'). The remaining five items are worded to imply that worry is not a problem, with higher numbers indicating less worry (e.g., I never worry about anything). Summing the first 11 items with the final five reversed scored items yields a total score. Total scores with higher PSWQ scores reflect more significant levels of pathological worry. In general, the PSWQ is a psychometrically sound instrument that exhibits psychometric specificity in that elevated scores are more typically

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

associated with GAD than other anxiety disorder groups or non-anxious controls and is often used as an indicator of treatment change (Stöber and Bittencout, 1998). (PSWQ; Meyer, Miller, Metzger, & Bokrovec, 1990).

### **Intervention**

The Cognitive Bias Modification (CBM) program consists of 124 trials that separately assess benign and negative interpretations. The procedures are based on the Word Sentence Association Paradigm used in previous interpretation bias modification research (Beard et al., 2009). Each unique trial of the CBM consists of four individual steps. First, a fixation cross is presented on the screen for 500 milliseconds (ms). The fixation cross directs the students' attention toward the screen to alert them that a trial is starting. Next, an ambiguous sentence (e.g., "People laugh after something you said") appears and remains on the screen until participants press a response key to indicate they have finished reading the sentence. Third, a word representing either a benign interpretation (e.g., "funny") or a threat interpretation (e.g., "embarrassing") appears on the screen for 500ms. Fourth, students are prompted to press a key if they think the word and sentence were related or press a different key if they believe the word and sentence were unrelated. The word-sentence association pair paradigm is modified to fit the unique needs of the training. The participant's task remains to judge as quickly as possible whether the word is related to the sentence. Unlike the traditional version, the modified version cannot be considered a priming task, however (this is important to consider when comparing the results of these different versions). Instead, the participant's ambiguity resolution influences their subsequent judgment of the word. As with the standard version, the strengths of the modified version include flexibility of stimuli categories and the collection of both direct and indirect measures (participant responses and response times, respectively). The potential for

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

improvement rests in a potential limitation of the traditional version. It is unknown if participants read each sentence presented and compared it to the single words or whether they responded only to the single words (Beard & Amir, 2009). The CBM intervention provides two types of data for analysis: endorsement or accuracy rates (i.e., relatively “offline”) and reaction time data (i.e., “online”). The CBM results in two primary indices of interpretation. First, the percentage of benign interpretations endorsed, and second, the rate of threat interpretations endorsed. Four reaction time variables are measured response latency to (1) benign endorsement, (2) benign rejection, (3) threat endorsement, and (4) threat rejection. The training aspect of the CBM is introduced following the presentation of each four-step trial.

For students in the treatment condition, a positive affirmation was presented following each correct endorsement (e.g., correct benign endorsement). Positive affirmations were presented for 500ms and consisted of short positive phrases (“great job!”). An interpretation that follows a negative interpretation (e.g., threat endorsement) were followed with feedback that offered the student negative feedback (“incorrect”). Following a complete round of training (140 trials), the student saw a display screen with their positivity score (number of benign endorsements minus the number of threat endorsements). Students were then prompted to increase their positivity score in their next round of training. Students were trained four times weekly over a two-week period. This will amount to a total of eight training sessions across.

Recent research has focused on improving the integrity of computerized mental health services (Rodrigues-Villa et al.; Wisniewski et al., 2019). The experimental CBM intervention has been embedded in an app for this study. As more schools and students invest in technology to help students learn, more opportunities for app-based interventions are created, following a framework for evaluating mental health apps (Henson et al., 2019) and guidelines developed by

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

the American Psychological Association (APA). The principal investigator has built the app with five broad domains of consideration: Access and background, privacy and security, clinical foundation, usability, and data integration towards the therapeutic goal.

The first step of the APA model suggests that app developers ensure that participants have access to as much helpful background information to evaluate their choice in using it. A front-page detailed the app to provide transparency in the user process. The front-page details specific background characteristics of the CBM app, such as app ownership, funding sources or conflicts of interest, medical claims, operating system and accessibility to particular OS features, and the last update to the app.

The second step of the APA model encourages app developers to consider participant privacy and security of information. The principal investigator included the following information in the consent form: a clear and transparent privacy policy, declaration of data use and purpose, ensured participant anonymity, deletion of data following withdrawal from the study, where data is maintained, and the collection, transmission, and use of sensitive data. The principal investigator has planned to keep data as secure as possible. A participant identification number was used not just for blinding purposes in the RCT but also to protect participant privacy. Clients' identification numbers served as their passwords for admittance to the website or app. Participant responses were sent and stored to a secure cloud-based server to which only the principal investigator will have access. Study data was not saved on participant devices, so there will be no possibility for data to be downloaded from any location other than the online server.

The third step of the APA model requires researchers to evaluate any evidence for potential benefits from the app. While the base training stimulus included in the present study

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

has been used in prior studies and has shown promising effects in reducing internalizing symptoms (Beard et al., 2017), no previous research has tested the use of the current training stimuli set from an app-based platform or with the proposed age range of students at school. Any claims of potential participant benefit would be drawn solely from the utility of the training stimuli and not from claims of the experimental app's utility.

The fourth step of the APA model considers app usability. In considering the previous criteria, the app has been evaluated to offer security and privacy to the participant and some potential for benefit. The usability aspect of the app relies on the participant's subjective experience. To increase usability, the principal investigator has relied on recommendations from past research to make cognitive bias modification programs more engaging and user-friendly. The training features of the app will reward participants by activating different sensory modalities (visually through dynamic visual displays and auditory through pleasant and unpleasant sounds). Using other senses differs from traditional clinic-based cognitive bias training approaches that present positive or negative feedback in a single word shown in black text on a white background. The use of the 'positivity score' allows users to continue increasing their effort from training session to training session to increase their treatment outcomes. The final consideration was the ease of use. Both the web-browser and the smartphone app have an easy-to-understand display with clear labels to make navigation within the training program easy and efficient.

The final step of the APA model promotes data integration towards a common therapeutic goal. Although the purpose of the present study is to test the program's utility in school-aged children experimentally, the principal investigator has considered how to allow for training information to be disseminated to teachers, school-based service providers, or outside



## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

clinicians. The CBM app includes some data that will be used as an outcome towards positive behavior change, such as daily behavior ratings (DBR) of participant happiness. Caregivers may be interested in changes in the DBR data, and could be made available in future iterations of the CBM app.

The CBM app itself was created using the Unity game engine. The game engine can be used to create three-dimensional, two-dimensional, virtual reality, and augmented reality games and simulations, and other experiences. Industries have adopted the engine outside video gaming, such as film, automotive, architecture, engineering, and construction. The CBM app targeted PC, iOS, and Android operating systems. The principal investigator stored information remotely via a cloud-based server provided by Microsoft's PlayFab service.

### **Intervention Revision Process**

The intervention was reviewed and tested by a sample of four students prior to recruitment to the wider population. Beta-testing is a common practice in application development. It provides a chance for real users to engage with a product to uncover any issues before a general release. The THINK intervention app had been tested by the principle researcher, in the "alpha" stage of development. Four students were selected to participate in the "beta" testing stage to provide qualitative feedback and test adolescent response latencies and endorsement rates. Results of the beta-testing found that adolescent users found the original training stimuli (300 word-sentence pair presentations) as overly laborious and intensely boring. The average completion time for these students was 20-25 minutes. Feedback from beta-tester students encouraged to reduce the time required to complete a training session. Students provided qualitative feedback on the intervention. General feedback included likes/dislikes of the training app. Students reported that they liked many of the training scenarios and described them

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

as realistic or likely to be encountered by the average middle or high school student. Beta-test students also commented on the usability and aesthetic appearance of the app. Students provided useful feedback regarding integration of symptom related questions into the intervention app. Rather than using a Qualtrics link to complete post-intervention measures, the DBR item was integrated into the training app and DBR ratings would appear along with interpretation indices data.

### **Procedures**

All recruitment and study procedures were approved by the University of Missouri Institutional Review Board to protect human subjects, and participation in the study was voluntary.

### **Recruitment and Screening**

Recruitment followed two paths, School recruitment, and Community Recruitment. The goal of recruitment was to identify students who had symptoms of anxiety and depression that were elevated above community norms. The CBM training app was referred to as ‘Project THINK- Training Helpful Interpretations In Kids’ on all recruitment materials. Due to the original conception of the study having an interest in training students’ interpretations within the context of school, teachers were contacted regarding their interest in having students participate in the training program. Three teachers from local area schools agreed to assist with recruitment by allowing class time for students to complete the 10-minute training program once per day. Teachers ensured investigators their classrooms did not have students meeting the exclusion criteria (e.g., students with intellectual disabilities or a reading level below 5<sup>th</sup>-grade abilities). Community recruitment was advertised through QR code flyers sent to community families via

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Parent-Teacher Association and county parks and recreation email listservs. Youth signed an assent to participate before beginning the assessment.

After receiving informed youth assent, participants were randomized into one of two conditions: (1) CBM active intervention or (2) waitlist control group. Data for this study were collected across multiple time points. Youths completed pre-treatment measures of negative cognition and internalizing symptoms online using Qualtrics survey software. Participants randomized into the treatment condition completed post-intervention measures and provided qualitative feedback on their intervention experience. The researchers collected post-intervention measures from participants under two circumstances. First, researchers provided participants with the post-intervention questionnaires if they completed a full training set (i.e., four consecutive sessions across a two-week training period, for a total of eight training sessions). To protect against participant attrition due to a long period in between completion of training and the post-intervention measures, the measures were also provided if three consecutive sessions were missed. Participants were given three days to complete the post-intervention questionnaire. Waitlist control condition youths completed another round of the same survey questions before being sent their THINK app access links. Children were offered the opportunity to retain full use of the THINK app following completion of the study.

After completing the pre-intervention measures, participants assigned to the CBM active intervention were provided with a link to the intervention website and an option to download the intervention app for completion on a smartphone, tablet, or personal computer. Youth participants completed a round of training each day for the two-week training period. Prompts were delivered in emails sent to the provided email address used to download the THINK app.

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Participant training data was collected and stored in an encrypted server that only the principal investigator could access.

### **Performance-Based Data**

Before data analyses, data were screened and cleaned to eliminate errors, which is typical practice in adult and youth cognitive processing studies (e.g., Beard & Amir, 2008, Rozenman, Weersing, & Amir, 2011.).

### ***Interpretation Indices***

Response latencies less than 200 ms were excluded from analyses (Beard & Amir, 2009). Latencies faster than 200 ms could be due to a lapse in focus or an indication of low effort in the task. Two youths who registered a single training session were identified as having response latencies faster than 200 ms and were excluded from the analyses.

Mean interpretation bias scores were derived for each participant as the percentage of positive interpretations possible (from trials when stimuli paired with ambiguous sentences produced positive endorsement and threat rejections) and negative interpretations possible (from trials when stimuli paired with ambiguous sentences produced positive rejections and threat endorsement). Youth reaction times on the interpretation training task were also measured to examine the relatedness of positive and negative interpretations. This resulted in four sets of reaction times (a) endorsement of positive interpretations, (b) rejection of positive interpretations, (c) endorsement of negative interpretations, and (d) rejection of negative interpretations.

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

### **Process Analyses**

The interpretation components (e.g., threat valence judgments and response speed) of the interpretation training program were examined. Mean reaction times for interpretations and endorsement rates were entered into a repeated-measures ANOVA to review changes in response style over time. Reaction times and endorsement rates were also entered into a growth model to examine changes in response style over time more robustly.

### **Data Analysis**

#### **Benign/Threat-Endorsement/Rejection**

To ascertain changes in interpretation bias, researchers will calculate the number of benign endorsements, benign rejections, threat endorsements, and threat rejections per training period. Endorsement/rejection rates will be averaged for each training period and used to identify improvements in adopting an increased overall positive interpretation.

#### **Reaction Time**

Reaction times were calculated for every single trial within each session. Reaction times were averaged for each of the four endorsement/rejection categories. The lead researchers calculated the rate of change at which participants endorsed benign interpretations and rejected threat interpretations.

#### **Linear Regression**

Internalizing symptoms served as a secondary outcome. Generalized linear model regression was used to model dichotomous outcomes (i.e., cut scores). Predictors included student demographic data and internalizing symptoms as fixed effects

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

### **Latent Profile Analysis**

To address research question 3, an unconditional latent profile analysis was conducted to determine if distinct classes of internalizing students could be identified by self-report. Possible profiles may be typified by treatment response type (e.g., increased positive endorsement/decreased threat rejection, increased positive endorsement only, decreased threat rejection only, no change in endorsement/rejection pattern). Model fit was estimated using the Bayesian Information Criteria (BIC), Bootstrap likelihood ratio test (BLRT), and entropy values. Latent class regressions were then used to determine if pre-intervention internalizing score severity predicted adoption of the most positive change in interpretation bias (e.g., increased positive endorsement/decreased threat rejection).

### **Growth Mixture Modeling (changes in reaction time as a function of training period)**

To model the changes in endorsement rate and reaction time over the training series, growth modeling techniques were used to estimate the trajectory of positive interpretation adoption. Growth curve modeling is a method for identifying multiple unobserved subpopulations, describing longitudinal change within each unobserved sub-population, and examining differences in change among unobserved subpopulations. The growth mixture model will draw from the classes obtained in the latent profile analysis and will look to identify differences in trajectories of symptom reduction (DBR data) and online (reaction) as well as offline (endorsement) interpretation data.

## CHAPTER 4: RESULTS

### Analyses

#### Tests of Randomization

To determine whether the randomization of groups was successful, an independent samples t-test was conducted using each baseline measure of participant symptoms and functioning. The baseline measures, including the ATQ-N, DII-Y, PHQ-9, PSWQ, and STAI-C, were compared to ensure equivalency for the intervention and control groups. Group equivalence was assessed using Levene's Test for Equality of Variances and a t-test for Equality of Means. Non-statistically significant results between the intervention and control group on the baseline measures would indicate that the group equivalence was achieved following random assignment. Non-statistically significant findings would fail to reject the null hypothesis that there is a difference between groups' scores. Levene's Test for Homogeneity of Variances failed to reject the null hypothesis for four of the five baseline measures. The ATQ-N outcome was significant, rejecting the null hypothesis of equal variance across treatment conditions. Due to its robustness to unequal variances, Welch's Test for Unequal Variances investigated the baseline ATQ-N measure. Welch's Test on the ATQ-N yielded a significant difference between the treatment and control groups, rejecting the null hypothesis of equality between groups. The t-test for equality of means indicated that treatment and control groups were equivalent across all measures except for the Automatic Thoughts Questionnaire-Negative ( $p < .05$ ). The ATQ-N of the treatment group was higher ( $M = 65.05$ ,  $SD = 26.35$ ) than that of the control group ( $M = 60.95$ ,  $SD = 18.21$ ). The normality of the ATQ-N will be reviewed further.

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

### **Data Missingness**

A missing value analysis (MVA) was conducted on demographic and baseline symptom indicator variables. Due to missed or skipped items, two participants produced incomplete baseline measurements on all variables, except for the DII-Y. Overall, this led to 2.02% missing baseline data. No post-intervention symptom indicator data was missing.

Little's Missing Completely at Random (MCAR) test was conducted using IBM SPSS 25 to examine the pattern of missing data across all participants. The analysis reported that the missing values reported from the MVA were likely to be missing completely at random,  $\chi^2(24) = 21.95, p < .05$ . Listwise deletion was used due to the small number of missing cases ( $n = 2$ ).

### **Assumption Testing**

The appropriateness of the data for the analysis plan was reviewed by testing the assumptions of the data for paired samples t-tests, repeated measures ANOVA, and multivariate regression. This included a review of homogeneity of variance (HOV), independence of observations, normality of data, linearity, auto-correlation, and homoscedasticity.

Homogeneity of Variance was previously discussed following the independent samples t-test between treatment and control group baseline scores.

Normality of the data was examined using measures of skewness, kurtosis, and visual inspection of Q-Q plots. The five symptom indicator variables and post-session Direct Behavior Rating (DBR) scale were normally distributed after identifying that skewness and kurtosis statistic values fell between 0 and 1. Visual inspection of Q-Q plots supported that the variables followed a normal distribution.



## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Multicollinearity was tested by examining correlation matrices, tolerance measures, and the Variance Inflation Factor. A correlation matrix of Pearson's Bivariate Correlations among all independent variables yielded correlation coefficients smaller than 1.0. Tolerance was calculated by investigating regression output. Tolerance is defined as  $T = 1 - R^2$ . With  $T < 0.1$  indicating multicollinearity, the regression analysis results in this study revealed adequate tolerance. The Variance Inflation Factor of the linear regression is defined as  $1/T$ . The VIFs obtained from the regression analysis in this study met acceptable standards (e.g.,  $VIF < 5$ ).

Homoscedacity was assessed using the Breusch-Pagan test following regression analyses. The Breusch-Pagan test was conducted in R version 4.0.3 using the `lmtest` package. The results of the Breusch-Pagan yielded a significant p-value ( $p < 0.5$ ), allowing for the rejection of the null hypothesis, meaning heteroscedasticity is present in the data. Due to heteroscedasticity, it was decided to use generalized linear models for regression analyses.

### Preliminary Analyses

*Table 2. Treatment Frequency and Setting*

	Group
	Treatment (n = 56)
	Count (%)
Sessions Completed	
1	12 (21.4%)
2	8 (14.3%)
3	6 (10.7%)
4	7 (12.5%)
5	3 (5.4%)
6	9 (16.1%)
7	11 (19.6%)
Training Location	
<i>Predominantly School</i>	15 (26.8%)
<i>Predominantly Home</i>	41 (73.2%)

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Table 1 reports correlations between questionnaire symptom measures with each other at the baseline time point. The baseline correlations show correlations across all measures, significant to  $p < .001$ . The correlation coefficients all show medium to large effects for baseline questionnaire relationships. A high degree of correlation can be expected, given that negative automatic thoughts, distress intolerance, and worry are related to symptoms of anxiety and depression (Dear et al., 2010, Mahali et al., 2020, Ozdel et al., 2014). Table 4 presents the mean scores for participants on questionnaire symptom measures of negative thinking, depression, and anxiety at each time point.

*Table 3. Baseline Questionnaire Correlations*

		ATQ	DII	PHQ	PSWQ	STAI
ATQ	Pearson Correlation	1	.580***	.594***	.751***	.644***
	Sig (2-tailed)		< .001	< .001	< .001	< .001
DII	Pearson Correlation	.580***	1	.487***	.641***	.570***
	Sig (2-tailed)	< .001		< .001	< .001	< .001
PHQ	Pearson Correlation	.594***	.487***	1	.418***	.424***
	Sig (2-tailed)	< .001	< .001		< .001	< .001
PSWQ	Pearson Correlation	.751***	.641***	.418***	1	.712***
	Sig (2-tailed)	< .001	< .001	< .001		< .001
STAI	Pearson Correlation	.644***	.570***	.424***	.712***	1
	Sig (2-tailed)	< .001	< .001	< .001	< .001	< .001

Note. \*\*\* Correlation is significant at the .001 level (2-tailed). ATQ – Automatic Thoughts Questionnaire; DII = Distress Intolerance Index, Youth Version; PHQ = Patient Health Questionnaire-9; PSWQ = Penn State Worry Questionnaire; STAI = State Trait Anxiety Inventory-6.

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Table 4. Internalizing Symptom Pre-Post Measures

	Treatment (n = 56)		Control (n = 45)	
	Time Point			
	Baseline	Post-Intervention	Baseline	Post-Intervention
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
ATQ-N	65.05 (26.35)	59.80 (24.38)	59.84 (18.38)	60.04 (17.88)
DII-Y	23.08 (8.48)	22.14 (9.39)	20.68 (9.30)	20.24 (8.47)
PHQ	14.64 (6.02)	13.48 (5.22)	13.73 (5.25)	13.66 (5.08)
PSWQ	49.48 (14.85)	47.01 (14.12)	43.35 (13.17)	43.62 (13.36)
STAI-C	12.98 (4.48)	12.41 (4.15)	11.28 (3.78)	11.44 (3.46)

**Latent Profile Analyses**

As was seen in the correlation of baseline symptom questionnaires, participants’ negative thinking, distress, worry, and internalizing symptoms were strongly related. Latent profile analysis was conducted with baseline and post-intervention symptom questionnaires to identify if a predictable response pattern could be observed within participants. The most common methods for deciding on the number of classes fall into three categories: information-theoretic methods, likelihood ratio statistical test methods, and entropy-based criteria. Akaike’s Information Criterion (AIC; Akaike, 1973, 1987) and Bayesian Information Criterion (BIC; Schwarz, 1978) are the two original and most commonly used information-theoretic methods for model selections. The AIC and BIC are based on the maximum likelihood estimates of the model parameters for selecting the most economical and correct model.

The second category of methods for evaluating model fit in latent class models involves likelihood ratio (LR) statistic tests. These tests compare the relative fit of two models that differ by parameter restrictions. The bootstrap likelihood ratio test (BLRT) derived by McCutcheon (1987) and McLachlan and Peel (2000) uses a bootstrap resampling method to approximate the p-value of the generalized likelihood ratio test comparing the K0-class mixture model with the K

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

-1-class mixture model. With BLRT, a small probability value (e.g.,  $p < .05$ ) indicates that the K0-class model provides a significantly better fit to the observed data than the K -1-class model.

The final category of the fit tests used to assess latent class models is the measure of entropy. The entropy index is based on the uncertainty of classification (see Celeux & Soromenho, 1996). Essentially classification uncertainty is assessed at the individual level by the posterior probability; entropy then is a measure of aggregated classification uncertainty. The uncertainty of classification is high when the posterior probabilities are very similar across classes. The normalized version of entropy, which scales to the interval [0, 1], is commonly used as a model selection criteria indicating the level of separation between classes. A higher value of normalized entropy represents a better fit; values  $> 0.80$  indicate that the latent classes are highly discriminating (Muthén & Muthén, 2007).

Based on the fit indices for Latent Profile Analyses conducted with baseline symptom measures, two classes best described the participants' response patterns. Across symptom measures, participants either fell into a “high” internalizing group, with higher mean scores across all five internalizing indicator variables, or a “low” group, with lower mean scores.

*Table 5. Model Fit Indices for 1-5 Class Solutions of Baseline Youth Internalizing Indicators*

Class	AIC	BIC	Entropy	BLRT
1	809.56	829.81	1.00	0.00
2	617.14	709.55	0.97	0.01
3	667.78	712.34	0.85	0.01
4	666.52	723.23	0.92	0.21
5	668.51	737.37	0.81	0.38

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; BLRT = Bootstrap Likelihood Ratio Test.

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Fit indices for post-intervention symptom questionnaires did not show the same two classes emerge as the best fitting solution. Taking information-theoretic indices, likelihood ratio test, and the entropy index into account, a two-class and four-class solution appeared the best fitting. The two-class model had the same structure seen in the baseline symptom questionnaire latent profile analysis. The four-class model was characterized by a group that had high significantly higher ATQ-N, and PSWQ mean scores compared to what was observed in the baseline questionnaires. The group was labeled as the “high internalizing” group. A second group had the lowest mean scores across every measure and comparatively lower scores than what was observed in the baseline questionnaires. This group was labeled as the “low internalizing group. The remaining two groups shared similarities to the two classes observed in the baseline LPA. These classes were labeled as “high medium” and “low medium.” The utility of creating the LPA Internalizing class variables was intended to provide another covariate that could be run in growth curve models or generalized linear regression models.

*Table 6. Model Fit Indices for 1-5 Class Solutions of Post-Intervention Youth Internalizing Indicators*

Class	AIC	BIC	Entropy	BLRT
1	2059.48	2079.74	1.00	0.00
2	1966.19	1998.59	0.88	0.01
3	1959.84	2004.40	0.82	0.05
4	1936.38	1993.09	0.89	0.01
5	1936.87	2005.73	.92	.26

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; BLRT = Bootstrap Likelihood Ratio Test.

### **Process Analyses**

The primary goal of the current study was to investigate whether the percentage of interpretations and reaction time indices could be trained towards a faster generation of positive

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

interpretations. To understand the training process, repeated measures ANOVAs were used to measure changes in the percentage of positive and negative interpretations that participants made and changes in response latency for positive and negative interpretations.

### **Primary Outcome Analyses**

#### ***Repeated Measures ANOVA for Interpretation Indices***

A repeated-measures ANOVA was performed to compare the effect of training on response latency of positive interpretations. There was a statistically significant difference in response latency for positive interpretations between at least two training sessions ( $F = 96.02$ ,  $p < .001$ ). Using Post-hoc testing, Least Significant Differences showed significant mean differences in mean response latency of positive interpretations only between sessions 2 and 3 ( $MD = .584$ ,  $p < .05$ ). Wilks' lambda, a measure of how well each function separates cases into groups, returned a nonsignificant value ( $.315$ ,  $p > .05$ ), indicating that time alone did not significantly decrease response latency.

A repeated-measures ANOVA was performed to compare the effect of training on response latency of negative interpretations. There was a statistically significant difference in response latency for negative interpretations between at least two training sessions ( $F = 43.22$ ,  $p < .001$ ). Using Post-hoc testing, Least Significant Differences did not reveal any significant session-to-session changes in response latency to negative interpretations. Wilks' lambda, a measure of how well each function separates cases into groups, returned a nonsignificant value ( $.315$ ,  $p > .05$ ), indicating that time alone did not significantly change response latency.

A repeated-measures ANOVA was performed to compare the effect of training on the endorsement of positive interpretations. There was a statistically significant difference in

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

response latency for positive interpretations between at least two training sessions ( $F = 409.27$ ,  $p < .001$ ). Using Post-hoc testing, Least Significant Differences showed significant mean differences in mean response latency of positive interpretations between sessions 1 and 2 ( $MD = -196$ ,  $p < .05$ ), sessions 3 and 4 ( $MD = .033$ ,  $p < .05$ ), sessions 4 and 5 ( $MD = .043$ ,  $p < .05$ ), and sessions 5 and 6 ( $MD = -.10$ ,  $p < .05$ ). Wilks' lambda, a measure of how well each function separates cases into groups, returned a nonsignificant value ( $.068$ ,  $p < .05$ ), indicating that time alone did significantly increase endorsement of positive interpretations.

A repeated-measures ANOVA was performed to compare the effect of training on the endorsement of negative interpretations. There was a statistically significant difference in response latency for negative interpretations between at least two training sessions ( $F = 28.67$ ,  $p < .001$ ). Using Post-hoc testing, Least Significant Differences showed significant mean differences in mean response latency of negative interpretations between sessions 1 and 2 ( $MD = -166$ ,  $p < .01$ ), sessions 3 and 4 ( $MD = 0.030$ ,  $p < .05$ ), sessions 4 and 5 ( $MD = -.046$ ,  $p < .01$ ), and sessions 5 and 6 ( $MD = -.10$ ,  $p < .05$ ). Wilks' lambda, a measure of how well each function separates cases into groups, returned a nonsignificant value ( $.110$ ,  $p < .05$ ), indicating that time alone did significantly increase endorsement of negative interpretations.

Using the Repeated Measures ANOVA to evaluate training on interpretation indices related to two limitations of the current study. Because such a small number of participants ( $n = 11$ ) completed the entire training duration that was proposed, the data contains many missing values for uncompleted session time points. As Repeated Measures ANOVA can only use listwise deletion, using the test statistic substantially reduces power and introduces the potential for bias. Additionally, because some participants did not uniformly engage with the THINK app on a day-to-day basis at the same time, Repeated Measures can only treat time as a categorical

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

factor rather than a continuous variable, such as a passing day. To address these limitations, it was decided to use growth curve analysis to provide a more robust estimate of training effects.

### *Growth Curve Analysis*

As mentioned above, restrictions of the dataset reduce the discriminatory power of the Repeated Measures ANOVA. Thus, a Growth Curve analysis using the multilevel modeling facilities in SPSS and R was produced for each indicator of interpretation bias. We began by creating a model with session time as a predictor of linear growth in latency of positive endorsements.

$$Y_{ti} = \beta_{00} + \beta_{10}T_{ti} + \mu_0i + \varepsilon_{ti}$$

The intercept of the model is interpreted as the grand mean of person-specific means with the fixed effects estimate  $\beta_{00} = 1.72$ ,  $p < .001$ . This intercept can be interpreted as the predicted latency to endorse a positive interpretation (averaged across time) for all persons 'i'. The estimate of fixed effects for the time parameter is also significant  $\beta_{10}T_{ti} = -.138$ ,  $p < .001$ , indicating that response latency will reduce by a fraction of a second for every session on average. The variance of residuals at level 1 (i.e., within persons across time) was significant  $\sigma_{\varepsilon_{ti}}^2 = .111$  ( $p < .001$ ). The variance of the means/intercepts at level 2 (i.e., between-student, intercept variance) was significant  $\sigma_{\mu_{ti}}^2 = .555$  ( $p < .001$ ). Lastly, estimates of covariance parameters provided a glimpse at significant estimates session by session. Significantly faster positive endorsement times were observed through session 6.



INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Table 7. Estimates of Covariance Parameters for Positive Endorsement Time Growth Curve

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Con. Interval	
					Lower Bound	Upper Bound
Time 1	1.687	.328	5.184	<.001*	1.153	2.469
Time 2	.865	.188	4.599	<.001*	.565	1.324
Time 3	.286	.070	4.056	<.001*	.176	.463
Time 4	.063	.019	3.385	<.001*	.035	.112
Time 5	.018	.009	2.091	.037*	.007	.047
Time 6	.014	.008	1.844	.065	.005	.042
Time 7	.029	.016	1.839	.066	.010	.086
Intercept Variance	.021	.008	2.436	.015	.009	.046

<sup>a</sup> Dependent Variable: Positive Endorsement Time

Another growth curve was modeled, using the same equation listed above, for changes in response latency for negative endorsements. The intercept of the model is interpreted as the grand mean of person-specific means with the fixed effects estimate  $\beta_{00} = 2.04$ ,  $p < .001$ . This intercept can be interpreted as the predicted latency to endorse a negative interpretation (averaged across time) for all persons ‘i’. The estimate of fixed effects for the time parameter was also significant  $\beta_{10}T_{ti} = -.194$ ,  $p < .001$ , indicating that response latency will reduce by a fraction of a second for every session on average. The variance of residuals at level 1 (i.e., within persons across time) was significant  $\sigma_{\varepsilon ti}^2 = .126$  ( $p < .001$ ). The variance of the means/intercepts at level 2 (i.e., between-student, intercept variance) was significant  $\sigma_{\mu ti}^2 = .401$  ( $p < .001$ ). Lastly, estimates of covariance parameters provided a glimpse at significant estimates session by session. Significantly faster positive endorsement times were observed at sessions 1 through 6.

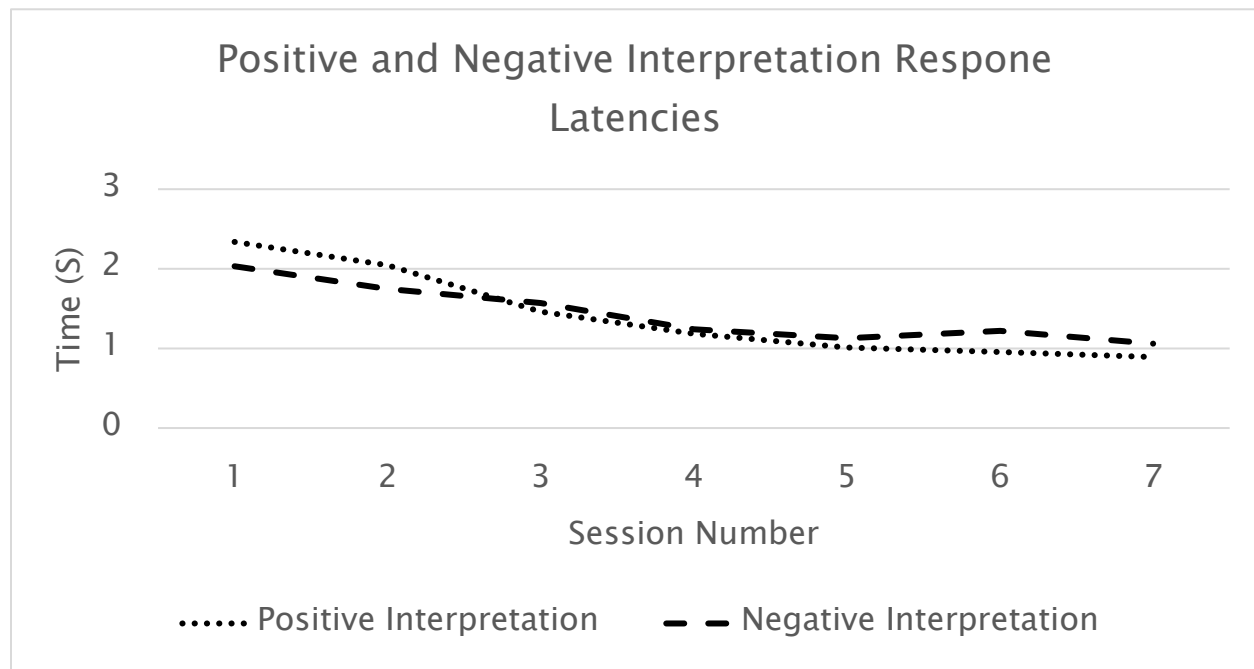
INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Table 8. Estimates of Covariance Parameters for Negative Endorsement Time Growth Curve

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Con. Interval	
					Lower Bound	Upper Bound
Time 1	.260	.074	3.506	<.001*	.148	.454
Time 2	.127	.042	2.994	.003*	.062	.244
Time 3	.083	.028	2.918	.004*	.042	.162
Time 4	.183	.056	3.272	.001*	.101	.333
Time 5	.053	.024	2.161	.031*	.021	.131
Time 6	.077	.032	2.423	.015*	.034	.172
Time 7	.020	.037	.537	.591	.001	.774
Intercept Variance	.334	.101	3.317	<.001	.185	.603

<sup>a</sup> Dependent Variable: Negative Endorsement Time

Table 9. Graph of the change in response latencies for positive and negative interpretations.



Next, growth curves were used to investigate changes in the positive and negative endorsement rates. Using the same equation listed above, a growth curve model was produced to estimate the average rate of positive endorsement across session times. The intercept of the model is interpreted as the grand mean of person-specific means with the fixed effects estimate

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

$\beta_{00} = .74$ ,  $p < .001$ . This intercept can be interpreted as the predicted endorsement of positive stimuli (averaged across time) for all persons ‘i’. The estimate of fixed effects for the time parameter was also significant  $\beta_{10}T_{ti} = .026$ ,  $p < .001$ , indicating that positive endorsement increases for every session on average. Lastly, estimates of covariance parameters provided a glimpse at significant estimates session by session. Significantly higher positive endorsement rates were observed in sessions 1 through 5.

Table 10. Estimates of Covariance Parameters for Positive Endorsement Rate Growth Curve

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Con. Interval		
					Lower Bound	Upper Bound	
Time 1	.043	.009	4.828	<.001*	.029	.064	
Time 2	.006	.002	3.549	<.001*	.004	.011	
Time 3	.001	.001	2.205	.027*	.001	.003	
Time 4	.001	.001	2.285	.022*	.000	.003	
Time 5	.003	.001	2.665	.008*	.001	.006	
Time 6	.001	.001	1.814	.070	.000	.004	
Time 7	.000	.001	.336	.737	7.508E-7	.087	
Intercept	Variance	.013	.003	3.622	<.001	.007	.021
	Time	.000	.000	2.440	.015	.000	.001

<sup>a</sup> Dependent Variable: Positive Endorsement Rate

Finally, using the same equation listed above, a growth curve model was produced to estimate the average rate of negative endorsement across session times. The intercept of the model is interpreted as the grand mean of person-specific means with the fixed effects estimate  $\beta_{00} = .254$ ,  $p < .001$ . This intercept can be interpreted as the predicted rate of negative interpretation (averaged across time) for all persons ‘i’. The estimate of fixed effects for the time parameter was also significant  $\beta_{10}T_{ti} = -.027$ ,  $p < .001$ , indicating that negative endorsement decreases for every session on average. Lastly, estimates of covariance parameters provided a

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

glimpse at significant estimates session by session. Significantly fewer negative endorsement rates were observed across all sessions.

*Table 11. Estimates of Covariance Parameters for Positive Negative Rate Growth Curve*

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Con. Interval		
					Lower Bound	Upper Bound	
Time 1	.029	.006	4.666	<.001*	.019	.044	
Time 2	.005	.001	3.362	<.001*	.003	.008	
Time 3	.001	.001	2.393	.017*	.001	.003	
Time 4	.001	.000	2.633	.008*	.001	.003	
Time 5	.003	.001	3.046	.002*	.002	.006	
Time 6	.001	.001	2.064	.039*	.000	.003	
Time 7	9.67E-10	.000					
Intercept	Variance	.011	.003	3.558	<.001	.007	.020
	Time	.000	.000	2.730	.006	.000	.001

<sup>a</sup> Dependent Variable: Negative Endorsement Rate

SPSS models for the four interpretation bias indices were recreated using the R software program with the ‘lmer’ and ‘growth’ functions to confirm the initial results.

### Secondary Outcome Analyses

The study's secondary goal was to identify if indicators of internalizing symptoms were reduced in the presence of interpretation bias training. A paired differences t-test was used to measure mean scores between the treatment group's baseline and post-intervention time points and two successive baseline time points for the waitlist control group. No significant differences were observed across time points for the control group. Three measures did show significant reductions in mean scores. The ATQ-N, PHQ-9, and PSWQ post-intervention measures were significantly lower than their baseline counterparts. Effect sizes, as indicated by Cohen's D, for differences on the ATQ-N, PHQ-9, and PSWQ were .281, .448, and .212 respectively.

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Table 12. Paired Differences t-test for Baseline and Post-Intervention Measures

Condition	Paired Differences					Significance		
	Mean	Std. Deviation	Std. Error	T	df	One-Sided p	Two-Sided p	
Control	ATQ Δ	-.08889	3.1465	.46907	-.190	44	.425	.851
	DII-Y Δ	.44364	2.0949	.31230	1.423	44	.081	.162
	PSWQ Δ	-.20000	1.8659	.27816	-.719	44	.238	.476
	PHQ Δ	.32110	6.1784	.92103	.338	44	.369	.737
	STAI Δ	.31111	1.4588	.21747	1.431	44	.080	.160
Treatment	ATQ Δ	5.2500	18.652	2.4923	2.106	55	.020	.040*
	DII-Y Δ	.94643	6.1921	.82746	1.144	55	.129	.258
	PSWQ Δ	1.1607	2.5921	.34639	3.351	55	<.001	.001*
	PHQ Δ	2.4642	5.9052	.78912	3.123	55	.001	.003*
	STAI Δ	.28571	1.3445	.17967	1.590	55	.059	.118

Note. Δ = change in Mean score of Post-Intervention Measure-Baseline Measure.

A One-way ANCOVA was conducted to determine a statistically significant difference between treatment conditions on the internalizing indicator variables, controlling for baseline scores. Of the five measures, the only treatment effect was found for the PHQ. There was a significant effect of treatment on the PHQ scores after controlling for baseline scores, ( $F = 6.941$ ,  $p < .05$ ). The effect size for the PHQ score (partial eta squared = .066) indicates a medium effect size.

Table 13. ANCOVA for Pre/Post Internalizing Indicators

Variable	F	Sig.	eta <sub>p</sub> <sup>2</sup>
ATQ	2.77	.098	.028
DII	.038	.847	.000
PHQ	6.941	.010*	.066
PSWQ	1.742	.190	.017
STAI	.439	.509	.004

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

**DBR**

Following the completion of each session, participants were prompted to complete a Direct Behavior Rating Single-Item Scale (DBR-SIS). The “Unhappy” rating scale is a 10-point scale that measures participant behavior following an observation. Participants made self-referential assessments about how unhappy they felt following the completion of a training session. A growth curve model was produced to estimate average DBR Unhappy ratings across sessions. The intercept of the model is interpreted as the grand mean of person-specific means with the fixed effects estimate  $\beta_{00} = 5.72, p < .001$ . This intercept can be interpreted as the predicted DBR score (averaged across time) for all persons ‘i’. The estimate of fixed effects for the time parameter was also significant  $\beta_{10}T_{ti} = -.992, p < .001$ , indicating that DBR scores decreased by almost one unit for every session on average. Lastly, estimates of covariance parameters provided a glimpse at significant estimates session by session. DBR scores decreased to a significant degree across the four of the seven time points.

*Table 13. Estimates of Covariance Parameters for DBR Unhappy Growth Curve*

Parameter	Estimate	Std. Error	Wald Z	Sig.	95% Con. Interval		
					Lower Bound	Upper Bound	
Time 1	1.539	.528	2.916	.004*	.786	3.015	
Time 2	.337	.194	1.737	.082	.109	1.041	
Time 3	.681	.208	3.278	.001*	.375	1.239	
Time 4	.409	.147	2.782	.005*	.202	.827	
Time 5	.200	.090	2.231	.026*	.083	.482	
Time 6	.117	.107	.1094	.274	.020	.703	
Time 7	.274	.189	1.447	.148	.071	1.061	
Intercept	Variance	.3.616	.788	4.590	<.001	2.360	5.542
+ Time							

<sup>a</sup> Dependent Variable: DBR-Unhappy Ratings

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Beyond the growth modeling to estimate changes in DBR scores, researchers also conducted generalized linear regression models, using the binomial logit link to predict post-intervention depressive symptom concern. We created a generalized linear regression model using dichotomous post-intervention PHQ-9 cut scores as the dependent variable. Cut scores were used to predict students who fell into ‘in-risk’ vs. ‘out-of-risk’. Demographic variables and other post-intervention measures were included as predictors while controlling for baseline symptom measures. Treatment was not identified as a significant predictor of differentiating between youth in the ‘in-risk’ vs. ‘out-of-risk’ categories.

### **Tertiary Outcome Analyses**

To test the third research question, to what extent does symptom severity, impact training outcome. We completed a growth curve model using the lmer package in R 4.0.3. We specified the model :

$$Y_{ti} = \beta_{00} + \beta_{01}Class_i + \beta_{02}NegRes_i + \mu_{0i}) + (\beta_{10}Class_i + \beta_{11}NegRes_i + \mu_{0i}) \beta T_{ti} + \varepsilon_{ti}$$

Class represents baseline symptom response profiles generated from the Latent Profile Analyses of the ATQ-N, DII-Y, PHQ, PSWQ, and STAI. LPA class serves as a predictor in this model. With class, a second predictor, negative endorsement rate, was chosen to measure ‘online’ process bias.

INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Table 14. Estimates of Fixed Effects – DBR Unhappy Scale Predicted by LPA Class and Negative Endorsement

Parameter	Estimate	Std. Error	df	T	Sig.
Intercept	10.095	1.261	101.166	8.007	<.001*
Time	-1.144	.219	17.198	-5.397	<.001*
LPA Class	-3.771	.819	96.686	-4.601	<.001*
Negative Endorsement	1.478	2.268	103.362	.652	.516
Time*LPA Class	.377	.139	14.870	2.713	.016*
Time*Negative Endorsement	.555	.293	49.580	1.896	.064

The intercept ( $\beta_{00} = 10.095$ ) for the model is the predicted DBR Unhappy score for the participants in session one who are in the ‘low’ internalizing LPA profile and has average negative endorsement rates. The slope for time ( $\beta_{T_{ti}} = 1.144, p < .001$ ), indicates a predicted decrease in DBR Unhappy scores of 1.144 with each passing session for participants in the ‘low’ internalizing LPA class. The slope for LPA Class, ( $\beta_{01} = -3.771, p < .001$ ) indicates that participants in the ‘high’ internalizing LPA profile were predicted to score 3.771 DBR units lower than participants in the ‘low’ internalizing profile. The slope for negative endorsement ( $\beta_{10} = 1.478, p = .516$ ) did not significantly affect participants' DBR scores changing over time. The cross-level interaction,  $\beta_{11} = .377, p = .016$ ) between time and LPA Class was significant. The regression slope for the interaction term indicates that for every one session increase, the difference between ‘high’ internalizers and ‘low’ internalizers increases. In session 1, the ‘low’ internalizing profile participants were predicted to score 3.77 DBR units lower (indicating more happiness, computed by  $-3.77 + (0 * .377) = -3.77$ ) than those in the ‘high’ internalizing group. In the second session, the ‘low’ internalizing group would score  $(-3.77 + (1 * .377) = -1.42)$ , 1.42 units less than the ‘high’ internalizing group. This formula continues across the seven sessions.



**Qualitative Acceptance of Intervention**

After completing seven training sessions or after three consecutive days of not using the THINK app, the principal investigator sent a short survey to participants inquiring about their experiences with the training program. Similar questions were used in a prior study of cognitive bias modification (Lisk et al., 2018). Participants were asked, “Were there any aspects of the program that you found particularly helpful/unhelpful,” “Were there any aspects of the program that you particularly liked/disliked.” The responses below are a collation of the surveys received at the analysis time.

*Table 15. Qualitative Feedback from Participants Regarding Their Training Experience*

Participant	Feedback
1	It took a lot longer than I thought. I was glad that it showed my progress on the screen.
2	This was mind-numbing.
3	I liked the sound that the app made when I got an answer right but it got old after a while.
4	I liked competing with my friends in class. I have the high score in our group.
5	Some of the sentences didn’t apply to me. I don’t use Facebook, I’m too young to get rejected for a job interview, and I don’t worry about having tumors.
6	It’s too many questions. It took me 20 minutes to play one round. Have fewer things show up on the screen.
7	Some of these situations really do happen! I worry all the time about doing something stupid in front of my class and getting laughed at. So, I liked that some of the situations really happen to people my age.
8	I think my happiness score went down after I played, it was kind of calming just to zone out for a couple minutes a day and play the THINK game.
9	I think if it was more like a real game, I would play more often.

## CHAPTER 5: DISCUSSION

### Primary Findings

The study explored a digital cognitive bias modification program designed to train youth and adolescent interpretations toward positive endorsement of ambiguous scenarios. Although Interpretation Bias has been extensively studied in adult anxiety and depression research, youth literature is still in the discovery stage of development. Only two investigations have assessed the utility of offering interpretation modification programs to students as they navigate the social context of school, which can provide specific stressors and negative thoughts.

The first goal of the study was to examine indices of performance-based interpretation. The percentage of negative endorsements across training sessions dropped at each subsequent session. In contrast, the rate of positive approvals increased across five of the six opportunities to observe changes in the training process. Due to the small number of participants who achieved six training sessions, the lack of a significant effect of the 6<sup>th</sup> training session on positive endorsement may reflect training fatigue. Between the two indices (endorsement rate and response latency), endorsement rates appeared to be more impacted by training. Response latencies did not have a complete linear trend in their reductions. After the fifth session, the interpretation response will be as fast as an individual can produce. Training beyond a handful of sessions to decrease response time does not appear to have much support. One interesting finding was the slope of response latencies. The negative slope for positive endorsement latencies appears steeper, potentially meaning that the program is more successful in training towards positive interpretations instead of solely training away negative interpretations. This thought would need to be examined further by adding a split training condition that receives training only on a percentage of trials (ex. 50/50 training/no training).

### **Secondary Findings**

Secondary findings assessed the impact of the training condition on youth internalizing symptoms. A paired-samples t-test was used to measure mean scores between the treatment group's baseline and post-intervention time points and two successive baseline time points for the waitlist control group. No significant differences were observed across time points for the control group. Three measures showed significant reductions in mean scores. The ATQ-N, PHQ-9, and PSWQ post-intervention measures were significantly lower than their baseline counterparts. Although it must be cautioned to interpret the findings related to the ATQ-N, due to some violated assumptions, the measure is most related to the concept of negative interpretations, setting a clear path to see significant differences following the training program. A significant reduction in mean score on the PHQ-9 is promising and supports the notion that broad training stimuli set can work effectively to reduce symptoms of depression. Similarly, lower mean scores on the PSWQ are a positive finding because general worry is a transdiagnostic feature. Reducing worry might serve as an adjunct treatment to a host of more specific concerns.

Similar to a trainability threshold observed with response latencies, the DBR Unhappy item showed significant effects related to training, but these effects became less impactful as training went on. The DBR Unhappy offered an efficient and objective measure of participants' happiness daily. The DBR Unhappy measure is also a broadband measure of mood and functioning, leading to the idea that the training program can create meaningful change in broad emotional concepts.

### **Tertiary Findings**

The final research question of the study inquired about the extent to which the severity of internalizing concerns predicts treatment success in the Interpretation Bias Modification Program. Baseline measures of internalizing symptoms were collapsed into a latent profile analysis that produced two distinct classes of internalizing responses. The latent profile analysis drew a 'high' and 'low' class. Future studies will use latent transition analyses to identify precisely which participants are likely to move into more adaptive groups. The LPA internalizing profile results were used as a predictor in a growth model examining how time, internalizing profile membership, and negative response rate can predict the extent to which DBR Unhappy scores change in the training condition. The latent profiles and the interaction between time and latent profiles appeared to be significant predictors of DBR Unhappy scores. This information can potentially target and disseminate the training app to individuals with more significant internalizing concerns. This thought supports the basic notion of the study that an interpretation bias training program may be helpful not necessarily for all students in a school but at least for students with tier 3 internalizing concerns.

### **Qualitative Perceptions**

Youth participants provided qualitative feedback on their experiences using the interpretation training app. Few participants completed the feedback survey at the time of the analyses ( $n = 9$ , 16%). Prompts encouraged participants to consider what they liked/did not like about the program and what was helpful/unhelpful. In advance of having qualitative data returned, we identified four themes that would be analyzed with a brief qualitative content analysis. Statements with keywords relating to themes of enjoyment and dissatisfaction were coded.

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Similarly, statements with keywords relating to themes of usefulness and inconvenience were coded. Out of the nine participants to give feedback, six statements met the criteria for a positive experience with the training program. Keywords such as “glad, liked, calming” were present. Four negative thoughts were coded, with boredom, exhaustion, and uselessness themes. Some participants offered positive criticisms (e.g., Have fewer trials or make it look more like a real game). The qualitative feedback helps tailor the intervention toward its consumers.

### **Limitations**

The study faced several limitations related to recruitment, participant fidelity to the intervention protocol, and design issues of the training program. One clear limitation was the inability to have a school district or individual school be willing to sponsor the study. The research team had obtained a commitment from a single private school to participate. Still, due to ongoing management of school resources due to the Covid-19 pandemic, schools were largely without the resources to support screening and disseminating the intervention to students with elevated concerns for internalizing issues. Because of the ongoing burden on teachers, it proved prohibitively expensive in terms of research effort and time to find teachers who were willing to provide teacher ratings on student performance. This drawback of the study removed the opportunity for good research practice of multi-method, multi-informant study design.

Fifteen students did complete the intervention during school hours while in their classrooms. These students were clustered within one classroom, however. They had distinct demographics compared to the rest of the group (e.g., significantly younger, Hispanic/Latino, and displayed relatively low mean scores on baseline measures of internalizing concerns). The skew of this subsample of students makes concluding the effects of the school-administered version of the intervention difficult. Future studies should emphasize the need to better

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

understand the effect of training within the context that negative thoughts may take place. Due to the focus on school related situations, this study was unable to accurately identify if completion of the training within the context of the school environment leads to a better training experience.

Another limiting factor for having students complete the intervention at school was technological limitations. In its original conception, the goal of the intervention was to have the training app be hosted via a self-supported website. Having the app be available through a website was feasible, but collecting data proved technologically challenging, and the research team resorted to having the app available through a download only. This created a technological hurdle for youths and their families to navigate (e.g., downloading a Zip file, uncompressing the file, and installing the app to their device).

Another technological limitation was the inability to run the training app on iOS-supported devices. The code used by the game engine to create the training app was not initially compatible with Xcode, the language used to create apps within the iOS platform. This issue was eventually resolved, but not in time to have participants in the active condition take advantage of the iOS-compatible version of the app.

A critical limitation was the lack of a neutral untrained session of the Word-Sentence Association Paradigm. Because the training app was set to train on 100% of all sessions, participants never received an opportunity to complete the task without feedback. Including a single session without feedback would have established a baseline interpretation index for the study. With this baseline, it would have been possible to have a more accurate understanding of the actual training effects of the study. A final limitation was the participant's poor adherence to the training schedule. The intervention protocol requested that participants log one play session per day across two weeks and play four consecutive days each week. Many participants did not

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

adhere to this training schedule and, in turn, 1) did not complete eight training sessions, 2) played multiple sessions in a single day, 3) missed consecutive training days, or 4) did not have a standard break (e.g., Friday through Monday) that was designed to be a minor test of short-term intervention effect retention. The poor adherence to the program created missing data, which in turn limited opportunities for specific statistical analyses to be used on the training data.

### **Future Directions**

The current study offered several potential outcomes that warrant further investigation. To maximize the research impact of future studies on the interpretation bias training program, we have identified specific goals to improve the program's effectiveness and validity.

Based on the qualitative feedback provided by the participants, a thorough analysis of the most effective training stimuli should be retained, and the overall length of the task may be shortened. Youth participants expressed boredom and fatigue while using the app, which may reduce treatment adherence. To improve engagement, the app's next version should focus on providing feedback in more varied ways, such as pleasant images, sounds, and more varied written reinforcement. Other research has also varied the training tasks, using visual search tasks and the dot-probe task utilized in the present study. Several studies have investigated a “gamified” approach to cognitive bias training. A central focus is having students earn ‘high scores’ throughout the session, unlike a single arcade style ‘high score’ present in the present study’s training program.

Aside from making the training program more engaging and pleasant, it should also focus on accessibility. Because of the file size required to download the app, many participants reported completing their training on a laptop or desktop computer. We desire to find a means to host the training program so it can be accessed without having to download the app files onto a

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

participant's device manually. Additionally, mobile platforms would offer a more significant opportunity to use the app in meaningful contexts. Like the training stimuli, a participant may benefit from playing a short session before engaging in an exposure with a therapist, or more naturalistic situations such as taking an important exam, performing in front of others, or receiving critical feedback. The app may hold some value in helping youth filter negative thoughts and prime them for a higher degree of success in their social environment.

The current study successfully reduced broad measures of internalizing symptoms. Many training programs have been designed to train attention or interpretation biases in specific contexts (e.g., social faux pas for individuals with social anxiety or self-doubt and hopeless thoughts for depressive symptoms). One of the participants in the qualitative feedback mentioned that some of the word-sentence association pairs did not feel applicable. This is likely true for most participants that some small number of training stimuli are not relevant. Future studies should allow participants to develop their own training stimuli that are unique to their worries to increase relevancy and engagement. For example, doctoral students may have many negative associations surrounding the quality of their research. A graduate student who experiences stress because of these negative thoughts may benefit from specific training stimuli such as "your advisor emailed you back with feedback on your paper," unsuccessful/approval. Typical social situations such as, "Your dissertation committee asks you to wait outside," common/fail, could be more potent to individuals if the negative thoughts are more salient and relevant in their everyday life.

Future research of school-based cognitive bias modification programs should reflect on how to best integrate the programs into a systemic focus. When an intervention is tailored specifically to one member of the school community (e.g., students), it is possible to



## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

misrepresent the program as implying that those members alone are responsible for changing maladaptive contexts. In this instance, it would be unfair and imprudent to place all responsibility onto the shoulders of students who are managing internalizing symptoms when other stakeholders have the potential to play a role in the intervention. We believe there is a possibility of better integrating teachers and school service providers into the intervention. First, teachers may benefit from receiving training on negative interpretation biases. Through professional development, teachers may learn how to best support students with strong negative interpretation biases by being explicit with their instruction and feedback. Additionally, if teachers strive to achieve basic tenets of universal positive behavior and intervention supports in the classroom (e.g., positive voice, opportunities to respond, and positive attention signals), these may reduce instances of negative cognition via negative interpretation. If teachers were to better understand the link between negative interpretation and classroom management interventions, students may experience a lowered risk for internalizing symptoms. Second, teachers may benefit from a specific cognitive bias program tailored for educators. Just as students hold negative interpretations about the world around them, it is fair to assume that teachers also likely hold some negative interpretations about their classroom and students. Teacher burnout is a common situation in many schools, especially in the context of the Covid-19 pandemic (Pressley, 2021). Perhaps teachers are a population who would benefit from viewing their circumstances in a more positive light. For example, a teacher is certainly likely to view the student who rolls their eyes as unappreciative or disrespectful, however it is possible to hold a more neutral interpretation of this scenario, such as developmentally appropriate or moody. By redirecting the focus of this students' negative behavior from being directed towards the teacher

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

because of student emotion, the teacher may benefit from viewing the student behavior as more global and not a reflection of their own teaching style.

The research provided an indication that depressive symptoms (e.g., PHQ-9 scores) and broad internalizing symptoms (e.g., DBR-Unhappy ratings) are impacted by the interpretation bias training program. Future research should investigate the potential mediation of interpretation indices (e.g., response latencies and endorsement rates) as mediators of growth models for understanding the change in broad internalizing and depressive symptoms. Although growth models in the current studies included baseline functioning (e.g., LPA class) as a covariate, this functions more as a moderator which affects the strength of the relationship between students and their improvement. The current research has not yet uncovered a mediating variable to explain the process through which training and symptom reduction occur.

The current study approached internalizing symptoms as being relatively untangled from other cooccurring conditions. We must recognize that internalizing symptoms are often uniquely tied to other experiences such as adverse childhood experiences and trauma. Internalizing symptoms are not solely caused by a negative interpretation bias. It is certainly possible that youth may hold neutral or even positive interpretation biases and objectively traumatic experiences maintain current internalizing symptoms. The interpretation bias training program that was utilized in the present study cannot extend beyond the scope of simply reinforcing more positive interpretations, and because of this, can be limited in who may benefit from the training. Students with specific adverse or traumatic experiences may be focused on their past experiences or be queued to recall negative memories of past events. Although information processing biases are likely implicated in trauma-related disorders (Buckley et al., 2000), the intervention in this

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

study is not suited to explain the process with which students may be able to manage negative interpretations and memories of past traumatic events.

### **Conclusions**

The current study successfully identified a relationship between interpretation bias modification training and decreased symptom severity. Negative interpretation biases have been documented and studied for decades (Beck, 1967, 1976, 1987, 2008). This study offers an additional account of information processing theory's notion that attention, interpretation, and memory are implicated in the development of mental health issues. Schools and online community resources offer a bridge to address cognitive bias outside of a therapist or counselor's office who may not be available, affordable, or manageable for some children. Future research should continue to address the relationship between the development of negative beliefs and the interpretation of ambiguity in youth and adolescents. As adolescence is a flexible time in individual development, it is crucial to act on pathways that can prevent the development of unhelpful or irrational beliefs.

A causal mechanism, not explicitly discussed in this paper, but central to the notion of what may make cognitive bias modification training work, is routine engagement in mindful practice of positive thought. Recent research shows that when individuals are able to mindfully interact with technology in a positive way, and develop a routine around that, both the individual and their family experience improved well-being (Koome, 2012). Similar to a daily devotional, adolescents' experiences with cognitive bias modification programs may offer a brief opportunity to think effectively about their interpretations. This notion would explain the higher effectiveness of interpretation training over attention training within CBM programs. Lastly, priming children and adolescents to think about these social scenarios may prime a positive

## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

mental image. Prior research has found that imagery can play a vital role in CBM procedures. Perhaps, by ‘inoculating’ an individual with positive mental imagery of real-life social scenarios they are likely to encounter, children and adolescents will be primed to view the situation as positive, just as they had during the training. The training speaks to wisdom that has existed for thousands of years, best summarized by Roman emperor and philosopher, Marcus Aurelius, “External things are not the problem. It’s your assessment of them. Which you can erase right now.” (Aurelius, 2002).

Recent research has made the point that for individuals who have grown up using digital technology, emotional support offered through a digital method may be just as beneficial (Colasante, 2022). The current study is one of a number that shows that tailoring interventions for ‘digital natives’, through transcending the time and space limitations of in-person support can be a new norm, and the good news is that it seems to be working.

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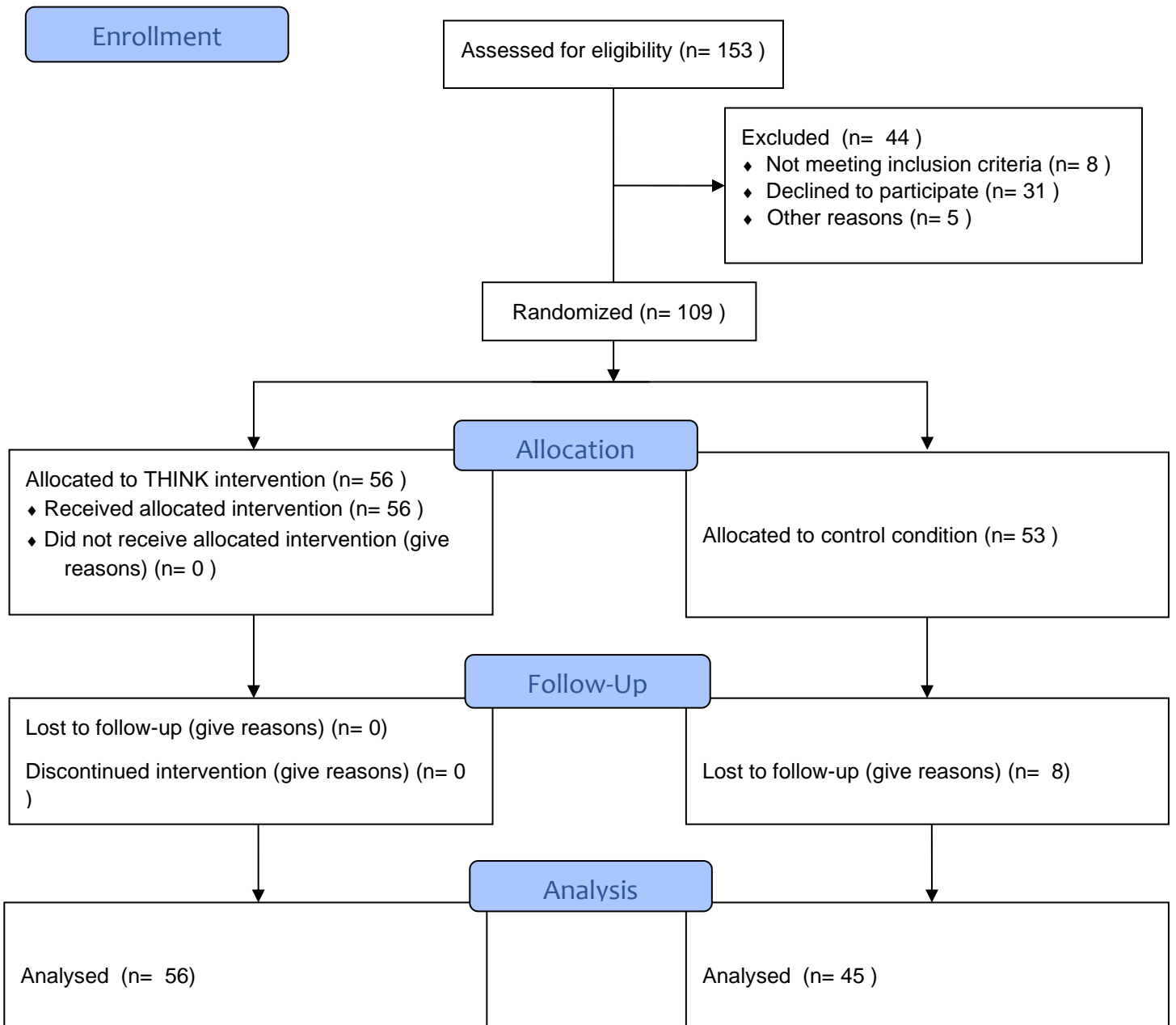
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Appendices

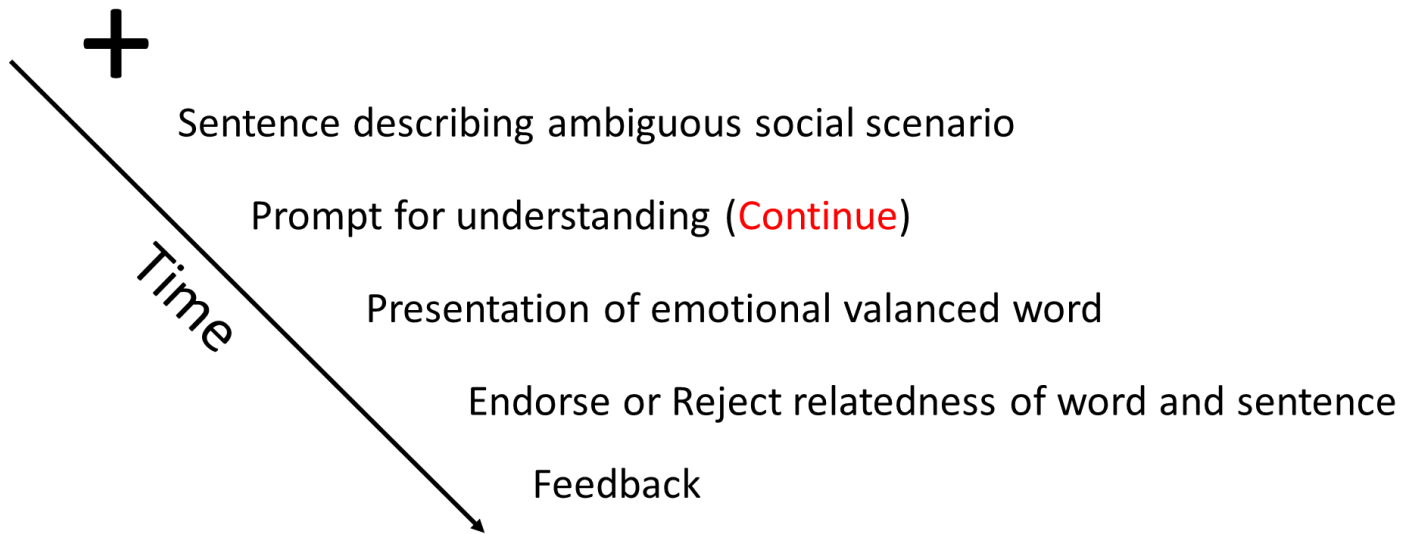
Figure 1. Recruitment & Procedures Diagram

**PROJECT THINK PROCEDURES DIAGRAM**



# INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Figure 2. Training Example Procedure.



# INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

Figure 3. Project THINK Word Prompt

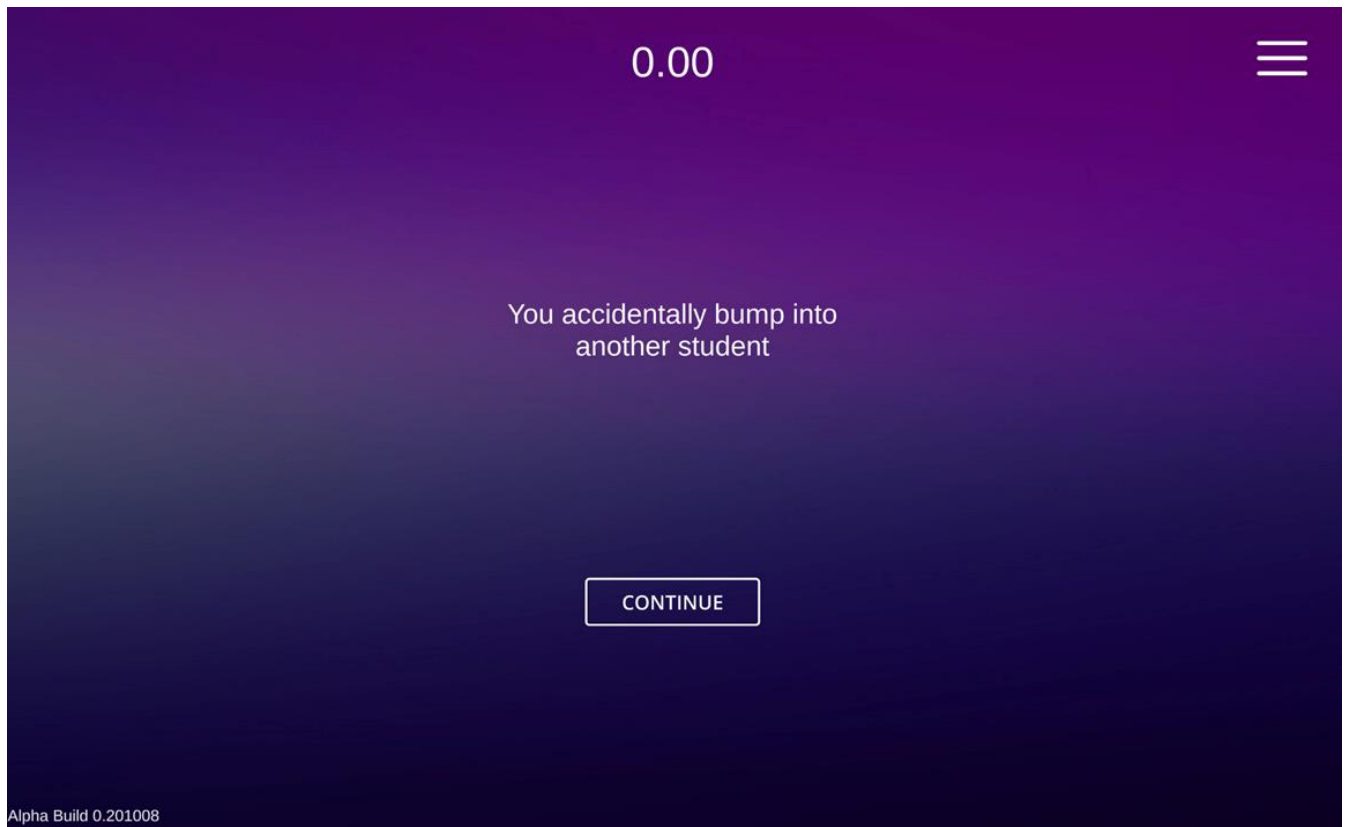


Figure 4. Recruitment Flyer



# Are you stressed?

Participate in an online study of reactions to a training program designed to reduce stress. All users are entered into a raffle for a \$50 gift card.

Researchers from the University of Missouri and Johns Hopkins School of Medicine have created a program designed to help people strengthen adaptive coping skills. It is the research teams' hope that by improving adaptive coping skills, users will see improvements in social and emotional well-being. The program offers a fast, free, and efficient resource in helping individuals manage any number of challenging social situations.



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## INTERPRETATION BIAS TRAINING IN SECONDARY STUDENTS

### VITA

Michael Van Wie graduated from the University of Maryland, College Park in May 2010, with a Bachelor of Science in Psychology. He served as a research assistant at the Comprehensive Assessment and Intervention Program at the University of Maryland from 2010-2011. From 2011-2013, Michael was employed as the project coordinator at the Binghamton Mood Disorders Laboratory at Binghamton University. From 2013-2014 he was research coordinator at the Center for Understanding and Treating Anxiety at San Diego State University. From 2015-2016, Michael was a clinical research coordinator for the National Institute of Drug Abuse, Neuroimaging Laboratory. In 2016, he entered the University of Missouri School Psychology Program. Michael earned his Master of Arts degree in December 2019. During his time as a graduate student, Michael conducted research and provided psychology services to youth in school and clinical settings through a variety of practicum experiences as well through funded mental health grants for schools. Michael will complete his pre-doctoral internship with Johns Hopkins School of Medicine/Kennedy Krieger Institute in June 2022. In September 2022, Michael will begin a postdoctoral fellowship with the Child and Family Therapy clinic at the Kennedy Krieger Institute.