The Role of Executive Function in Adolescent Affective Problems

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Abstract

Objective: The current study examined the associations among executive function, secondary control coping and affective problems. **Method**: A sample of 104 young to middle adolescents (ages 9-15 years old) completed cognitive assessments and self-report measures of affective problems and secondary control coping. **Results**: A history of maternal depression was associated with higher levels of affective problems in adolescents. Additionally, lower levels of working memory were associated with higher levels of affective problems in older adolescents. Secondary control coping and an interaction between age and working memory both predict levels of affective problems in adolescents, but secondary control coping did not explain the relationship between working memory and affective problems. **Conclusions:** Results highlight the potential importance of executive function in addition to secondary control coping when examining affective problems in adolescents.

The Role of Executive Function in Adolescent Affective Problems

This study examined how deficits in executive function (EF) may be associated with depression or affective problems in adolescents with and without maternal history of depression. Additionally, the study considered the role of secondary control coping in the relationship between EF and depression. It is important to consider how EF and secondary control coping relate to depressive symptoms in adolescents. Increased understanding of this relationship can lead to deeper insight into factors that should be included in programs designed to prevent depression in high-risk adolescents.

Depression

Major Depressive Disorder (MDD) is a widespread psychiatric disorder with a lifetime prevalence estimated at 16.6% in the U.S. (Kessler et al., 2005). The World Health Organization named depression as the number one cause of disability worldwide (World Health Organization, 2018). MDD has a high rate of recurrence, with 63% of people who experience a first episode have a recurrence in a five-year period (Solomon et al., 2000). Additionally, with each episode of depression, the likelihood of future recurrences increases by 16% (Solomon et al., 2000). Children of depressed parents are at a higher risk for developing depression because of both biological and environmental factors (Goodman, 2011; Silberg, Maes, & Eaves, 2010). Given the severity and debilitating nature of the disorder, it is imperative that efforts be made to prevent depression in high-risk adolescents.

Adolescents in general are at an elevated risk for the onset of depression. Over 35% of individuals who develop MDD have an onset of the disorder before the age of 18 (Zisook et al., 2007). An earlier age of onset of depression is associated with greater severity of depressive symptoms, more episodes of depression in the lifetime, greater functional impairment, and

greater levels of suicide ideation (Zisook et al., 2007). Children of depressed parents who develop depression have a mean age of onset around the age of 12-13, whereas children of non-depressed parents who develop depression have a mean age of onset around 16-17 years (Weissman et al., 1987).

Understanding risk and protective factors for MDD in adolescents is imperative for the development of prevention programs. Risk factors for depression in adolescents include a family history of depression (Beardsley, Gladstone & O'Connor, 2011), impaired executive function (Snyder, 2013), exposure to harsh and withdrawn parenting (Gruhn et al., 2016), adverse childhood experiences (McLaughlin et al., 2012), being female (Nolen-Hoeksema & Girgus, 1994), being economically disadvantaged (Goodman, Slap, & Huang, 2003), being a racial minority (Rohde, Beevers, Stice & O'Neil, 2009), social isolation, and exposure to stressful events or circumstances (Grant et al., 2003). Protective factors against adolescent depression include the use of certain types of skills to cope with stress (Compas et al., 2017), parents who provide high levels of warmth and structure (Gruhn et al., 2016), family connectedness (Costello, Swendenson, Rose & Dierker, 2008), and peer and social support (Dumont & Provost, 1999). Some of these factors such as gender, race or socioeconomic status are not feasible to change in order to prevent depression. Rather, prevention programs should focus on minimizing risk factors and strengthening protective factors that are malleable with potential targets including adolescents' executive function skills and coping skills, and parents' parenting skills.

Executive Function

Executive function is defined as "a set of general-purpose control processes that regulate one's thoughts and behaviors" (Miyake & Friedman, 2012, p. 8). Miyake and Friedman (2012) developed a model of executive function that is comprised of three components: updating,

shifting, and inhibition. In this model, "updating" is the continual addition and deletion of information from short-term memory. It is often synonymous with working memory, as the content that someone would update might never enter long-term memory. The second component, "shifting", is the ability to mentally switch between tasks. The third component, "inhibition" (also referred to as attentional control) is the ability to prevent immediate responses to a stimulus. There is overlap among these three components of executive function. Miyake and Friedman (2012) refer to the aspects of executive function that are shared by the three components as "common executive function." After controlling for what is shared among the three components, there is no variation in inhibitory control that is explained outside of common executive function. This suggests that when considering components of executive function, it can be separated into three groups: common executive function, or what is shared across updating, shifting, and inhibition; what is unique to updating; and what is unique to shifting (Miyake & Friedman, 2012).

When a child is young, the different categories of EF are highly intercorrelated, and it is difficult to distinguish between the components of EF. As children get older, however, the components become more differentiated from common EF (Akshoomoff, Brown, Bakeman & Hagler, 2018). Given how EF changes during development, it is important to consider a framework of EF specific to children and adolescents. Cirino et al. (2018) created a model for EF based on individuals 8 to 11 years old. Their model consists of a common EF factor, similar to that of Miyake and Friedman (2012) as well as five specific factors: working memory (span/manipulate), working memory (updating), generative fluency, self-regulated learning, and metacognition. Although this does model does not include the entire age range of individuals in

the present study, it still provides evidence for the need to examine the EF deficits in adolescent depression separate from adults given the developmental differences between the samples.

Executive Function and Depression

Depression is widely associated with impairments in cognition. EF is an aspect of cognition that has consistently shown strong effects for impairment in individuals with MDD (Snyder, 2013). Snyder (2013) examined the relationship between EF and depression in a meta-analysis of 113 research studies. When controlling for current depressive symptoms, age, and use of medication, individuals diagnosed with major depressive disorder had significantly lower measures of EF. Snyder (2013) further examined the following categories of cognitive measures that include components of EF: inhibition, shifting, updating, verbal and visuospatial working memory, planning, and verbal fluency. Additionally, Snyder (2013) included non-EF comparison cognitive measures: the Trail Making Test, the Stroop test and measures of processing speed or vocabulary. Collectively, the meta-analysis compared 3,936 MDD participants to 3,771 health controls. All categories of EF included in this meta-analysis showed that MDD patients had significant impairment in EF compared to the healthy controls, with the effect sizes for these results ranging from $d = 0.39$ to 0.97 (Snyder, 2013). The consistency of moderate to large effects across 113 studies establishes that individuals with major depressive disorder have impaired levels of executive function compared to the non-depressed population.

The majority of the studies in Snyder's (2013) meta-analysis included adult samples. However, other research has shown similar findings in adolescents. For example, one study found that adolescents who had major and minor depression scored lower on EF measures than outpatient controls (Holler, Kavanaugh & Cook, 2014). Another study examining the effects of peer stress on adolescents found that females with EF deficits who experienced peer stress had

higher levels of depression, but the same finding was not found in males (Agoston & Rudolph, 2016). However, the association between depression and EF impairment is not as widely documented in adolescents and effects that are found are not as strong as those reported by Snyder (2013) in adults. Inconsistencies in the literature also include research that finds no link between adolescent depression and EF impairment (e.g., Wagner, Allow & Abramson, 2015). Further research needs to be conducted to more definitely determine how the two factors are related in adolescents.

A recent meta-analysis by Ahern and Semkovska (2017) examined impairments in cognitive functioning in individuals who are experiencing their first episode of MDD versus healthy controls. This review examined 31 studies and found small to large effects of depression on various measures of cognitive functioning. This meta-analysis shows that even in a person's first episode of depression, impairments to cognition and EF are present. Given the high prevalence of first episodes of depression in adolescence, it is important to examine how these factors are related. The effects reported by Ahern and Semkovska (2017) are not as robust as those of Snyder (2013). An explanation for this could be that symptom severity moderates the relationship between EF impairment and depression. Snyder (2013) found greater effect sizes as the severity of depressive symptoms increased with EF impairments in inhibition, shifting, verbal working memory, verbal fluency, and vocabulary. Further, severity of symptoms increases in individuals with recurrent episodes of depression compared to the first episode of MDD (Rocaa et al., 2011). Therefore, it is possible that the effects of EF impairment are not as strong in an individual's first episode of depression because on average, the severity of the episode is not as great as those who have had more than one episode.

Higher levels of inhibition and mental flexibility in children of depressed parents have shown to be associated with lower depressive symptoms in the adolescents (Davidovich et al., 2016). The same study also found that inhibition and shifting moderate the association between adolescent depressive symptoms and current parental depression, such that adolescents who have a parent that is currently depressed and have lower levels of EF display higher levels of depressive symptoms (Davidovich et al., 2016). In their discussion, Davidovich et al. (2016) suggest a possible explanation for their results is that higher levels of EF enable the child to cope with stress more effectively. Given the importance of executive function in the ability to copy, it is important to consider the role of coping in the relationship between EF and depression.

Coping with Stress

Coping is defined as "conscious, volitional efforts to regulate emotion, cognition, physiology and the environment in response to stressful events or circumstances" (Compas, Connor-Smith, Saltzman, Harding Thomsen, & Wadsworth, 2001, p. 89). A control-based model proposed by Compas et al. (2001) subdivides effortful coping into primary control coping, secondary control coping and disengagement coping. Primary control coping (e.g., problem solving, emotional expression, emotional modulation) consists of skills that help an individual change a source of stress or directly change their emotional response. Secondary control coping (e.g., cognitive reappraisal, distraction, acceptance, positive thinking) is comprised of skills that help an individual adapt to stressful situations that are not within their control. Disengagement coping (e.g., avoidance, denial, wishful thinking) involves the redirection of an individual's response away from the stressor and away from their emotions and thoughts (Compas et al., 2001). This control-based coping has guided research on the prevention of depression because it identifies skills that can be taught, practiced and controlled (Compas et al., 2010, 2017).

Additionally, this model emphasizes the use of observable behaviors within an adolescent's awareness, such that the skills can be intentionally activated to respond to stressful and emotionally arousing circumstances (Compas et al., 2017).

Executive Function and Coping with Stress

EF is important because it allows us to do a variety of things such as make decisions, prepare for future situations, regulate emotions, and change patterns of thinking amongst other things (Snyder, 2013). It has also been proposed that EF provides a foundation of basic skills for the development of skills to cope with stress since the process of coping requires higher levels of cognition (Compas et al., 2017). EF also is responsible for controlling operations that are goal-oriented (Cirino et al., 2018). Given that effortful coping (i.e., primary control coping and secondary control coping) is goal-directed, with the objective of reducing stress and managing reactions to it (Compas et al., 2001), it is plausible that EF would affect an individual's ability to cope. Deficits in EF may be problematic because they can lead to less effective coping with stress, which can lead to increased depressive symptoms.

It has been hypothesized that extended exposure to stress can negatively impact coping because of its impact on portions of the brain that are responsible for EF that provide the basis for effortful coping (Compas, 2006; Reising et al., 2017). Stress can impact regions of the prefrontal cortex (PFC) that are responsible for EF that can negatively impact emotion regulation and coping with stress (Reising et al., 2017). For example, cognitive reappraisal is a secondary control coping skill that utilizes working memory because it requires an individual to hold the current stressor in their short-term memory while changing the perception of the stressor in order to view it in different, more positive terms. Reising et al. (2017) found that activation of the dorsolateral prefrontal cortex (DLPFC) and the anterior prefrontal cortex (APFC) during an N-

back test were positively correlated with exposure to stress. Additionally, they found that activation of DLPFC, dorsal anterior cingulate cortex (dACC) and APFC were all negatively correlated with secondary control coping. These results suggest that exposure to stress may impede activation of the brain, such that regions of the brain responsible for EF must be increased in stressed adolescents in order to achieve comparable results to non-stressed adolescents (Reising et al., 2017).

Coping and Depression

Stress is one of the primary risk factors for mental health problems in adolescents (Grant et al., 2003). Therefore, how a child copes with stress is an important factor to consider in reducing risk for depression in adolescents. Both primary and secondary control coping have been associated with fewer symptoms of depression and anxiety in adolescence. A meta-analysis examining the role of coping and emotion regulation in psychopathology in children and adolescents found that primary control coping and secondary control coping consistently showed negative associations with internalizing and externalizing symptoms in children and adolescents (Compas et al., 2017). Disengagement coping (e.g. avoidance, denial, wishful thinking) has been linked to higher levels of depressive symptoms in adolescence (Dunbar et al., 2013). Additionally, teaching high-risk children secondary control coping skills is an effective way to prevent depression (Compas et al., 2010, 2015), which provides further evidence for the association between coping and depression.

Negative cognitive style could help explain the relationship between depression and coping in adolescents. Negative attributional style is defined by interpreting negative events as being caused by a stable factor (this negative event is never going to end), global (this negative event extends into many facets of life), and internal (this negative event occurred because of

something related to one's self) (Dunbar et al., 2013). Negative cognitive style expands on the definition of negative attributional style by adding expectations of additional negative outcomes and negative effects for one's self because of the event (Dunbar et al., 2013). Negative cognitive style is negatively correlated with primary control coping and secondary control and is positively correlated with disengagement coping, affective problems, and depressive symptoms in adolescents (Dunbar et al., 2013). These findings show that children with higher levels of negative cognitive style are more likely to engage in disengagement coping strategies and less likely to engage in active coping strategies and are therefore at a higher risk for depression given that active coping strategies (i.e., primary control and secondary control coping) act as protective factors against depression and disengagement coping acts as a risk factor for depression (Compas et al., 2017). Additionally, children of depressed parents show higher levels of negative cognitive style (Dunbar et al., 2013), which could help explain their higher predisposition to develop depression.

Depression, Executive Function and Coping

Relationships have been established between depression and EF, between depression and coping, and between EF and coping. Additionally, research has been done to examine all three factors together. Andreotti et al. (2013) examined how working memory, secondary control coping, and cognitive reappraisal are associated with depressive symptoms in a sample of college students. They found that working memory was a significant predictor of depression on its own, when in a regression model with cognitive reappraisal, when in a regression model with secondary control coping, and when in a regression model with cognitive reappraisal and secondary control coping (Andreotti et al., 2013). These results show secondary control coping, cognitive reappraisal and working memory all individually account for some of the variance of

depression in college students. However, no interactions between working memory and secondary control coping were tested.

Research by Evans, Kouros, Samanez-Larkin, and Garber (2016) found that primary control coping and secondary control coping partially mediate the relationship between working memory and depressive symptoms in the children. Higher levels of working memory were positively associated with the use of primary control coping strategies and secondary control coping strategies. They also found that secondary control coping partially mediated the relationship between cognitive flexibility and depressive symptoms. Higher levels of cognitive flexibility were associated with greater use of secondary control coping strategies.

Campbell et al. (2009) found that coping mediates the relationship between three domains of EF (working memory, cognitive flexibility and self-monitoring) and their behavioral outcomes in children who survived Acute Lymphocytic Leukemia. However, while this study did use measures commonly used to report affective symptoms in children, they only reported results for the Total Behavior Problems scale and did not describe how coping mediates EF and affective or depressive symptoms in the children.

Prussien et al. (2018) used a control-based model of coping to show that working memory and secondary control coping are directly associated with depressive symptoms in adolescents with Sickle Cell Disease. On a bivariate level, they found that working memory is not significantly related to secondary control coping, working memory is negatively associated with depressive symptoms, and secondary control coping was negatively associated with depressive symptoms. They then looked for indirect relationships between depression and working memory through secondary control coping. This indirect pathway was not significant. However, when they examined an indirect pathway between depression and verbal

comprehension through secondary control coping, the indirect association was significant. In this model, secondary control coping accounted for a significant amount of the variance in the association between verbal comprehension and depressive symptoms (Prussien et al., 2018). Verbal fluency is not in the model for EF proposed by Miyake & Friedman (2012). However, other research considers it a domain of EF (Snyder, 2013) and impairments in verbal fluency are associated with increased depression (Snyder, 2013). These results, therefore, provide partial support for an indirect association between EF and depressive symptoms.

The Present Study

It is important to understand factors that affect the association between coping and depression since coping with stress is one element of programs designed for depression prevention that has shown to be effective (Compas et al., 2015). Given the connection between executive function and coping with stress, and the importance of coping in depression prevention, it is important to develop a model that explains the relationship between these three variables. I examined the following research questions: (1) How do affective problems differ between adolescents of depressed mothers and adolescents of non-depressed mothers? (2) Are affective problems in adolescents associated with impaired executive function? (3) How does coping explain the relationship between executive function and affective problems in adolescents? The following hypotheses were tested: (1) Children of depressed mothers will have higher levels of affective problems than non-depressed mothers. (2) Deficits in EF will significantly predict levels of affective problems in adolescents. (3) Secondary control coping will explain the relationship between EF and affective problems in adolescents.

Methods

Participants

The sample included 104 adolescents between the ages of 9 and 15. Fifty-five children had mothers who had no history of MDD and 49 had mothers with a history of MDD. Out of the mothers with MDD history, 6 were in a current episode, 43 have had an episode during their child's life, and 2 have had an episode but it occurred before their child was born. The sample included 48 females (M age = 12.29, SD = 1.91) and 56 males (M age = 12.68, SD = 1.62). 68.9% identified as White and 31.1% identified as non-White (24.3% African American).

Measures

Demographics. Demographics such as age, race, ethnicity, SES, gender, education, and maternal education were obtained from the parent of the participant.

Children's affective problems. Affective problems in the subjects were assessed using the Child Behavior Checklist (CBCL; Achenbach & Rescorla, 2001) and the Youth Self-Report (YSR; Achenbach & Rescorla, 2001). The mothers of the children reported on child's affective problems using the CBCL. The CBCL has the parent rate the child's behavior from 0 (not true), 1 (somewhat or sometimes true), or 2 (very true or often true) for 118 items. This report assesses affective problems in the child in the past six months. Additionally, the children completed the YSR to provide a self-report measure of the child's affective problems. The YSR is the self-report version of the CBCL.

Children's coping with stress. The Responses to Stress Questionnaire (RSQ; Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman 2000) was used to measure how the child copes with stress. Both the parent and child filled out this assessment regarding how the child copes with their parent's depression. This questionnaire consisted of 57 hypothetical situations that proposed various techniques for how the child responded in stressful conditions. The respondent rates each statement using a 4-point Likert scale (1 = not at all; 2 = a little; 3 = some;

4 = a lot) to describe the degree to which the child responds in the given situation. This study used 3 subscales of scores on the assessment: primary control coping, secondary control coping and disengagement coping. Proportion scores of the base rates were calculated by dividing each subscale score by the total score. This was done so that the scores show how much the child uses a particular type of coping in comparison to the other coping strategies.

Children's executive function. Executive function was measured using the Wechsler Intelligence Scale for Children (WISC-IV). The digit span subset of this assessment has shown to be a reliable and valid measure of working memory in adolescents (Leffard et al., 2006). The digit span assessment of the WISC-IV consists of a digit forward component, where the child repeats the numbers heard in the same order, and a digits backward component, where the child repeats the numbers they heard in reverse order. For each sequence of numbers the subject correctly answers, they get 1 point, with a maximum of 28 points total (14 points for forward digit span and 14 points for backward digit span).

Procedures

Mothers with children between the ages of 9 to 15 years old were recruited from the Southeastern metropolitan area. Some of the mothers had a history of depression while some did not. Recruitment was done by sending out emails to employees at Vanderbilt and by placing fliers in local mental health clinics. After expressing interest in the study, mothers underwent a phone screen to determine whether they were eligible for the study. Exclusion criteria included the mother having a diagnosis of bipolar I disorder, bipolar II disorder, or schizophrenia. Additionally, families were excluded if the adolescent had a diagnosis of schizophrenia, a pervasive developmental disorder, or an intellectual disability. For families that had more than one eligible adolescent, the older adolescent participated in the study. The mother-adolescent

dyads visited the laboratory one time and completed questionnaires and clinical assessments. All of the clinical assessments were administered by doctoral students. They were compensated with $100. Additionally, the families were given a pamphlet with information on parent-adolescent communication, parenting, and the effects of depression on parenting. The Institutional Review Board at Vanderbilt University approved all of the procedures, and all participants provided informed consent.

Data Analytic Approach

All data analyses were conducted using SPSS 24 and PROCESS. An independent t-test was used to test the first hypothesis. Originally, the data was divided into 4 groups: no maternal depression, past maternal depression (only before child's birth), past maternal depression (since the child's birth), and current depression. These groups were consolidated into 2 groups: depression during the child's lifetime and no depression during the child's lifetime. I included the children whose mothers had episodes of depression before they were born with the children who have no maternal depression history because parental depression during the course of a child's life is a greater risk factor for MDD in the child than before they were born (Beardslee et al., 1998). Bivariate correlations were conducted to examine the relationships between child affective problems, working memory, secondary control coping and age. Moderation analyses were used to determine how working memory is related to children affective problems. Multiple regression analyses were used to determine the association of working memory and secondary control coping on children affective problems.

Results

An independent samples *t*-test showed that adolescents' self-reported affective problems in adolescents of parents with a history of MDD in their lifetime ($M = 4.98$, SD = 3.75) versus

adolescents whose mothers have not had an episode of depression during their lifetime (M = 3.80, SD = 2.71), approached significance, $t(102) = -1.85$, $p = .07$. However, parents' report on their children showed that children whose mothers have a history of MDD in their lifetime (M = 3.20, SD = 3.80) had significantly higher affective problems than children of mothers with no history of MDD in their lifetime (M = 1.18, SD = 1.74), $t(102) = -3.55$, $p < .001$.

As shown in Table 1, the bivariate correlation between working memory and child affective problems was not significant, $r(103) = -.07$, $p = .50$. Given the medium sized correlation between working memory and age, $r(103) = .32$, $p < .001$, a linear regression model was tested where age acted as a moderator between working memory and affective problems. In this model, the main effect of age ($\beta = .03$, $p = .81$) and the main effect of working memory ($\beta = -.04$, $p = .69$) were not significant predictors of affective problems (Table 2). However, the interaction between age and working memory was a significant predictor of affective problems in adolescents ($\beta = -.26$, $p < .01$).

In order to understand the interaction between age and working memory on adolescent affective problems, the results from the regression analyses were plotted using PROCESS (Figure 1). Working memory was related to self-reported affective problems among older adolescents. Among adolescents who were younger ($b = .20$, $t(104) = 1.39$, $p = .17$) or average age ($b = -.04$, $t(104) = -.04$, $p = .70$), working memory was not significantly related to affective problems. However, among older adolescents there was a significant negative relationship between working memory and affective problems ($b = -.27$, $t(104) = -2.35$, $p = .02$), such that lower levels of working memory predict higher levels of affective problems.

Multiple regression analyses were used to the test the relationship between working memory, secondary control coping and adolescent affective problems. Given the significant

interaction effect between age and working memory, age was also included in the models. The analyses consisted of four steps. In the first step, the main effects of age, working memory, and secondary control coping were tested. The second step added two-way interactions between the three predictor variables, which were all tested in separate models. The third step tested all three two-way interactions together. The fourth step added a three-way interaction between age, working memory and secondary control coping.

In step one, secondary control coping ($\beta = -.59$, $p < .001$) was negatively associated with adolescents' affective problems. The main effect of secondary control coping held in all of the models. Age and working memory were not significant predictors of affective problems in any of the models. Step two showed that the interaction between age and secondary control coping ($\beta = .01$, *ns*) and working memory and secondary control coping ($\beta = .10$, *ns*) were not significant. The interaction between age and working memory approached significance ($\beta = -.17$, $p = .053$). Although it was not significant, the interaction showed the same pattern as it did in the regression analysis without secondary control coping. For older adolescents, the association between working memory and affective problems approached significance ($b = -1.75$, $t(103) = -1.77$, $p = .08$). Average age and younger adolescents showed no association between working memory and affective problems. This demonstrates that incorporating secondary control coping into the model to predict affective problem does not diminish the effects of working memory. The interaction of age and working memory was also significant in step three ($\beta = -.17$, $p < .05$) and approached significance in step four ($\beta = -.17$, $p = .051$), demonstrating the consistency of the effect of working memory on affective problems in older adolescents. The three-way interaction between age, working memory and secondary control coping was also not significant ($\beta = .06$, *ns*). Overall, all of the models reached significance.

Discussion

The present study analyzed the relationship among EF, secondary control coping and affective problems in adolescents with and without maternal history of depression. The results showed that adolescents with maternal history of depression are at a higher risk for affective problems. Support was found for an association between working memory and affective problems in adolescents when age was introduced into the model as a moderator. While there was not an indirect relationship between affective problems and working memory through secondary control coping, secondary control coping and working memory (when moderated by age) were both significant predictors of affective problems in adolescents.

Consistent with previous research (Beardslee et al., 1998) the first hypothesis showed that children of mothers with a history of MDD experience higher levels of affective problems compared to children whose mothers have no history of MDD. Although the self-report of affective problems did not show a difference between the groups, it approached significance. However, the parent report clearly showed that children of depressed mothers have higher levels of affective problems. This study provides further evidence that children of depressed parents are at a higher risk for depression. It also demonstrates the need for prevention interventions targeted towards children of depressed parents.

The second hypothesis was supported. Deficits in working memory were associated with higher levels of affective problems in adolescents, which is consistent with prior research (Ahern & Semkovska, 2017). However, this was only true for older adolescents. For average age adolescents, there was no association between working memory and affective problems. For the younger adolescents in the study, the relationship approached a positive relationship between working memory and affective problems. This finding is interesting because it offers a possible

temporal explanation between depression and EF. Although a strong relationship between EF and depression has been established, it is unclear whether EF deficits lead to depression or if depression leads to EF deficits (Snyder, 2013). Given that the young adolescents who display signs of depression have high levels of EF, this could suggest that depression leads to subsequent declines in EF. It is possible that the young adolescents who display affective problems develop cognitive deficits over the next few years, such that their levels of EF decrease over time. This could be an explanation for why the effects between depression and EF deficits in adolescents are not as strong as in adult populations. However, given that this finding only approached significance and since this was not a longitudinal study, further research needs to be done in order to establish how patterns of EF deficits change in depressed adolescents throughout development.

The third hypothesis was not supported. Although secondary control coping and the interaction between working memory and age were both significant predictors of affective problems, secondary control coping did not explain the relationship between working memory and affective problems in adolescents. However, these results are consistent with Prussien et al.'s (2018) study not finding an indirect association between working memory and depressive symptoms through secondary control coping. This relationship needs to be examined in other components of EF to determine whether secondary control coping explains the association between EF and affective problems for only specific EF domains.

Additionally, the moderation effect of age on working memory in predicting affective problems could make it difficult to uncover the role of secondary control coping in the model. Working memory was not a significant predictor of affective problems in any of the steps of the regression model, but the interaction between working memory and age was significant or

approached significance in all of the models. If the sample consisted of older adolescents who showed a significant association between working memory and affective problems without the need for age to moderate the relationship, it is possible that the indirect effects of secondary control coping would be more prominent.

The present study had several strengths. First, the study included adolescents with and without maternal history of depression, which allowed for the findings to be more generalizable beyond just high-risk adolescents. Second, the study collected both child self-report and parent report on child for the YSR and RSQ so that the measures were not reliant on a single informant. Third, the sample included a relatively large sample size and moderate statistical power. Last, the study focused on EF impairments specifically in adolescents, whereas other samples have included mostly adults.

The present study also had limitations. First, the study was cross-sectional so we were not able to determine the temporal relationship between EF and depression or how the relationship changes during adolescent development. Future research can address this limitation by implementing longitudinal research designs. Second, the only EF component examined in the study was working memory. Future research can address this limitation by including measurements of inhibition, shifting and updating in their analysis. Finally, self-report measures were used for gathering information on affective problems in the children. Future research can address this limitation by substituting questionnaires with semi-structured interviews.

In summary, the findings of the current study further solidify the association between EF impairments in individuals displaying depressive symptoms. Additionally, working memory and secondary control coping both independently predict affective problems in adolescents. However, the role of secondary control coping in relation to EF needs to be further explored to

determine if it explains the relationship between working memory and affective problems through an indirect pathway in an older sample of adolescents. Future research should also look further into how age moderates the effect of working memory on affective problems. These findings increase general understanding of depression in adolescents as well as suggest possible targets for interventions that focus on depression prevention.

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Table 1. *Descriptive Statistics and Bivariate Correlations for Variables of Interest*

Measure	M	SD	1	2	3	4
1. Child affective problems	4.36	3.28	-			
2. Child working memory	17.40	3.59	-.07	-		
3. Child secondary control coping	.26	.05	-.59*	.04	-	
4. Child Age	12.50	1.76	.06	.32*	-.04	-

Note. Pearson coefficients. *p < .01.

Table 2. *Age as a Moderator of Working Memory and Child Affective Problems*

Predictor	β	*t*	$R^2 = .08$*
Child age	.03	.25	
Working memory	-.04	-.40	
Working memory x child age	-.26	-2.66**	

*$p < .05$. **$p < .001$

Table 3. *Working Memory, Age and Secondary Control Coping Predict Child Affective Problems*

Predictor	β	*t*	R^2
Step 1			.35**
Child age	.06	.69	
Working memory	-.06	-.68	
Secondary control coping	-.59	-7.22**	
Step 2a			.38**
Child age	.02	.20	
Working memory	-.03	-.39	
Secondary control coping	-.56	-6.87**	
Age x working memory	-.17	-1.96†	
Step 2b			.35**
Child age	.06	.69	
Working memory	-.06	-.68	
Secondary control coping	-.59	-7.17**	
Age x secondary control coping	.01	.08	
Step 2c			.36**
Child age	.04	.43	
Working memory	-.05	-.57	
Secondary control coping	-.58	-7.16**	
Working memory x secondary control coping	.10	1.24	
Step 3			.39**
Child age	-.01	-.12	
Working memory	-.01	-.16	
Secondary control coping	-.55	-6.77**	
Age x working memory	-.17	-2.05*	
Age x secondary control coping	-.03	-.38	
Working memory x secondary control coping	.12	1.38	
Step 4			.39**
Age	-.00	-.02	
Working memory	-.02	-.22	
Secondary control coping	-.56	-6.78**	
Age x working memory	-.17	-1.98‡	
Age x secondary control coping	-.02	-.19	
Working memory x secondary control coping	.11	1.35	
Age x working memory x secondary control coping	.06	.68	

†$p = 0.0528$. ‡$p = .0506$. *$p < .05$. *$p < .001$.

Figure 1. *Interaction of Age and Working Memory in Relation to Child Affective Problems*