Affective, Physiological, and Cognitive Response to Imagery- and Verbally-Based Rumination and Distraction in Adolescence

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AFFECTIVE, PHYSIOLOGICAL, AND COGNITIVE RESPONSE TO IMAGERY- AND VERBALLY- BASED RUMINATION AND DISTRACTION IN ADOLESCENCE

by

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A DISSERTATION
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To date, rumination and interventions for rumination have largely been verbal in focus. Rumination has been conceptualized as dwelling on negative affect in the form of verbal thought, and interventions aim to interrupt cycles of rumination using verbal strategies. Yet, emerging evidence suggests that many individuals dwell on negative affect in the form of imagery (e.g., Lawrence, Haigh, Siegle, & Schwartz-Mette, 2018) and that imagery-based interventions may be even more effective (e.g., Arntz, 2012). This is not surprising as imagery is more affectively arousing (Holmes & Mathews, 2010), physiologically stimulating (Vrana, Cuthbert, & Lang, 1986), and realistic/vivid (Mathews, Ridgeway, & Holmes, 2013) than verbal thought. No research, however, had compared imagery- and verbally-based rumination and distraction. It was especially important to examine these processes in adolescents, when rumination emerges (Nolen-Hoeksema, 1998) and early intervention is key.

Using a multi-method experimental design, adolescents ($N = 145$; age range: 13-17 years) completed assessments of trait rumination, depressive symptoms, and rumination style. They then experienced Cyberball (i.e., a negative mood induction) followed by rumination or distraction in the form of imagery or verbal thought. Affect ratings, heart rate variability (HRV),
and galvanic skin response (GSR) data were collected. Adolescents rated realism and vividness post-rumination/distraction. Imagery-based rumination was expected to result in a more maladaptive response than verbally-based rumination and imagery-based distraction was expected to result in a more adaptive response than verbally-based distraction.

Imagery-based rumination was just as impairing, if not more impairing, than verbally-based rumination. Trait rumination was most highly associated with depressive symptoms when adolescents ruminated in the form of imagery. When induced, imagery- and verbally-based rumination led to similar affective, HRV, and GSR response. Imagery-based distraction was more effective than verbally-based distraction. Compared with verbally-based distraction, imagery-based distraction promoted a more adaptive affective, HRV, and GSR response.

Findings emphasize the need to evaluate and treat both imagery- and verbally-based rumination. Imagery-based distraction may provide an especially effective means of intervening, despite the field’s historic focus on verbally-based treatments. Consideration of imagery-based rumination and use of imagery-based interventions in adolescence is especially vital given the potential benefits of early, effective intervention.
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CHAPTER 1
INTRODUCTION

Imagery plays a prominent role in the etiology, maintenance, and treatment of psychopathology both in adulthood and adolescence (Hagenaars & Holmes, 2012; Holmes & Mathews, 2010). One important, but as of yet, understudied area of inquiry is how imagery impacts the experience and treatment of rumination, a well-established cognitive risk factor for depression (e.g., Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). To date, rumination, or repeatedly dwelling on negative emotion, has nearly exclusively been examined as verbal thought (i.e., dwelling in the form of words or sentences; Fresco, Frankel, Mennin, Turk, & Heimberg, 2002) despite evidence that many individuals dwell on negative emotion in a visual way (i.e., in the form of imagery; e.g., Lawrence, Haigh, Siegle, & Schwartz-Mette, 2018). Interventions targeting rumination also have been largely verbal in focus, although recent research suggests that imagery-based alternatives may be even more effective (Blackwell & Holmes, 2017; Renner, Ji, Pictet, Holmes, & Blackwell, 2017; Lawrence & Schwartz-Mette, 2018; Torkan et al., 2014).

Maladaptive affective, physiological, and cognitive responses to rumination have been documented in adulthood. Rumination keeps distressing mental representations in mind, increasing negative affect (e.g., Nolen-Hoeksema & Morrow, 1993) and prolonging cardiovascular response to stress (e.g., Ottaviani, Shapiro, Davydov, Goldstein, & Mills, 2009). Compared to negative verbal thought, negative imagery also has been found to result in higher negative affect (e.g., Holmes & Mathews, 2010), to produce a more maladaptive physiological response (e.g., Vrana, Cuthbert, & Lang, 1986), and to be more realistic and vivid (e.g., Mathews, Ridgeway, & Holmes, 2013). Thus, ruminating in the form of imagery (i.e., imagery-
based rumination) may be even more impairing than ruminating in verbal form (i.e., verbally-based rumination). Researchers have yet to examine, however, how affective, physiological, and cognitive response to imagery- and verbally-based rumination may differ.

Imagery-based interventions may also be effective in interrupting cycles of rumination. Compared to positive verbal thought, positive imagery results in higher positive affect (e.g., Holmes & Mathews, 2010; Lawrence & Schwartz-Mette, 2018), promotes a more adaptive physiological response (e.g., Vrana et al., 1986), and again, is more realistic and vivid (e.g., Mathews et al., 2013). Imagery-based interventions have also been shown to be effective in treating multiple forms of psychopathology (see Holmes, Arntz, & Smucker, 2007 for a review) and may be more effective than verbally-based interventions in treating depression (Blackwell & Holmes, 2017; Renner et al., 2017; Torkan et al., 2014). However, studies have yet to examine whether affective, physiological, and cognitive response to imagery- and verbally-based distraction, as an analog for intervention, may differ.

Comparing imagery- and verbally-based rumination and distraction in adolescents (defined here as 13 to 17 years old) is particularly important. Adolescence is a period during which rumination becomes more common, risk for depression increases, and at the same time, still developing neurocognitive abilities may make disengaging from rumination more difficult. Effective intervention during this early developmental period could prevent recurrent depression, reducing the prolonged distress often experienced by those for whom depression onset occurs during adolescence. Although understudied with youth, what evidence does exist on response to rumination in adolescence suggests that rumination results in increases in negative affect and maladaptive physiological response during this critical developmental period as well (e.g., Abela & Hankin, 2011; Hankin, 2008; Park, Goodyer, & Teasdale, 2004; Vögele, Sorg, Studtmann, &
Weber, 2010). Intervening during adolescence is therefore critical to preventing concurrent and prospective distress. No research, however, has compared imagery- and verbally-based rumination and distraction in adolescence.

Using a multi-method experimental design, the current research examined the relation between rumination style (imagery-based, verbally-based, both) and depressive symptoms (Aim 1) as well as affective (Aim 2), parasympathetic (Aim 3), and sympathetic (Aim 4) response to induced imagery- and verbally-based rumination and distraction with an adolescent sample. Realism and vividness were evaluated as cognitive factors that may impact differences in affective and physiological response to imagery- and verbally-based rumination and distraction (Aim 5). Gender differences and the role of depressive symptoms were considered in the context of each aim. Adolescents (N = 145) self-reported rumination style (imagery-based, verbally-based, both) and underwent an original imagery- or verbally-based rumination/distraction induction. Affective, physiological (i.e., heart rate variability [HRV]; galvanic skin response [GSR]), and cognitive (i.e., ratings of realism, vividness) data were collected. This work expands our understanding of rumination and depression in adolescence and informs prevention and intervention efforts.

**Imagery**

Imagery, or “seeing with the mind’s eye” (Kosslyn, Ganis, & Thompson, 2001, p. 635), has long been assumed to play a prominent role in the etiology, maintenance, and treatment of psychopathology. In fact, since their inception, cognitive behavioral approaches to treatment of psychopathology have emphasized that maladaptive cognition can take the form of either images or verbal thoughts (Beck, 1976). However, strikingly little empirical research has been conducted on imagery in a clinical domain (Holmes, Blackwell, Heyes, Renner, & Raes, 2016;
Pearson, Deeprose, Wallace-Hadroll, Heyes, & Holmes, 2013), despite numerous calls for research on imagery and psychopathology (e.g., Di Simplicio, McInerney, Goodwin, Attenburrow, & Holmes, 2012; Holmes & Mathews, 2005; Watts, 1997). Fortunately, recent evidence that imagery may be more impairing than verbal thought has pushed research on mental imagery to the forefront, resulting in a spotlight on imagery as one of the current “hot topics” in cognitive behavioral therapy (Holmes, Arntz, et al., 2007).

**Imagery and Psychopathology in Adulthood**

What research does exist suggests that imagery is present in numerous forms of adult psychopathology (for reviews see Hagenaars & Holmes, 2012; Holmes & Mathews, 2010) and that imagery may play a role in the maintenance of disorders during adulthood (e.g., Holmes et al., 2016). The most prominent example is imagery in the form of “flashbacks” associated with post-traumatic stress disorder (PTSD; Brett & Ostroff, 1985; Brewin, Gregory, Lipton, & Burgess, 2010), though imagery has now been cited as playing a transdiagnostic role. Specifically, along with flashbacks in PTSD, there is empirical evidence for the detrimental effects of contamination imagery in obsessive-compulsive disorder (e.g., de Silva, 1986; Rachman, 2007), images of feared social situations in social phobia (e.g., Hackmann, Clark, & McManus, 2000; Hirsch, Clark, Mathews, & Williams, 2003), images of phobic stimuli in specific phobia (e.g., Pratt, Cooper, & Hackmann, 2004; Price, Veale, & Brewin, 2012), catastrophic imagery in agoraphobia (Day, Holmes, & Hackmann, 2004; Hackmann, Day, & Holmes, 2009; Wells & Papageorgiou, 1999), appearance-related images or images of food cravings in eating disorders (Harvey, Kemps, & Tiggemann, 2005; Osman, Cooper, Hackmann, Veale, 2004), and imagery deficits in schizophrenia (D’Argembeau, Raffard, & Van der Linden,
2008). Although imagery is clearly present in multiple forms of psychopathology in adulthood, far less research has examined imagery and psychopathology in adolescence.

**Imagery and Psychopathology in Adolescence**

Adolescence is a developmental period characterized by increased abilities to form, but not effectively disengage from, imagery (e.g., Kosslyn, Margolis, Barrett, Goldknapf, & Daly, 1990). Across studies, results suggest that youth rely on imagery-based processing even more so than adults (Heyes, Lau, & Holmes, 2013) and that imagery task performance peaks in adolescence (Kosslyn, et al., 1990). Relative to adults, however, adolescents may be less capable of full cognitive control over emotionally charged imagery, resulting in greater difficulties disengaging from maladaptive cycles of imagery-based cognition (Heyes et al., 2013).

At the same time, first onset of many mental health disorders occurs during adolescence (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003; Kessler et al., 2007), with an average age of onset for any disorder falling at 14 years old (Kessler, Berglund, Demler, Jin, Merikangas, & Walters, 2005). Anxiety disorders, mood disorders, psychosis, eating disorders, personality disorders, and substance abuse all increase in incidence during this developmental period (Giedd, Keshavan, & Paus, 2008). Although there is even less research on imagery and psychopathology in adolescence than there is in adulthood, some evidence exists for intrusive imagery among early adolescents with PTSD symptoms (Holmes, Creswell, & O’Connor, 2007), negative imagery of the self among adolescents with social phobia (Alfano, Beidel, & Turner, 2008), and distorted imagery of one’s body among adolescents with eating disorders (Cattarin & Thompson, 1994).
Imagery-Based Treatment in Adulthood

Since the inception of cognitive behavioral therapy (CBT), leading theorists have emphasized the potential role of imagery in treatment (e.g., Beck, 1976). In fact, some of the earliest work discussing CBT for adults posited that altering imagery-based cognition may lead to meaningful improvement in treatment (Beck, Emery, & Greenberg, 1985). Despite this early focus on imagery, CBT intervention strategies have remained largely verbal (Holmes, Arntz, et al., 2007; Holmes, Lang, & Deeprose, 2009). There is now emerging evidence that imagery-based treatments may be even more effective (see Arntz, 2012 for a review).

Holmes, Arntz, and colleagues (2007) put forth a range of imagery-based techniques that can be used to address maladaptive imagery, including imaginal exposure, imagery rescripting, and imagery-based attentional training. Strategies also exist to promote positive imagery, including positive interpretation bias training and positive imagery about the self. Most of the sparse research to date on imagery-based treatments has examined imagery rescripting and imaginal exposure and has focused on the treatment of PTSD and anxiety.

When studied empirically, imagery-based treatments have been found to be effective for adults with PTSD (Arntz, Tiesema & Kindt, 2007; Ehlers & Clark, 2000; Ehlers, Clark, Hackmann, McManus, & Fennell, 2005; Grunert, Weis, Smucker & Christianson, 2007; Kindt, Buck, Arntz, & Soeter, 2007), social phobia (Clark et al., 2006; Wild, Hackmann, & Clark, 2007), snake phobias (Hunt et al., 2006; Hunt & Fenton, 2007), and eating disorders (Cooper, Todd, & Turner, 2007). More recently, researchers have begun to examine the efficacy of imagery-based interventions for depression, again finding them to be effective (Blackwell & Holmes, 2017; Brewin et al. 2009; Dainer-Best, Shumake, & Beevers, 2018; Moritz et al., 2018). This body of work includes studies showing imagery to be effective both as a stand-alone
treatment (Brewin et al., 2009; Grunert et al., 2007; Hunt et al., 2007; Wheatley et al., 2007; Wild et al., 2007) and as part of larger treatment packages (Arntz et al., 2007; Clark et al., 2006; Ehlers & Clark, 2000; Ehlers et al., 2005; Kindt et al., 2007). Preliminary evidence also suggests that the addition of imagery-based techniques to treatments may lower client dropout rates and may be more in line with therapist preferences for treatment approach (Arntz et al., 2007).

**Imagery-Based Treatment in Adolescence**

The small body of research that has examined imagery-based interventions for adolescents has also found them to be effective during this developmental period. Some of this work has evaluated imagery-based treatments for adolescents with chronic nightmares (Krakow et al., 2001), imagery as part of a larger CBT treatment package for 8- through 18-year-olds with PTSD (Smith et al., 2007), and imagery-based cognitive bias modification (CBM) for adolescents with anxiety (Fu, Du, Au, & Lau, 2013). Although these studies found imagery to be a successful means of intervening, they were limited in that they had small sample sizes and did not make comparisons with active treatment controls. Additionally, treatment was often short (i.e., a 1-day workshop in Krakow et al., 2001; one session of CBM in Fu et al., 2013), and long-term treatment effects were not assessed. Thus, little is known regarding efficacy of imagery-based treatments for adolescents.

**Imagery and Depression**

One particularly important area to examine imagery is in the context of adolescent depression. Depression is the leading cause of worldwide adolescent illness and disability (World Health Organization, 2014). In the United States alone, 2.8 million adolescents experience at least one depressive episode each year (Center for Behavioral Health Statistics and Quality, 2014), a rate that represents a fourfold increase in depression prevalence from childhood
Symptoms of depression include persistent depressed or irritable mood, loss of interest or pleasure in activities once enjoyed, problems with sleep, appetite, and attention, feelings of guilt and worthlessness, and suicidality (e.g., Nagar, Sherer, Chen, & Aparasu, 2010). As such, depression causes significant distress and impairment, especially for adolescents who already are confronting the complex social, academic, and physical challenges inherent in this developmental period. Furthermore, adolescent depression increases risk for subsequent mental and physical health difficulties during adulthood, including a 60 to 70% chance of depression recurrence and a higher likelihood of anxiety disorders, substance use disorders, bipolar disorder, suicidality, and cardiovascular problems (e.g., Thapar, Collishaw, Pine, & Thapar, 2012). Consequently, depressed adolescents face not only severe concurrent impairment but also future risk for chronic mental and physical illness.

Identifying factors such as maladaptive imagery that influence the etiology, maintenance, and treatment of adolescent depression is critical for enhancing the efficacy of interventions designed to interrupt these enduring patterns of distress. Without considering imagery, both basic and intervention science likely ignore a substantial proportion of adolescents who process their depressive cognitions in the form of imagery. It remains unknown what proportion of adolescents experience depressive cognitions (e.g., rumination) in imagery versus verbal form, how imagery- and verbally-based depressive cognition may be differentially related to risk for depression in adolescence, and how adolescents may respond to imagery- and verbally-based interventions. These gaps in the literature were addressed by the present study.

The following section details what is currently known about imagery and depression. The sparse research that has been conducted suggests that depression is characterized by impoverished positive imagery but vivid negative imagery and that cognitions common to
depression (e.g., intrusive memories, suicidal ideation, rumination) are commonly imagery-based. Although most research on imagery and depression has focused on adulthood, the few studies that have examined imagery and depression in adolescence will be highlighted throughout.

**Selectively Impoverished Positive Imagery**

Emerging evidence from research with adults suggests that individuals with depression experience less frequent and less vivid positive imagery compared with nondepressed individuals, while their ability to generate negatively valenced imagery remains intact. In the first study of its kind, Stöber (2000) presented a non-clinical sample of undergraduates with a list of negative (e.g., “you will fall badly behind on your work”) and positive (e.g., “you will make good lasting friendships”) future events. Participants were instructed to form an image of each event and then rate the image for the speed with which it came to mind, the vividness of the image, and how detailed their image was (averaged to create a single index of imagery). Increased self-reported depressive symptom severity was associated with lower scores on the index of imagery for positive future events but not negative future events, suggesting the depression may uniquely inhibit one’s ability to vividly imagine positive prospective events.

Holmes, Lang, Moulds, and Steele (2008) replicated and extended Stöber’s work using samples of undergraduates high and low in dysphoria. First, participants completed the same prospective imagery task as in Stöber (2000) in which participants imagined positive and negative future events and rated the vividness of their images. In line with Stöber (2000), Holmes, Lang, and colleagues (2008) found that individuals categorized as high dysphoric reported less vivid positive prospective imagery compared with individuals categorized as low dysphoric. Results also indicated that high dysphoric individuals reported more vivid negative
prospective imagery compared with low dysphoric individuals. Moreover, when depressive symptoms were examined continuously across all participants, higher depressive symptoms were associated with greater vividness when imagining negative future events but were associated with lower vividness when imagining positive future events.

Following this prospective imagery task, Holmes, Lang and colleagues (2008) had participants complete a task in which they formed images of homographs (i.e., words that are spelled the same but have different meanings) that could be interpreted positively or negatively. For example, an item such as “break” could be interpreted to mean “as in broken” or “rest.” Participants rated their image for pleasantness and vividness and described their image to the experimenter who later coded the response as a positive, negative, or ambiguous interpretation of the homograph. Although individuals classified as low and high dysphoric did not differ in their tendency to interpret the homographs as positive, negative, or ambiguous, high dysphorics did describe their positive images as significantly less pleasant than low dysphorics.

Finally, Morina, Deeprose, Pusowski, Schmid, and Holmes (2011) instructed adult participants ($M_{age} = 42.0$ years) to mentally imagine 10 positive and 10 negative prospective events. For each image, participants rated the image’s vividness, the likelihood that the event would actually occur in the future, and the level of emotional arousal elicited by the imagined event. Individuals with major depressive disorder (MDD) rated imagined positive prospective events as less vivid but negative prospective events as just as vivid compared to healthy control participants. All participants in Morina et al. (2011) also completed a self-report measure of the impact of intrusive prospective imagery (i.e., how much this imagery feels like pre-experiencing events, how much they avoid prospective imagery, how arousing prospective imagery tends to be). Depressed individuals reported that imagining future events was overall more impactful
compared with healthy control participants, suggesting that depression may lead some 
individuals to experience their imagery as being more real and arousing. Unfortunately, no 
studies to date have examined these questions in adolescent samples. Replication with adolescent 
samples is needed to determine whether depressed adolescents also struggle with generating 
positive imagery compared with negative imagery, which appears to remain vivid and arousing 
for adults with depression.

**Imagery and Depressive Cognitions**

Although yet to be fully studied in adolescence, there is evidence that maladaptive 
cognitions characteristic of depression can take the form of imagery in adulthood. Moritz and 
colleagues (2014) found that, in a general sense, depressive cognitions can be sensory-rich and 
that depressive cognitions with sensory qualities are associated with more severe depressive 
symptoms compared with verbal depressive thoughts. Their sample of mildly to moderately 
depressed adults (age range: 18-65 years) described the sensory qualities of their cognitions 
when feeling depressed and completed the Sensory Properties of Depressive Thoughts 
Questionnaire (SPD; Moritz et al., 2014), which measures five sensory modalities (visual, 
auditory, tactile, somatic, olfactory, other) of depressive cognitions. Out of the total sample, 
56.5% reported that their depressive cognitions had some kind of sensory qualities, with 27.2% 
of participants reporting that their depressive thoughts were visual. What is more, individuals 
who reported sensory-rich depressive thoughts had significantly more severe depressive 
symptoms, had a greater number of depressive episodes, and had been hospitalized more 
frequently compared with individuals who reported that their depressive cognitions did not have 
sensory properties (i.e., were verbal-only).
These estimates are in line with a series of two studies conducted by Lawrence et al. (2018). In Study 1, 41.2% of healthy undergraduates reported experiencing predominately imagery-based depressive cognitions, while 57.1% reported predominately verbally-based depressive cognitions. In Study 2, 23.8% of undergraduates reported depressive cognitions only in the form of imagery, 38.9% only in the form of verbal thought, and 37.3% in the form of both imagery and verbal thought. Further research has now confirmed that, along with more general depressive cognitions (Lawrence et al., 2018; Moritz et al., 2014), specific types of depressive cognitions (intrusive memories, suicidal ideation, ruminative cognitions) also can take the form of imagery.

**Imagery and intrusive memories.** For one, there is evidence that intrusive memories can be imagery-based in the context of depression (Brewin et al., 2010). Intrusive memories are involuntarily retrieved memories that spontaneously appear in consciousness without deliberate retrieval from long term memory storage (Brewin et al., 2010). Intrusive memories tend to be repetitive, uncontrollable, and especially in the case of individuals with depression, quite distressing (Brewin et al., 2010). Although estimates of the prevalence of imagery-based intrusive memories vary widely across samples with depression [7.4% of depressed individuals in Reynolds and Brewin (1998) to 87% of depressed individuals in Brewin, Hunter, Carroll, and Tata (1996)], studies consistently provide evidence that intrusive cognitions can be experienced in imagery form, at least for adults.

Using a non-clinical sample of undergraduates, Williams and Moulds (2007) interviewed participants about their experience of intrusive memories and had participants describe features of any intrusive memories they experienced in real time during the week following their visit to the laboratory. Participants were asked about the frequency, content, and sensory/emotional
qualities of their intrusive memories. Conducting analyses only with those individuals who did report negative intrusive memories, Williams and Moulds (2007) found that 89.1% of intrusive memories reported in the lab session and 92.3% of intrusive memories reported in real time had sensory qualities of some kind. More specifically, 80.2% of intrusive memories reported in the lab included visual qualities, and 17% were purely visual in nature. When reported in real time, 87.2% of intrusive memories had visual qualities, and 25.6% were purely visual. Extending these findings to a clinical sample of adults (age range: 24-61 years), Patel et al. (2007) found that 44% of their currently depressed sample reported experiencing imagery-based intrusive memories, defined as a visual image complete with surrounding context of a specific event that took place and repeatedly came to mind. An additional 10.26% of the sample reported that their intrusive memories took the form of a “partial visual memory” (e.g., a still image of a person).

Brewin et al. (1996) and Reynolds and Brewin (1998) also conducted a series of studies in which they interviewed adults with depression about their experiences with intrusive cognitions specifically related to past trauma. In Brewin et al. (1996), participants \( M_{\text{age}} = 41 \) years) reported whether they experienced any imagery-based intrusive memories about trauma in the past week and indicated how much distress they felt related to experiencing these intrusive memories. Of participants with depression, 87.1% reported experiencing imagery-based intrusive memories. Brewin et al. (1996) also noted that the mean score on their measure of distress indicated that participants reported “an abnormal level of intrusion and avoidance” related to these imagery-based intrusive memories.

In Reynolds and Brewin (1998), adult participants were asked to describe their most disturbing intrusive memory and indicate whether they experienced that memory as a thought (i.e., in verbal form) or image (i.e., in pictorial form), both immediately after the traumatic event
and currently. Out of those adult participants with depression ($M_{age} = 41$ years), 7.4% indicated that their cognitions were mainly images at the time of the event and 3.7% currently, 18.5% indicated that their cognition was a combination of images and thoughts at the time of the event and 12.9% currently, and 74.1% indicated that their cognition was mainly verbal thoughts at the time of the event and 66.7% currently. Although these estimates of imagery-based intrusive memories are lower than those reported by Williams and Moulds (2007) or Patel and colleagues (2007), this may be due to the fact that Reynolds and Brewin (1998) restricted their inquiry to intrusive memories specific to the experience of trauma.

In addition to the existence of imagery-based intrusive memories, it appears that experiencing imagery-based intrusive memories may exacerbate depression. Although they used a non-clinical sample of adults, Williams and Moulds (2007) had participants not only describe the content and features of their intrusive memories but also self-report the severity of their depressive symptoms on the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996). Increased sensory richness of intrusive memories predicted depressive symptom severity over and above the frequency of intrusive memories. This finding was replicated in a subsample of individuals who reported elevated levels of depressive symptoms (i.e., BDI-II score $\geq 12$).

Deeprose and Holmes (2010) also found that severity of depressive symptoms as measured by the BDI-II was significantly and positively associated with prospective increases in intrusive imagery. Further analyses comparing non-dysphoric individuals with individuals experiencing mild dysphoria revealed that individuals with mild dysphoria also reported greater intrusive imagery of future, personally relevant events than non-dysphoric individuals (Deeprose & Holmes, 2010). In addition, Brewin et al. (1996) reported that greater imagery-based intrusive
memories were correlated with longer depressive episodes, suggesting that imagery-based intrusive memories are also associated with more prolonged depression.

Finally, Brewin, Watson, McCarthy, Hyman, and Dayson (1998) compared matched samples of depressed and nondepressed adult cancer patients (age range: 24-81 years). Participants were interviewed about intrusive memories surrounding topics of death and illness and were asked whether any imagery-based memories of death, stressful life events, or childhood trauma came to mind in the past week. Depressed cancer patients reported significantly more imagery-based intrusive memories compared to nondepressed cancer patients, with 65% of the depressed subsample reporting that the onset of their imagery-based intrusive memories coincided with the onset of their depressive symptoms. Greater incidence of imagery-based intrusive memories was positively related to increased feelings of helplessness and hopelessness. Thus, it appears that intrusive memories can be represented in the mind as images and that imagery-based intrusive memories may exacerbate depressive symptoms (and vice versa). No known studies, however, have examined imagery-based intrusive memories in adolescents.

**Imagery and suicidal ideation.** Like intrusive memories, suicidal ideation also has been documented in the form of imagery in adults. Holmes, Crane, Fennell, and Williams (2007) interviewed a sample of adults ($M_{\text{age}} = 41.1$ years) with a history of depression and suicidal ideation or suicidal behavior who had recently completed cognitive therapy. As part of this interview, participants indicated on a checklist whether they had experienced suicidal cognitions surrounding nine topics (e.g., *of what might happen to you if you died; of a time you tried to harm yourself in the past*). For each topic, participants further indicated whether these cognitions took the form of imagery or verbal thoughts. All participants reported experiencing imagery when they felt most intensely suicidal. For all topics, participants were at least as likely to report
that their suicidal cognitions took the form of imagery as they were to report that they took the form of verbal thoughts. For two topics (what might happen if you died; planning or preparing to make a new suicide attempt or harm yourself), participants were significantly more likely to report imagery than verbal thoughts.

Further evidencing the prevalence of imagery-rich suicidal cognitions, Hales, Deeprose, Goodwin, and Holmes (2011) compared suicidal imagery of adults ($M_{age} = 37$ years) with unipolar depression and adults with bipolar disorder. As with Holmes et al.’s (2007) sample, Hales et al. (2011) found that all individuals with unipolar depression reported suicidal imagery when asked about their suicidal cognitions at the time they felt most suicidal. Crane, Shah, Barnhofer, and Holmes (2012) also found that in a sample of adults ($M_{age} = 28$ years) with a history of depression (but who were in remission at the time of the study), 78% of participants who reported any suicidal ideation stated that they experienced suicide-related cognitions in the form of imagery, and 100% of participants who had previously attempted suicide reported suicidal imagery (Crane et al., 2012).

Evidence also suggests that experiencing suicidal ideation in the form of imagery may increase risk for more severe suicidality. In Hales et al.’s (2011) adult sample, participants reported that they were significantly more preoccupied with suicidal imagery compared with suicidal verbal thoughts. Holmes, Crane et al. (2007) also demonstrated that increased preoccupation with suicide-related imagery and increased “realness” of suicide-related imagery were both positively associated with increased scores on a measure of overall suicidality. Together, these findings suggest that for depressed adults, suicidal cognitions very frequently take the form of imagery and that when they do, preoccupation with these vivid, seemingly real images can be associated with increased impairment. In line with Joiner’s model of acquired
capability for suicide (Joiner, 2005), it may be that recurrent images of suicide help individuals, at least in part, to habituate to the pain and fear of suicide, increasing the likelihood of engaging in suicidal behaviors (Crane et al., 2012). Again, however, imagery-based suicidal cognition has yet to be examined in adolescents.

**Imagery and rumination.** One vitally important, but as of yet understudied, area in which to examine imagery is the study of rumination. Rumination, or repeatedly dwelling on negative affect, increases risk for depression in both adults (e.g., Nolen-Hoeksema & Morrow, 1993) and adolescents (e.g., Hankin, 2008; Schwartz & Koenig, 1996). Historically, rumination has been conceptualized as an entirely verbal process (Fresco et al., 2002). Emerging research, however, suggests that rumination, like intrusive memories and suicidal ideation, can also take the form of imagery (Lawrence & Schwartz-Mette, 2018; McLaughlin, Borkovec, & Sibrava, 2007; Newby & Moulds, 2012).

First, rumination and imagery are linked in everyday life. Although not central to their study’s hypotheses, Sloftsra, Eisma, Holmes, Bockting, and Nauta (2017) reported on the relation between rumination and imagery. Trait rumination was positively and significantly associated with trait and state imagery-based processing. The more individuals respond to negative affect with rumination, the more they experienced imagery in their daily lives and the more imagery they reported during an autobiographical memory recall task.

Imagery-based rumination also has been reported in specific clinical groups. Given that imagery has most frequently been examined in PTSD, it is not surprising that the first study to examine imagery-based rumination in a clinical context comes from the PTSD literature. Speckens, Ehlers, Hackmann, Ruths, and Clark (2007) interviewed adults ($M_{age} = 38.3$ years) with PTSD about the verbal and sensory qualities of their ruminative cognitions surrounding
their experience of trauma. Along with other qualities of their ruminative thoughts, participants rated to what extent they experienced imagery as part of rumination. Although ruminative cognitions were most commonly described to be “like a thought” (i.e., verbal), almost half of participants reported that their ruminative cognitions were at least partially sensory in nature. Forty percent reported visual aspects, 20% auditory aspects, and 8% olfactory aspects to their rumination. When questioned further about specific features of their ruminative cognitions, 45% stated that images were “often present” and 36% reported that images were “always present” when dwelling on the traumatic event. Similarly, when dwelling specifically on the consequences of the traumatic event, 39% often experienced imagery and 29% always experienced imagery.

Newby and Moulds (2012) extended these findings on imagery-based rumination to adults with depression. Adults ($M_{age} = 27$ years) with MDD were interviewed regarding various features and topics of their ruminative cognitions. Newby and Moulds found that 52.6% of the adult sample reported that their ruminative cognitions consisted of imagery.

Two studies (Lawrence & Schwartz-Mette, 2018; McLaughlin et al., 2007) have examined imagery and verbal thought in response to induced rumination. McLaughlin and colleagues (2007) had undergraduate participants identify three topics about which they frequently ruminated. Rumination was defined as involving either thoughts (i.e., “words that you say to yourself in your head or talking to oneself”) or images (i.e., “pictures in your mind”). Participants were then instructed to ruminate about the topics they had identified. Every 60 seconds, they were interrupted and asked to describe the content of their rumination at the time and to indicate whether their rumination involved thoughts, images, or both.

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1 Participants could select more than one sensory quality.
In Study 1 with a healthy sample of undergraduates, the authors documented decreases in participant-reported verbal thought from pre- to post-rumination and increases in participant-reported imagery from pre- to post-rumination. Further, during the rumination induction, 60.53% of participants reported that their rumination took the form of verbal thoughts, 35.92% reported imagery, and 3.55% reported neither verbal thought nor imagery. In Study 2 with a sample of undergraduates high in trait rumination and/or worry, McLaughlin and colleagues again found decreases in participant-reported verbal thought from pre- to post-rumination and increases in participant-reported imagery from pre- to post-rumination. During the rumination induction, 70.57% reported that their rumination took the form of verbal thoughts, 27.27% reported imagery, and 2.16% reported neither verbal thought nor imagery.

Lawrence and Schwartz-Mette (2018) also induced rumination, this time in a sample of college students with elevated depressive symptoms. After the induction, participants rated the degree to which they experienced imagery, verbal thought, or neither imagery nor verbal thought on scales ranging from 1 (Not at all) to 9 (Totally). Across two samples, participants reported moderate amounts of imagery during induced rumination (Study 1: $M = 4.75$, Study 3: $M = 4.61$), though these values were significantly lower than the amount of verbal thought reported during induced rumination (Study 1: $M = 6.41$, Study 3: $M = 6.28$).

Finally, only one study has examined how imagery-based rumination may be linked with depression. In Lawrence et al. (2018), undergraduate participants self-reported the extent to which they ruminate, whether they tended to experience depressive cognition as verbal thought or imagery (i.e., depressive cognitive style), and the severity of their depressive symptoms. In Study 1, rumination was similarly associated with depressive symptom severity for individuals who experienced depressive cognition as verbal thought or as imagery. In Study 2, individuals
were also given the option to indicate that they experienced depressive cognition as both imagery and verbal thought. When these individuals were taken into account, depressive cognitive style (imagery, verbal thought, both) significantly moderated the relation between rumination and depressive symptom severity. Those individuals who experienced depressive cognition as only imagery or both imagery and verbal thought were at significantly higher risk compared with those who experienced depressive cognition only verbally. This series of studies suggests that imagery-based rumination is not only common but impairing as well.

Despite emerging evidence that imagery-based rumination exists (Lawrence & Schwartz-Mette, 2018; McLaughlin et al., 2007; Newby & Moulds, 2012; Speckens et al., 2007) and that imagery-based rumination may be particularly detrimental for depressive symptoms (Lawrence et al., 2018), little research has been conducted with youth samples or using methods other than self-report. In fact, only one study (Rood, Roelofs, Bogels, & Arntz, 2012) has examined imagery-based rumination in an adolescent population. As part of a larger study on emotional coping styles in response to stress, Rood et al. (2012) exposed a non-clinical sample of adolescents aged 13 to 18 years to a stress-induction followed by experimental induction of rumination, acceptance, positive reappraisal, or distancing. In addition to rating their affect throughout, participants indicated the extent to which they thought in words or sentences or in images on visual analogue scales (VAS) ranging from 0 to 100. When specifically examining the rumination condition, participants indicated a mean of 52.45 for thinking in words/sentences and a mean of 58.93 for thinking in images, suggesting that adolescents may experience similar levels of imagery and verbal thought when ruminating.

Given that the main focus of Rood et al.’s (2012) study was to compare coping strategies following stress, further analyses were not conducted to determine whether thinking in
words/sentences or images differentially related to response during rumination. Even more importantly, it does not appear that Rood et al. (2012) effectively induced rumination in their adolescent sample given that negative affect actually decreased in the rumination condition. This may not be surprising as Rood et al. (2012) screened out adolescents with depression and used instructions only to “think about the causes of [the] stressful event over and over again, about the consequences, and about how the event moves you.” Previously employed rumination induction procedures use multiple rumination prompts to keep individuals consistently engaged in ruminative cognition. Additionally, prior research has found that rumination inductions cause greater negative affect in individuals already experiencing depressed mood, but not non-clinical samples (e.g., Lyubomirsky & Nolen-Hoeksema, 1995). Further research is clearly needed on imagery- and verbally-based rumination when rumination is actually induced in adolescents.

**Imagery-Based Treatment of Depression**

Just as researchers have begun to pay increased attention to the role of maladaptive imagery-based cognition in depression, a parallel line of research has begun examining the benefits of imagery-based treatments. Although relatively nascent, some research has found imagery-based interventions to be effective in treating depression. Two approaches have been pursued: targeting negative imagery to reduce maladaptive imagery-based cognition and targeting positive imagery to increase adaptive imagery-based cognition.

In terms of reducing negative imagery, three studies have evaluated imagery rescripting as a standalone treatment for adults with depression. Brewin et al. (2009) treated adults (N = 10, \(M_{age} = 41.3\) years) with severe, recurrent depression who reported that they had experienced imagery-based intrusive memories at least once in the past month. Patients were provided with 8 sessions of imagery rescripting. They were guided through modifying their intrusive imagery to
become more accurate and/or helpful and they practiced generating new, more adaptive imagery. Post-intervention, large treatment effects were observed; patients’ depressive symptoms decreased as evidenced by BDI score reductions of 16.60 points on average. These treatment gains were maintained one year post-treatment.

Using the same design, Wheatley et al. (2007) treated two adults ($M_{age} = 42$ years) with depression who reported at least one intrusive image in the past week using only imagery rescripting. Again, both patients experienced significant reductions in depressive symptoms which were maintained at 3-, 6-, and 12-month follow-ups. This series of studies suggests that imagery rescripting may serve as an effective treatment for depression, even in the absence of typical components of CBT for depression such as verbal cognitive restructuring or behavioral activation. Promisingly, effects were also found after a relatively short course of treatment (e.g., an average of 8.1 sessions in Brewin et al., 2009) and persisted over long periods (i.e., one year post-treatment; Brewin et al., 2009; Wheatley et al., 2007). These studies were limited, however, in that they did not have control or comparison groups and used small samples of chronically depressed adults.

To address these limitations, Moritz et al. (2018) randomly assigned 127 adults ($M_{age} = 43.13$ years) with depression to waitlist control, brief imagery rescripting (3369 word manual), or long imagery rescripting (4959 word manual). In contrast to previous trials of stand-alone imagery rescripting for depression (Brewin et al., 2009; Wheatley et al., 2007), Moritz et al. employed a self-help, at-home version of the intervention. Participants in the treatment conditions were emailed either a brief or long version of an imagery rescripting manual that detailed how to bring to mind intrusive imagery and then use imagery to protect/comfort themselves or resolve the imagery using a more pleasant or adaptive ending. Specific exercises
included “time travel” to the past to resolve intrusive imagery-based memories and “imaging a brighter future” to increase positive prospective imagery. Six weeks later, treatment effects were assessed. All groups experienced significant reductions in depressive symptoms and increases in self-esteem, but only the long imagery rescripting group was statistically superior to the control group. This indicated that comprehensive imagery rescripting instruction is effective in treating depression over and above waitlist comparisons, even in the absence of therapeutic contact. Notably, the long version of the imagery rescripting manual also was rated as helpful by patients; 85.7% of patients in the long imagery rescripting group reported that they felt that treatment improved their depressive symptoms (compared to 56% of participants in the brief imagery rescripting group) with 90.5% of these participants reporting that they would use imagery rescripting in the future.

Additional studies have attempted to treat depression by increasing positive imagery. Blackwell and Holmes (2017), for example, presented a case study of an adult with recurrent depression (gender and specific age not reported) treated with 12 sessions of internet-based positive imagery training. For the first 6 sessions, the patient imagined audio recordings of everyday scenarios that started ambiguously but ended positively (e.g., “As you are getting dressed in the morning you think about the day ahead. You anticipate it with pleasure and feel full of energy.”) and was instructed to imagine themselves actively involved in each scenario and to focus on the positive outcome. In the second six sessions the patient viewed ambiguous images that were paired with positive word captions and was instructed to generate a mental image that combined the presented image with the word caption. Post-treatment, the patient experienced significant reductions in depressive symptoms (falling in the “minimal” range at
post-treatment) and increased positive imagery abilities. Additionally, the patient reported increased behavioral and social engagement. Gains were maintained at 3-month follow-up.

Using a larger sample ($N = 87$), Dainer-Best, Shumake, and Beevers (2018) randomly assigned adults ($M_{age} = 26.45$) with moderate or severe depressive symptoms to Positive Self Reference Training (PSRT) or control training (NTC). Both conditions were computerized mental imagery training interventions delivered via the Internet. In the PSRT condition participants practiced imagining their involvement in positive future events. In the NTC condition participants practiced imagining neutral locations or objects. Participants completed 10-16 training sessions across a two-week period. Dainer-Best et al. (2018) found that participants in the PSRT condition experienced increases in positive self-referent processing relative to participants in the NTC condition, as intended by the intervention. There were not, however, differences between conditions in changes in negative self-referent processing or depressive symptoms post-intervention. Thus, computerized imagery training paradigms such as PSRT may be effective in altering the cognitions they specifically target (in this case positive self-referent processing), but they may not generalize to other forms of imagery-based cognition.

Linke and Wessa (2017) employed a similar design, assigning adult females ($M_{age} = 23.80$ years) to computerized imagery training or waitlist control. The imagery training involved training positive associations with pleasurable activities and food stimuli. Participants completed the imagery training for eight 15-minute sessions every other day for two weeks. Although the intervention had no immediate effects on affect ratings from pre- to post-training session, compared to participants assigned to waitlist control, participants who received imagery training experienced greater approach towards positive activities and larger reductions in depressive symptoms. As in Dainer-Best et al.’s (2018) study, the computerized imagery training had
specific effects on targeted processes (in this case engagement in pleasurable activities), but the training also generalized to overall depressive symptoms.

Although these studies suggest that imagery-based treatments may be effective for treating depression, it is important to consider whether imagery- or verbally-based interventions may be most effective. This is especially the case given that verbally-based interventions are most typically used in CBT. In order for the field to shift towards using more imagery-based approaches, there must be evidence that they provide benefit over the current standard of care.

**Comparing imagery- and verbally-based interventions.** Few studies have directly compared imagery- and verbally-based interventions. Holmes, Arntz, and Smucker (2007) theorized that if imagery results in greater positive affect than verbal thought, imagery-based interventions should be more effective in relieving depressed mood compared with verbally-based interventions. Although little work has been done to empirically substantiate this idea, what research has been conducted suggests that imagery-based interventions may in fact be more effective than verbally-based interventions.

In the first study to compare imagery- and verbally-based interventions, Jacob et al. (2011) assigned women ($N=17$, $M_{age}=27.9$) with borderline personality disorder (BPD) to watch videos that were either stress-inducing or neutral after which they either imagined a positive memory, imagined being soothed, verbally distracted themselves, or completed a neutral counting task. After neutral videos, positive affect increased only in women who imagined a positive memory or imagined being soothed. After negative movies, positive affect increased significantly more for women who imagined a positive memory or imagined being soothed relative to women who verbally distracted themselves or completed the neutral counting task.
Thus, it appears that imagery-based strategies may be more effective in helping individuals recover from negative affect relative to verbal strategies, at least for women with BPD.

Three studies have since extended these findings to adults with depression, all of which compared imagery- and verbally-based CBM procedures. CBM involves use of computerized training to modify interpretation biases inherent in depression. Imagery-based CBM involves training individuals to use imagery to interpret ambiguous situations more positively. Verbally-based CBM similarly involves increasing positive interpretations but using mental verbal sentences instead.

First, Torkan and colleagues (2014) provided depressed Iranian adults \((N = 39, M_{\text{age}} = 26.40\text{ years})\) with one week of either imagery-based CBM, verbally-based CBM, or no treatment. After treatment, individuals in the imagery-based CBM had greater improvements in depressive symptoms compared with individuals in the verbally-based CMB or no treatment conditions, with gains maintained after 2 weeks. Blackwell et al. (2015) extended the duration of CBM treatment, with depressed individuals \((N = 150, M_{\text{age}} = 35.46\text{ years})\) completing 12 sessions of computerized CBM training done at home across a 4 week period. Imagery-based CBM improved anhedonia and reduced depressive symptoms compared to verbally-based CBM, but only for participants who reported fewer than five depressive episodes. Finally, Renner et al. (2017) replicated these results, finding that depressed adults \((N = 150; M_{\text{age}} = 35.49\text{ years})\) experienced significantly more rapid decreases in depressive symptoms after completing 4 weeks of imagery- compared with verbally-based CBM.

Although these studies provide some evidence that imagery-based interventions may be more effective in treating adult depression compared with verbally-based interventions, they are limited in important ways. Namely, they employed computerized CBM training rather than in-
person therapeutic techniques traditionally used in CBT, and they were confined to solely adult samples. No work has compared imagery- and verbally-based interventions in adolescents.

It is now clear that imagery plays a role in many forms of psychopathology, including depression. Maladaptive imagery-based cognitions are associated with increased risk for depression, and imagery-based intervention techniques may be especially effective in relieving depressive symptoms. The focus of the remaining discussion is on how imagery may impact the experience of rumination, a particularly prominent risk factor for depression, and distraction, a more adaptive alternative.

**Rumination and Depression**

Rumination provides a particularly interesting venue in which to examine imagery given the strong ties of rumination with depression. Nolen-Hoeksema’s response styles theory of depression (Nolen-Hoeksema, 1987, 1991) posits that the ways in which individuals respond to depressed mood influence their risk for depression. Repetitive focus on depressed mood, on depressive symptoms, and on the causes and consequences of those symptoms (i.e., rumination) results in more prolonged and severe depression. Given that depressed individuals already experience a bias toward recalling negative information and making negative attributions, rumination results in a problematic cycle in which depressed individuals are inclined to focus their attention on their negative mood and associated negative cognitions. Continually replaying these negative cognitions then further exacerbates negative mood (Lyubomirsky & Nolen-Hoeksema, 1995). Repetitively rehashing negative cognitions also hijacks the cognitive resources (e.g., attention, concentration, working memory) necessary to engage in more adaptive distraction or problem solving, further increasing risk for depression (Morrow & Nolen-Hoeksema, 1990). It is therefore not surprising that both trait rumination (i.e., the general
tendency to respond to stress with rumination) and state rumination (i.e., the act of ruminating in response to a stressor) are associated with increased severity of depressive symptoms both concurrently and over time in adult and adolescent samples. The following section outlines current knowledge on the relations between rumination and depression, highlighting rumination as a prominent risk factor for depression in both adulthood and adolescence.

**Rumination and Depression in Adulthood**

Rumination has most comprehensively been studied in adulthood, with a vast research base evidencing the association between rumination and depression with adult samples (e.g., Nolen-Hoeksema & Morrow, 1993). Concurrently, increased trait rumination is consistently associated with greater depressive symptom severity (for reviews see Lyubomirsky & Tkach, 2004; Nolen-Hoeksema et al., 2008; Smith & Alloy, 2009; Thomsen, 2006). Having a ruminative response style also puts individuals at risk for later depression. Just and Alloy (1997), for example, found that nondepressed undergraduates with a tendency to ruminate in response to negative mood were more likely to experience a depressive episode in the following 18 months compared with those who tended to distract themselves from negative mood.

In a longitudinal study, Nolen-Hoeksema and Morrow (1991) also found that undergraduates who reported a ruminative response style had increased depressive symptoms both 10 days and 7 weeks following a life stressor (i.e., the San Francisco Bay earthquake in 1989) compared with those who did not have a ruminative response style. Similarly, Nolen-Hoeksema, Parker, and Larson (1994) found that following the death of a loved one, adults ($M_{age} = 51$ years) with a ruminative response style experienced greater increases in depressive symptoms and more prolonged depressed mood 6 months later compared with individuals who had also experienced a loss but did not have a ruminative response style. In Kuehner and
Weber’s (1999) study, depressed adult inpatients (age range: 18-65 years) completed the Response Styles Questionnaire while in the hospital as well as 4 weeks and 4 months after they were discharged. Greater rumination was associated with greater depressive symptoms and a higher likelihood of receiving a diagnosis of MDD at follow-up.

Rumination also prolongs depressed mood in adulthood. Nolen-Hoeksema, Morrow, and Fredrickson (1993) had healthy undergraduates report on their mood and how they responded to negative mood for 1 month. Participants indicated whether they had felt sad or depressed in the previous 24 hours, rated how severe this mood was and how long it lasted, and selected their response to this mood from a list of 16 possible ruminative responses and 16 possible distracting responses. The more participants responded to their negative affect with rumination, the more frequently they experienced days characterized by long-lasting severe depression, the longer their depression lasted each day, and the longer the duration of episodes of depressed mood were. Thus, findings consistently show that rumination exacerbates depression in adulthood, both in terms of severity and duration.

**Rumination and Depression in Adolescence**

Although most studies examining links between rumination and depression have been conducted with adult samples (see Rood, Roelofs, Bögels, Nolen-Hoeksema, & Schouten, 2009 for discussion), rumination has also been shown to be impairing for adolescents. Developmental change during adolescence results in greater likelihood and ability to engage in the self-reflective, introspective cognition inherent in rumination (Schwartz & Koenig, 1996). It is therefore not surprising that, as in adulthood, rumination has also been shown to predict depression in adolescence (e.g., Abela & Hankin, 2011; Hankin, 2008; Park et al., 2004).
First, trait rumination is consistently associated with concurrent depressive symptom severity. Greater rumination was related to greater concurrent depressive symptom severity in samples of nonclinical 11- to 17-year-olds (Hankin, 2008), 12- to 17-year-olds (Muris, Roelofs, Meesters, & Boomsma, 2004), 12- to 18-year-olds (Muris, Fokke, & Kwik, 2009), and 14- to 18-year-olds (Schwartz & Koenig, 1996). Schwartz and Koenig (1996) also found that when groups of high and low ruminators and high and low dysphorics were derived based on median splits of rumination and depression scores, the highest level of depressive symptoms was found in those adolescents who were high on rumination and low on distraction, while the lowest level of depressive symptoms was found in those adolescents who were low on rumination and high on distraction. Rood, Roelofs, Bogels, Nolen-Hoeksema, and Schouten (2009) conducted a meta-analytic review of studies examining the association between rumination and depressive symptoms in youth in an effort to summarize findings across studies on rumination in adolescence. When rumination and depression were examined concurrently, the mean effect size ($r = .48$) indicated that the strength of the relation between rumination and depressive symptom severity is, on average, moderate to high in adolescence.

Additional research also has found rumination to predict depressive symptom severity over time; adolescents who tend to have a ruminative response style are more likely to experience future depressive symptoms compared with adolescents who do not tend to respond to depressed mood with rumination (Abela, Brozina, & Haigh, 2002; Broderick & Korteland, 2004; Burwell & Shirk, 2007; Schwartz & Koenig, 1996). In the first study to empirically test the response styles theory of depression in adolescence, Schwartz and Koenig (1996) had high school students (age range: 14-18 years) complete measures of emotional adjustment and trait rumination (i.e., the Response Styles Questionnaire; Nolen-Hoeksema, Morrow, & Fredrickson,
1993) at three time points, each two weeks apart. Greater rumination predicted both increased concurrent and more severe future depressive symptoms 6 weeks later, even after initial levels of depressive symptoms were controlled.

Hankin (2008) replicated these findings over a longer, 5-month period. Adolescent participants (age range: 11-17 years) completed measures of rumination (i.e., the Children’s Response Styles Questionnaire; Abela, Rochon, & Vanderbilt, 2000) and depressive symptom severity (i.e., the Children’s Depression Inventory; Kovacs, 1992) at four time points. Again, baseline rumination was significantly associated with severity of depressive symptoms prospectively across 5 months. Rumination also predicted fluctuations in depressive symptoms, such that changes in depressive symptoms across time points reflected similar changes in degree of rumination (Hankin, 2008).

Roelofs et al. (2009) further extended this work, examining the ratio of rumination versus distraction in response to depressed mood. A sample of 10- to 17-year-olds completed measures of rumination, distraction, and depression at baseline and 8 to 10 weeks later. Greater rumination relative to distraction was associated with increases in depressive symptoms whereas greater distraction relative to rumination was associated with decreases in depressive symptoms. The tendency for rumination to prospectively predict depressive symptoms in adolescence has since been replicated in a sample of 4th through 6th graders followed over three years (Broderick & Korteland, 2004), 11- to 15-year-old females followed over four years (Nolen-Hoeksema, Stice, Wade, & Bohon, 2007), and 12- to 15-year-olds followed over the transition to high school (Burwell & Shirk, 2007). In their meta-analysis, Rood et al. (2009) pooled findings to estimate the mean strength of the relation between rumination and depressive symptoms over time. When rumination and depression were examined longitudinally, the pooled effect size was moderate
(ranged from $r = .30$ to $r = .32$ depending on length of time to follow-up), suggesting that rumination both concurrently and prospectively predicts depression in adolescence.

**Gender Differences in Rumination**

Gender differences in rumination suggest that rumination may function differently for males and females. Nolen-Hoeksema’s Response Styles Theory (Nolen-Hoeksema, 1987; 1991) was originally formulated to help account for gender differences observed in depression, in which females are more susceptible than males (Kuehner, 2003; Nolen-Hoeksema, 1990). Nolen-Hoeksema theorized that women may be more prone to depressive disorders because they have a greater tendency to ruminate in response to depressed mood compared to men, who were less susceptible due to their tendency to use distraction when feeling sad or down (e.g., Rood et al., 2009). In line with this theory, most studies find higher rates of rumination in females than males both in adulthood (e.g., Butler & Nolen-Hoeksema, 1994; Nolen-Hoeksema, Larson, & Grayson, 1999; Nolen-Hoeksema, Morrow, & Fredrickson, 1993; Rood et al., 2009) and in adolescence (e.g., Broderick, 1998; Grant & Compas, 1995; Hankin, 2008; Hilt, McLaughlin & Nolen-Hoeksema, 2010; Jose & Brown, 2008; Muris et al., 2004; 2009; Schwartz & Koenig, 1996). In addition to rumination being more prevalent in females than males starting in adolescence, rumination has been found to at least partially account for gender differences in risk for depression in adolescent and adult samples (Hankin & Abramson, 2001; Jose & Brown, 2008; Nolen-Hoeksema, 1994; Nolen-Hoeksema et al., 1999; Schwartz & Koenig, 1996). Thus, it appears that although rumination is detrimental for both male and female adolescents and adults, it is especially impairing for females.
Imagery- and Verbally-Based Rumination and Distraction

It is now clear that rumination is strongly associated with depression (e.g., Abela & Hankin, 2011; Hankin, 2008; Lyubomirsky & Tkach, 2004; Nolen-Hoeksema et al., 2008) and that rumination may be experienced as verbal thought or as imagery (Lawrence & Schwartz-Mette, 2018; McLaughlin et al., 2007; Newby & Moulds, 2012; Speckens et al., 2007). It also has been demonstrated that imagery-based interventions can be effective in treating depression (Blackwell & Holmes, 2017; Brewin et al., 2009; Dainer-Best et al., 2018; Linke & Wessa, 2017; Moritz et al., 2018; Wheatley et al., 2007), and may be even more impactful compared with verbally-based treatments (Blackwell et al., 2015; Renner et al., 2017; Torkan et al., 2014).

What remains unclear, is whether response to imagery- and verbally-based rumination varies in adolescents and how adolescents may differentially benefit from imagery- and verbally-based interventions. To begin to address these gaps, the current study examined affective, physiological, and cognitive response to imagery- and verbally-based rumination and distraction in an adolescent sample.

What evidence does exist comparing imagery and verbal thought suggests that imagery is more affectively arousing, physiologically impactful, and cognitively realistic and vivid. This suggests that imagery-based rumination may be even more impairing than verbally-based rumination and that imagery-based distraction may be more effective than verbally-based distraction. The following review outlines affective, physiological, and cognitive correlates of rumination and distraction, with discussion of how imagery and verbal thought may differ along these dimensions. Where possible, the sparse research that has been done with adolescent samples will be highlighted.
Affect

Affectively, rumination increases negative mood via perseveration on negative cognition. When experimentally induced, rumination increases and maintains negative affect (McLaughlin et al., 2007; Morrow & Nolen-Hoeksema, 1990; Nolen-Hoeksema & Morrow, 1993; Vickers, & Vogeltanz-Holm, 2003). Distraction, on the other hand, reduces negative affect and improves mood by drawing attention away from negative stimuli (e.g., Joormann & Siemer, 2004). Evidence for rumination’s negative impact on affect and distraction’s positive impact on affect has been found in both adult and adolescent samples.

Affective response to rumination and distraction in adulthood. Rumination consistently maintains and/or worsens negative affect in adults. In one of the first studies to experimentally compare induced rumination and distraction in adulthood, Nolen-Hoeksema and Morrow (1993) randomly assigned depressed and nondepressed undergraduates to rumination or distraction. In the rumination condition, participants were presented with prompts that focused them on their emotions and symptoms (e.g., Think about what your feelings might mean). In the distraction condition, participants were presented with prompts that focused the participant externally (e.g., Think about the layout of the local shopping center). Depressed participants who were assigned to ruminate experienced greater increases in depressed affect compared with depressed participants who were assigned to distraction, or nondepressed participants who were assigned to either rumination or distraction (the three later groups did not differ in affect change). Thus, rumination was shown to worsen depressed affect for those individuals already experiencing negative affect. Distraction, on the other hand, relieved negative affect relative to rumination for those individuals with depression.
Lyubomirsky and Nolen-Hoeksema (1995) replicated these findings across three studies where dysphoric and nondysphoric undergraduate participants were exposed to the same ruminatin/distraction induction. As in Nolen-Hoeksema and Morrow (1993), dysphoric participants assigned to the rumination condition reported greater dysphoria than participants in the other three groups (dysphoric distraction, nondysphoric rumination, nondysphoric distraction), who did not differ from one another. Similarly, McLaughlin et al. (2007) found that, in two studies with a healthy undergraduate sample and a sample of undergraduates classified as high ruminators, induced rumination resulted in increases in negative affect, decreases in positive affect, and increases in feelings of both anxiety and depression. No comparisons were made between rumination and distraction, however.

Using ecologically valid methodology, Moberly and Watkins (2008) further extended this work, conducting an experience-sampling study. Undergraduate students rated their negative affect and the degree to which they were engaging in ruminative self-focus eight times per day for one week. Participants who were higher in trait rumination were more likely to ruminate during the week and experienced higher negative affect throughout the week.

Rumination also maintains negative affect relative to distraction once it has been induced. In a healthy sample of undergraduates induced to feel sad, rumination prevented remediation of negative affect more so than distraction (Morrow & Nolen-Hoeksema, 1990). Healthy participants read a depressing story while listening to sad music to induce negative affect. Next, they were randomly assigned to condition in a 2 (distraction, rumination) X 2 (active, passive) design. In passive conditions, participants sat and thought about prompts that were either self- and emotion-focused (rumination condition; e.g., I often wonder why I feel the way I do) or externally-focused (distraction condition; e.g., Canada’s biggest industry is lumber). In active
conditions, participants sorted cards with prompts on them into categories that were placed around a room so participants were forced to stand and walk. In the rumination condition, cards were sorted based on affect (negative, positive, neutral). In the distraction condition, cards were sorted based on how industrialized countries were. Participants assigned to ruminate following the negative mood induction maintained their negative affect to a greater extent than participants assigned to distraction conditions who recovered to baseline affect. This was particularly the case for participants who ruminated passively, as they experienced the least amount of remediation of negative affect compared with all other conditions. Thus, it appears to be well-established that relative to distraction, rumination increases or maintains negative affect in adulthood.

**Affective response to rumination and distraction in adolescence.** Adolescence is a developmental period characterized by heightened emotional instability and reactivity (e.g., Hare et al., 2009). Longitudinal research also finds that negative affect increases across early adolescence and then remains stably high through 18 years of age (Larson, Moneta, Richards, & Wilson, 2002). It appears that underlying these experiences of emotional lability and potential negativity during adolescence may be still-developing emotion regulation capabilities (Silvers et al., 2012).

Rapid changes in neural systems responsible for emotion regulation occur during adolescence (Giedd, Keshavan, & Paus, 2008). In particular, maturation of the amygdala and prefrontal cortex appear central. The amygdala plays a role in emotional reactivity and emotional learning (Gallagher & Chiba, 1996) and the prefrontal cortex (PFC) is implicated in emotion regulation (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015). Developmentally, there appears to be an imbalance between neural systems responsible for emotional reactivity (i.e., the amygdala) and emotion regulation (i.e., the PFC) during adolescence, such that development of the PFC
lags behind that of the amygdala (e.g. Casey, Jones, & Hare, 2008; Somerville & Casey, 2010). As a result, adolescents may experience high levels of emotional reactivity (i.e., greater amygdala reactivity to emotional stimuli in adolescence compared with childhood or adulthood; Hare et al., 2009) without fully-formed cognitive capabilities to appropriately and effectively regulate those emotions.

It is therefore not surprising that rumination, conceptualized as a maladaptive attempt to regulate emotion, increases negative affect in adolescent samples as it does in adult samples. Aldao, McLaughlin, Hatzenbuehler, and Sheridan (2014), for example, examined the relation between trait rumination and affective response to a stressor. Adolescents (age range: 13-17) reported on the degree to which they ruminated in general and completed the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). Adolescents had 5 minutes to prepare their speech, which they then gave in front of two evaluators who provided mildly negative feedback. After their speech, they completed a subtraction task out loud in front of the evaluators. The higher adolescents were in trait rumination, the greater negative affect they experienced in response to the stressor (i.e., the TSST paradigm).

Additional research likewise has found induced state rumination to result in negative affect in adolescents. Park et al. (2004) compared affective response to rumination and distraction in adolescents. In a counterbalanced, within-subjects design, 12- to 17-year-olds completed both rumination and distraction inductions approximately 2 weeks apart. Using the rumination/distraction induction developed by Nolen-Hoeksema and Morrow (1993), participants were instructed to think about a series of prompts designed to either focus attention on emotions and symptoms (rumination) or focus attention externally (distraction). Prompts used were similar to those employed previously in samples of adults (e.g., Lyubomirsky & Nolen-
Hoeksema, 1995; Nolen-Hoeksema & Morrow, 1993), though two prompts were removed as they were difficult for adolescents to understand during a pilot study. In both conditions, participants read and thought about the prompts for 8 minutes. Before and after the induction, participants provided an ‘in the moment’ rating of their sad/depressed mood on a VAS from 0 to 100. Park et al. (2004) found that both depressed and healthy adolescents experienced significantly greater increases in depressed affect when induced to ruminate compared to when induced to distract themselves. This finding held for adolescents both with current depression and partially remitted depression.

Ottaviani et al. (2017) also had youth (age range: 7 to 12 years) complete a rumination induction in which they read sad vignettes and described a time a similar sad event happened to them. To determine whether youth continued to ruminate after this task, they then completed a tracking task during which they reported on their thoughts. Specifically, youth were instructed to follow a white circle on the screen and press the space bar when the circle turned red. At random intervals during this task, youth reported on whether they were focused on the task, distracted, or ruminating. Ottaviani documented a significant increase in sadness from pre- to post-rumination induction. Additionally, continuing to ruminate during the tracking task was associated with greater sadness and less happiness compared with focusing on the task. Together, these studies demonstrate that both trait and state rumination are in fact associated with increased negative affect in adolescence as in adulthood, especially relative to alternate, more adaptive processes such as distraction. Next, differences in affective response to imagery and verbal thought are discussed to aid in determining whether affective response to imagery- and verbally-based rumination and distraction may differ.
Affective correlates of imagery versus verbal thought. Compared with verbal thought, imagery acts as an emotional amplifier. Negative imagery elicits greater negative affect compared with negative verbal thought, and positive imagery elicits greater positive affect compared with positive verbal thought. First, research relevant to negative affect is highlighted.

Aversive imagery is consistently shown to intensify negative emotion relative to verbal thought. Mathews et al. (2013), for example, found imagery to be more strongly associated with unpleasantness compared with verbal mental sentences. Researchers presented undergraduate participants with negative word captions, one-third of which were followed by a corresponding picture, one-third with instructions to imagine the word caption, and one-third with instructions to construct a descriptive sentence of the word caption. Participants rated each picture, mental image, or constructed sentence for pleasantness. Across two experiments using this procedure, negative word captions that were imagined were rated as more unpleasant compared with constructed descriptive sentences. These findings suggest that negative images may be more aversive than negative verbal thoughts. Mathews et al. (2013) did not, however, test whether the experience of negative imagery resulted in greater change in negative affect compared with the experience of negative verbal thoughts.

To address this gap, Holmes and Mathews (2005) conducted a series of studies comparing affective response to imagery and verbal thought. In Experiment 1, adult participants ($M_{age} = 46.2$ years) listened to threatening, emotionally negative event descriptions. While listening, participants were randomly assigned to either imagine the event or think about the verbal meaning of the event. Participants in the imagery condition experienced greater increases in anxiety compared with participants in the verbalize condition. More specifically, participants instructed to imagine the unpleasant events experienced a significant increase in anxiety after
imagining the event descriptions, whereas participants instructed to process the events verbally did not experience a significant change in anxiety. In Experiment 2, the same methodology was employed, but adult participants ($M_{age} = 45.5$ years) listened to either benign or unpleasant event descriptions. Holmes and Mathews (2005) replicated findings from Experiment 1 for unpleasant events (i.e., greater increases in anxiety for participants in the imagery condition compared with those in the verbal condition), but no difference between conditions was found for processing benign events.

In response to concerns that previously employed methodology used verbal instructions and verbal event descriptions (which inherently involve verbal processing) Holmes, Mathews, Makintosh, and Dalgleish (2008) designed a study in which adult participants ($M_{age} = 36.56$ years) were presented with both pictures and word captions concurrently. Participants saw a series of picture and word combinations that were designed such that the combination suggested a negative outcome (e.g., a picture of stairs and the word “fall”). Participants were then instructed to mentally combine the picture and caption. No explicit instructions were given on how to integrate (i.e., using imagery or verbal thought) to capture natural preferences for encoding information as imagery or verbal thought. Participants then rated each picture-word combination for extent of imagery experienced, extent of verbal thought experienced, and the emotional intensity of the constructed image/verbal thought. As predicted, those participants who self-reported greater use of imagery when combining the picture and word caption also reported higher emotionality, whereas use of verbal representations was not associated with participant ratings of emotionality.

Study 2 extended these findings, experimentally manipulating whether participants ($M_{age} = 48.8$ years) were instructed to produce an image or verbal sentence to combine the picture with
its caption. Again, participants were presented with picture-word combinations though this time half were intended to be negative and half were designed to be benign. Participants then rated the emotional intensity of the constructed image/verbal thought. Participants who were instructed to use imagery to combine negative stimuli experienced greater negative affect (i.e., increased ratings of anxiety) compared with participants who were instructed to produce a sentence to combine negative stimuli. Holmes, Mathews, et al. (2008) also asked a subsample to describe their cognitions aloud. Holmes et al. found that individuals in the imagery condition described their images as having greater emotion compared with the mental sentences described by individuals in the verbal thought condition.

Only two studies have compared affective response to imagery and verbal thought in the context of rumination. Sloftsra et al. (2017) assigned a sample of adults ($M_{age} = 21.4$ years) to process an aversive autobiographical memory in the form of verbal rumination or imagery. Imagery-based processing of negative memories resulted in greater affective response compared with verbal rumination, but only for those individuals with low depressive symptoms. Thus, for individuals with elevated depressive symptoms, processing negative experiences in the form of imagery or verbal rumination was similarly affectively arousing. Lawrence and Schwartz-Mette (2018) found similar results when comparing affective response to imagery and verbal thought during induced rumination. Using a sample of undergraduate students with elevated depressive symptoms, induced rumination resulted in similar increases in negative affect regardless of the degree of imagery or verbal thought experienced. This again suggests that imagery-based rumination may be just as affectively impactful as verbally-based rumination. The present study tested this question empirically with an adolescent sample.
Importantly, imagery is not just more negative than verbal thought. Imagery acts as a nonspecific emotional amplifier, increasing positive affect relative to verbal thought as well. Next, evidence is highlighted that positive imagery elicits greater positive affect compared with positive verbal thought.

In a follow-up study to Holmes and Mathews (2005), Holmes, Mathews, Dalgleish, and Mackintosh (2006) randomly assigned adult participants ($M_{age} = 38.85$ years) to imagine or verbally process event descriptions, though this time, events were resolved positively. Participants were verbally presented with 100 scenarios with positive resolutions (e.g., *It’s your birthday, and your partner reaches over to you with a present. You open it and feel incredibly happy*) and were randomly assigned to either imagine the event or verbally think about the meaning of the event. After the description, participants rated their subjective experience during the task including the extent to which they used imagery or verbal processing. Participants in the imagery condition reported significantly greater reductions in anxiety and increases in positive affect compared with participants in the verbalize condition, demonstrating that positive imagery increases positive affect more so than positive verbal thought.

Holmes, Lang, and Shah (2009) replicated Holmes et al. (2006). In Experiment 1, they used the same task to assess whether imagery or verbal thought resulted in differential response to positive events. Again, adult participants ($M_{age} = 30.98$ years) were instructed to either imagine the events or think about the event’s verbal meaning. As in Holmes et al. (2006), Holmes et al. (2009) found significantly greater reductions in anxiety and increases in positive affect for the imagery group compared with the verbal thought group.

Holmes and colleagues (2009) also exposed adult participants to a negative mood induction following the task to examine whether imagery versus verbal thought during the task
differentially protected against later negative affect. After a filler task (i.e., music ratings), Holmes et al. had all participants read negative Velten (1968) statements (i.e., negatively valenced sentences) while listening to sad music played at half speed to induce negative mood. Before and after the induction, participants completed the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) and rated their affect on two VAS from 0 to 100, one measuring how “sad” they felt in the moment and one measuring how “happy” they felt in the moment. During the induction, there were no specific instructions as to how participants should process (i.e., they were not told to imagine or think about the verbal meaning of the statements). Compared to the group initially instructed to imagine the positive events, the group initially instructed to verbally process the positive events experienced significantly greater reductions in PANAS scores, significantly greater increases in sadness, and significantly greater decreases in happiness in response to the negative mood induction. Thus, imagining positive events not only results in greater increases in positive affect in the moment, but also protects against later negative affect over and above verbally processing positive events.

Finally, Lawrence and Schwartz-Mette (2018) included a distraction condition in their study evaluating affective response to induced rumination and distraction in depressed college students. Imagery-based distraction was especially effective in relieving negative affect; the more imagery one experienced, the more his/her affect improved. Thus, for depressed individuals, imagery-based distraction may be especially effective in promoting positive affect change compared to verbally-based distraction.

Until the present study, research had yet to compare affective response to imagery versus verbal thought in adolescents. There has been some work evaluating affective response to imagery alone, however. Heyes et al. (2017) assigned male adolescents ($M_{age} = 13.80$ years) to
computerized imagery training in which they imagined positive or a mixture of positive and negative picture-word combinations (e.g., positive: a picture of a smartphone with the words “funny text”; negative: a picture of a smartphone with the words “ignoring me”). Before and after imagery training, adolescents rated their affect. Adolescents experienced significantly greater increases in positive affect following positive imagery training compared with following imagery training that involved a mixture of positive and negative imagery training. Positive imagery may therefore bolster positive affect in adolescents, but no comparisons with positive verbal thought were made. The present study evaluated adolescents’ affective response to both imagery- and verbally-based distraction.

**Implications for imagery- and verbally-based rumination.** It is well-evidenced that rumination increases negative affect through perseveration on negative maladaptive cognitions (e.g., McLaughlin et al., 2007; Morrow & Nolen-Hoeksema, 1990; Nolen-Hoeksema & Morrow, 1993; Park et al., 2004). Adolescents in particular may be especially impacted by rumination given their still developing emotion regulation capabilities (e.g., Ahmed et al., 2015). Additional research indicates that negative imagery results in greater negative affect compared to negative verbal thought (e.g., Holmes & Mathews, 2005; Holmes, Mathews, et al., 2008). The limited research that has compared affective response to imagery- and verbally-based rumination in adulthood has found rumination to be detrimental regardless of the degree of imagery or verbal thought experienced, however (e.g., Lawrence & Schwartz-Mette, 2018). Thus, although it is expected that imagery-based rumination would lead adolescents to experience greater increases in negative affect than verbally-based rumination, it is also possible that rumination in both imagery and verbal form will be found to be affectively impairing. The present study
investigated these possibilities, evaluating affective response to experimentally induced imagery- and verbally-based rumination in adolescents.

**Implications for imagery- and verbally-based distraction.** Research also finds that distraction improves affect relative to rumination (e.g., Nolen-Hoeksema & Morrow, 1993). Providing adolescents with adaptive alternatives to rumination, such as distraction, could help to interrupt cycles of rumination, lowering their risk for depression. Imagery-based distraction may be an especially effective means, given evidence that positive imagery results in greater positive affect than positive verbal thought (Holmes, Lang, & Shah, 2009; Holmes, Mathews, Dalgleish, & Mackintosh, 2006) and that greater imagery during distraction is associated with greater affective improvement (Lawrence & Schwartz-Mette, 2018). The present study tested affective response to induced imagery- and verbally-based distraction in adolescence. Imagery-based distraction was predicted to provide adolescents with greater affective relief compared with verbally-based distraction.

**Gender.** In both adult and adolescent samples, gender moderates the relation between rumination and depressed mood, with stronger associations for females than males (Hankin & Abramson, 2001; Nolen-Hoeksema, 1994). Adult females also experience greater increases in negative affect during rumination compared to adult males (Mor & Winquist, 2002), though this finding did not replicate in the only study to date to examine gender differences in affective response to induced rumination in adolescence (Park et al., 2004). No work has evaluated gender differences in affective response to imagery and verbal thought. Thus, it is unknown whether adolescent males’ and females’ affective response to imagery- and verbally-based rumination and distraction might differ. The present study therefore tested for gender differences in affective response to imagery- and verbally-based rumination and distraction in adolescence. It was
expected that, should gender differences be found, females would experience greater affective response than males and that these gender differences would be exaggerated in response to imagery-based rumination/distraction compared with verbally-based rumination/distraction.

**Physiology**

In addition to increasing negative affect, rumination prolongs physiological response to stress. The autonomic nervous system (ANS) is the body’s regulatory system, which acts predominately unconsciously to control internal functions including heart and respiratory rates. The ANS is further comprised of the sympathetic and parasympathetic nervous systems. The parasympathetic system prepares the body to rest and recover by decelerating bodily functions whereas the sympathetic system prepares the body for “fight or flight” by accelerating bodily functions. Research has linked rumination with autonomic dysregulation, including reduced parasympathetic and increased sympathetic effects on heart rate (e.g., Brosschot & Thayer, 2004). The vast majority of research on physiological response to rumination has been done with adult samples, though what work has been conducted with adolescents suggests that rumination impacts autonomic function during this developmental period as well.

**Physiological response to rumination and distraction in adulthood.**

**Parasympathetic response to rumination.** First, rumination is associated with reduced parasympathetic activity in adulthood. One particularly effective means of capturing parasympathetic response is through measurement of high-frequency heart rate variability (HF-HRV). HF-HRV represents the beat-to-beat fluctuations in heart rate that index cardiac vagal tone, or the contribution of the parasympathetic nervous system to cardiovascular regulation (Laborde, Mosley, & Thayer, 2017; Levy, 1990; Stein, Bosner, Kleiger, & Conger, 1994). From
this point forward, HRV refers to vagally mediated indices of heart rate variability that isolate parasympathetic influence (e.g., HF-HRV).

It is well-established that HRV is associated with emotion regulation. Both are tied with amygdala reactivity and prefrontal control, or in other words, emotional reactivity and efficiency of affect regulation (Williams et al., 2015; Woody, McGeeary, & Gibb, 2014). High HRV is a sign of adaptive, flexible physiological responding to the environment and is correlated with strong PFC modulation of amygdala activity. High HRV is associated with appropriate emotion regulation and good health. Low HRV is correlated with parasympathetic inefficiency and has been interpreted as a sign that functional connectivity between the amygdala and PFC may not be as strong. Low HRV is associated with emotion regulation deficits and increased risk for disorders such as depression (Aldao, Mennin, & McLaughlin, 2013; McEwen, 2003; Sakaki et al., 2016; Thayer, Åhs, Fredrickson, Sollers, & Wager, 2012; Williams et al., 2015).

Rumination is consistently found to be associated with low HRV. An initial approach to examining this relation has been to assess the association between trait rumination and resting HRV. In the first study to evaluate this relation empirically, Woody et al. (2014) recruited adult females with and without a history of depression to respond to measures of trait rumination and depressive symptoms and to complete a 5-minute rest period during which HRV data were collected. In line with hypotheses, higher trait rumination (in particular, brooding rumination) was significantly correlated with lower HRV in the overall sample, though the relation between HRV and rumination was not reported separately based on whether women had a history of depression.

Williams et al. (2015) also examined associations between resting HRV and trait rumination. Pooling data across five studies in which healthy undergraduates participated in a
measure of baseline HRV prior to completing other tasks, Williams et al. found that HRV was inversely related to trait rumination such that higher trait rumination was associated with lower resting HRV. In addition, participants were stratified into groups with high and low resting HRV. Participants classified as having low HRV reported significantly more trait rumination than those participants classified as having high HRV.

Carnevali, Thayer, Brosschot, and Ottaviani (2018) extended these studies by evaluating relationships among trait rumination, HRV, and depression over a three-year period. During the initial lab visit, adult participants ($M_{age} = 23.35$ years) reported on their trait rumination and depressive symptoms and completed a 20-minute resting baseline assessment of HRV. Thirteen and 34 months later participants completed the same self-report measures and also wore a heart rate device for 24 hours to capture HRV. In line with previous work, rumination and depressive symptom severity were each negatively correlated with HRV at all three time points. Additionally, HRV mediated the relationship between initial rumination and later depressive symptoms. This suggests that cardiovascular regulatory abilities, as indexed by HRV, may prospectively predict whether individuals who tend to ruminate go on to later develop depression.

Extending these findings to HRV response to stress, Woody, Burkhouse, Birk, and Gibb (2015) had adult female participants complete the RRS to measure trait rumination and exposed participants to an interpersonal stressor designed to induce social rejection while HRV data were collected. Participants listened to rejection scenarios (e.g., overhearing two friends criticize their appearance) and were asked to imagine themselves in that scenario. Higher self-reported trait rumination (i.e., the brooding subscale of the RRS) was associated with significantly larger
decreases in HRV from baseline to the interpersonal stressor, after controlling for depressive symptoms.

In addition to evidence for a relation between trait rumination and low HRV, research also has found induced state rumination to be associated with reductions in HRV in adulthood. Key, Campbell, Bacon, and Gerin (2008) classified undergraduate women as high or low trait ruminators based on their responses to the Stress Reactive Rumination Scale. Participants then experienced a 10-minute baseline period, 5-minute stressor, and 15-minute recovery period while HRV data were collected. During the stressor, participants gave a speech about a recent stressful negative life event that they “found difficult to stop thinking about.” Participants also reported state rumination using a thought-report technique 5 and 10 minutes after the stressor. This task involved participants writing down one or two words at these time points to remind them what they were thinking about. Then, following the recovery period, participants elaborated on what they were thinking about in those moments, with responses later coded as rumination or not rumination. For low trait ruminators only, those that continued to ruminate 5 and 10 minutes after the stressor experienced less HRV recovery than those who did not continue to ruminate.

A study by LeMoult, Yoon, and Joormann (2017) revealed similar results. Adults (M_{age} = 37.93 years) with and without MDD were induced to ruminate or distract themselves following a forced failure experience. Induced rumination resulted in decreases in HRV for individuals both with and without depression. Counter to predictions, distraction also lowered HRV, though more so for those participants with depression. The authors hypothesized that this latter finding may potentially be due to the cognitive effort associated with distraction.

There are some inconsistencies in findings, however, as other studies have not observed reduced HRV in response to state rumination. In a sample of adult participants, Aldao, Mennin,
and McLaughlin (2013) examined the relation between state rumination and HRV response to film clips designed to elicit fear, happiness, or sadness. Rumination during the task was not specifically manipulated, though participants did report extent of rumination experienced in the moment by completing a rumination VAS. In this case, rumination was not associated with HRV in response to any of the emotional film clips.

Similarly, Ottaviani et al. (2009) examined change in HRV in response to induced rumination with an adult sample. After a 10-minute baseline period, participants completed an anger-rumination task with HRV recording in which they were instructed to “recall an episode in which you felt intense anger or rage (i.e., being insulted, experiencing abusive or unfair treatment, witnessing others receiving unfair or abusive treatment) and think about the causes and consequences of this episode until I tell you to stop.” Again, the rumination task did not elicit significant changes in HRV. Importantly, however, neither Aldao et al. (2013) nor Ottaviani et al. (2009) explicitly induced rumination in response to depressed mood (as defined by Nolen-Hoeksema, 1998), leaving room for additional research on HRV response to state depressive rumination.

**Sympathetic response to rumination.** Rumination also is associated with increased sympathetic response in adulthood. Galvanic skin response (GSR) (also referred to as galvanic skin conductance, skin conductance, and electrodermal activity in the literature) provides one salient marker of sympathetic response to rumination given its sensitivity to sympathetic change. GSR represents change in electrical conductance of the skin generated by sweat on the palms (Gutrecht, 1994). It is considered an index of sympathetic activation given that sweat gland secretions increase during periods of heightened emotional arousal when the sympathetic nervous system stimulates the adrenal catecholamine and cardiovascular systems, preparing the
body to respond (Hansen & Sawatzky, 2008; Jansen, Nguyen, Karpitsky, & Mettenleiter, 1995). Increases in GSR are associated with increased activity in the prefrontal cortex, and in particular areas implicated in emotional reactivity and attention (Critchley, Elliott, Mathias, & Dolan, 2000). As such, GSR has been conceptualized as reflecting emotional arousal (Backs & Boucsein, 2000). High GSR is a sign of increased activation of the sympathetic nervous system and heightened emotional arousal. Low GSR is a sign of decreased activation of the sympathetic nervous system and reduced emotional arousal.

Although far less work has been done on sympathetic response to rumination as compared to parasympathetic response to rumination, some research has found depressive rumination to be associated with increased GSR. Steinfurth, Alius, Wendt, and Hamm (2017), for example, asked healthy adult participants (\(M_{age} = 22.72\) years) to provide written descriptions of personal events or topics that they currently ruminate about, worry about, and consider to be neutral. The researchers subsequently induced participants to worry, ruminate, or think about the events/topics they generated while GSR data were collected. Although GSR response to worry and rumination did not differ, ruminating did elicit a significantly higher GSR response compared with neutral thinking.

A small set of studies has also compared GSR response to induced rumination and distraction. In a sample of college women high and low in anxiety sensitivity, Sigmon, Dorhofer, Rohan, and Boulard (2000) had participants complete an 8-minute rumination/distraction induction. In line with Steinfurth et al.’s (2017) finding, induced rumination was associated with

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\(^2\) Of note, GSR also has been conceptualized as an index of attention (e.g., Critchley et al., 2000). Given the design of the present study, attentional demands could be considered similar across rumination conditions and across distraction conditions, as well as across imagery conditions and across verbal conditions. Thus, GSR is interpreted as an index of emotional arousal in the present study. See the discussion section for further attention to this consideration.
a significantly higher GSR response compared with induced distraction. Similarly, Capobianco, Morris, and Wells (2018) induced college students to ruminate or distract themselves following a stress induction (a modified version of the Trier Social Stress Test). Participants then experienced a 30-minute recovery period. GSR data were captured throughout. Relative to distraction, rumination hindered GSR recovery. As compared to the distraction condition, individuals in the rumination condition experienced prolonged GSR that persisted across the entire 30-minute recovery period. GSR response to rumination is not entirely consistent, however. Vickers and Vogeltanz-Holm (2003) did not find differences in college students’ GSR response to induced rumination and distraction when post-induction GSR was compared to pre-induction GSR.

**Physiological response to rumination and distraction in adolescence.** Few studies have examined physiological response to rumination in adolescence (see Somers, Borelli, & Hilt, 2018 for a discussion). This dearth of research is surprising given that rumination tends to emerge during adolescence, at the same time that ongoing neural development impacts physiological regulation (Patriquin, Lorenzi, Scarpa, & Bell, 2014). The findings from work that has been done on physiological response to rumination during this developmental period have been mixed.

**Parasympathetic response to rumination.** As previously noted, major neural development of the amygdala and PFC occur during adolescence, with the PFC continuing to develop through early adulthood (e.g. Casey et al., 2008; Somerville & Casey, 2010). Given that HRV is thought to index the PFC’s ability to effectively modulate amygdala activity (e.g., Sakaki et al., 2016), HRV may serve as an especially interesting marker of physiological response to rumination in adolescence because of the ongoing brain development that is occurring.
Few investigations to date have examined associations between HRV and rumination in adolescent samples. Additionally, this research has focused predominately on younger age groups and on trait, rather than state, rumination. In one such study, Borelli, Hilt, West, Weekes, and Gonzalez (2014) had youth ($M_{age} = 9.83$ years) self-report the degree to which they tended to engage in rumination and complete a lab session in which they read sad, fear eliciting, or neutral vignettes while HRV data were recorded. After controlling for response to the neutral vignettes, higher trait rumination was associated with significantly greater decreases in HRV in response to the sad vignettes, but not the fear-eliciting vignettes. Thus, it appears that, at least in younger children, higher rumination may be associated with lower HRV in response to sad mood as it is in adult samples.

This finding is not consistently obtained, however. Somers, Borelli, Smiley, West, and Hilt (2015) followed these same youth over approximately two years ($M_{age}$ at 2$^{nd}$ visit = 11.42 years). At the second lab visit, youth participated in an unsolvable puzzle task during which the experimenters captured HRV. After controlling for baseline HRV, trait rumination at Time 1 was not associated with HRV response to this stressful task at Time 2. Similarly, Gentzler, Wheat, Palmer, and Burwell (2013) did not find a significant relation between rumination and parasympathetic response. Youth aged 6 through 14 years ($M_{age} = 9.67$ years) attempted an impossible puzzle task. HRV was collected for the purposes of assessing whether trait rumination was associated with the degree to which youth parasympathetically recovered following the task relative to their baseline HRV. Self-reported rumination was not associated with HRV recovery following the puzzle task.

Using a slightly older population, Somers, Borelli, and Hilt (2018) had 6$^{th}$ and 7$^{th}$ grade students ($M_{age} = 12.68$ years) report on the severity of their depressive symptoms and their
tendency to ruminate. They then watched a baseline nature video followed by completing a sad mood induction in which they wrote about a time they felt sad while listening to sad music. Trait rumination was not significantly associated with baseline HRV or HRV response to the sad mood induction. Again, Aldao et al. (2014) did not find an association between adolescent ($M_{age}$ = 14.9 years) trait rumination and HRV during a stressor (i.e., the Trier Social Stress Test) or during a 5-minute recovery period following the stressor. It is critical, however, that researchers examine physiological response to state, rather than only trait, levels of rumination in this age group.

Vögele and colleagues (2010) did examine HRV response to state rumination in adolescence, though their study induced anger rumination rather than depressive rumination. Adolescents ($M_{age}$ = 14.7 years) were monitored for HRV while they experienced an anger induction (i.e., participants played the Ultimatum Game in which money is split unfairly between players). After the induction, participants completed an open-ended questionnaire in which they reported the cognitions they experienced during the induction. Responses were later coded as cognitive reappraisal (e.g., *Money isn’t everything*) or anger rumination (e.g., *How dare he do this to me*). Adolescents who coped with their anger using rumination had lower HRV during resting baseline and greater declines in HRV during the anger induction compared with adolescents who coped using cognitive reappraisal (i.e., a more adaptive strategy).

Only one known study (Ottaviani et al., 2017) examined HRV response to state depressive rumination in youth. In their previously described study, Ottaviani et al. also captured HRV in addition to affect ratings while youth (age range: 7-12 years) underwent a rumination induction and subsequent tracking task during which they reported whether they continued to ruminate. Youths’ self-reported trait rumination was not significantly associated with baseline
HRV. State rumination was related to HRV response, however. Continuing to ruminate during the tracking task was associated with lower HRV compared with focusing during the task. Youths’ trait rumination was not a significant moderator of these associations, suggesting that state rumination reduces HRV regardless of how much youth ruminate in general. Thus, what evidence does exist regarding the relation between state rumination and HRV in adolescence suggests that rumination is in fact associated with reduced HRV in this age group, even when associations between trait rumination and HRV are not found. The present study contributes additional information on whether state rumination is consistently associated with reductions in HRV in this age group.

**Sympathetic response to rumination.** Even less work has examined sympathetic response to rumination in adolescence. In fact, no known studies have evaluated GSR during induced depressive rumination in this age group. There have been limited other investigations evaluating other markers of sympathetic response that may speak to whether rumination may result in increased GSR. The previously described study by Aldao and colleagues (2014), for example, included pre-ejection period (PEP), a measure of sympathetic nervous system activity, in addition to HRV. Mirroring their findings with HRV, adolescent trait rumination was not significantly associated with PEP during or following a stressor (i.e., the TSST). Additional research is certainly needed, however, to determine whether adolescent rumination is truly not associated with sympathetic response, or whether sympathetic response to rumination mirrors that found in adulthood (i.e., increases in GSR in response to rumination; Sigmon et al., 2000; Steinfurth et al., 2017). Therefore the present study investigated GSR response to imagery- and verbally-based rumination and distraction to clarify sympathetic response in adolescence.
Physiological correlates of imagery versus verbal thought. Despite calls for research on potential differences in physiological response to imagery and verbal thought (e.g., Holmes, Mathews, et al., 2008), few studies have compared parasympathetic or sympathetic response to imagery- and verbally-based tasks. There is some evidence that emotional imagery elicits a strong physiological response and that the physiological response to imagery may be more pronounced than the physiological response to verbal thought. Imagery and verbal thought have yet to be compared on physiological indices in adolescence, however.

For one, there is evidence that more vivid imagery is associated with greater physiological activation compared with less vivid imagery (Miller et al., 1987). Miller et al. grouped undergraduate participants into good imagers (reported that imagery was vivid and frequent) and poor imagers (reported that imagery was vague and infrequent) based on their responses to the Questionnaire upon Mental Imagery. They then recorded participant heart rate, GSR, respiration, and eye movement in response to a task in which participants imagined audiotaped scripts that varied in whether the script was designed to be action-oriented, or to induce fear, anger, or a neutral response.

Most notably, Miller et al. (1987) found that for good-imagers only, the pattern of physiological activity varied based on whether imagining the script elicited action, fear, anger, or was neutral. In particular, for good-imagers, affect-rich scripts induced greater increases in heart rate, relative elevations in GSR, more eye movement, and a shorter respiration period than all other scripts. For poor imagers, the emotional content of the mental image did not matter. Furthermore, training good imagers to mentally imagine the scripts as even more vivid further enhanced good imagers’ differential physiological response to the scripts. Miller et al. therefore provided evidence that good imagers are imagining scripts along with associated emotional
content, which is resulting in differential physiological change. Poor imagers, on the other hand, who may not be able to form a vivid mental image of the scene with its paired emotions, do not experience equivalent physiological response.

What few studies have compared physiological response to verbal thought and imagery suggest that there may also be heightened physiological responses to imagery relative to verbal thought. Reyher and Smeltzer (1968) instructed undergraduates (all male) to imagine or verbally process pairs of words about sex, hostility, or family relationships while GSR data were collected. Reyher and Smeltzer found that men experienced a significantly greater GSR reactivity when they imagined the pairs of words compared with when they verbally processed the pairs of words.

Consistent with these results, Vrana et al. (1989) found visual processing to result in higher heart rate than verbal processing. In the week prior to their lab visit, all undergraduate participants memorized a set of sentences designed to elicit fearfulness. Then, during the lab visit, participants were instructed to process the previously memorized sentences in one of three ways: no processing (i.e., participants were told not to process the sentence), silent articulation (i.e., participants said the sentence to themselves), or imagery (i.e., participants imagined the sentence). Heart rate was measured throughout the task. Imagining the fearful sentences resulted in significantly greater increases in heart rate compared with silently articulating the sentence or not processing the sentence, again suggesting amplified physiological response to imagery compared with verbal thought. Counter to these results, however, Baker and Jessup (1980) found that when dysphoric and nondysphoric undergraduate participants either verbally narrated or imagined depressing, neutral, or pleasant scenarios, there was a higher GSR response to verbal processing compared with visual processing.
Two additional studies (Hyett et al., 2018; Reiss, Warnecke, Tibubos, Tolgou, Luka-Krausgrill, & Rohrmann, 2018) examined physiological reactivity following imagery- and verbally-based interventions. Reiss et al. measured college students’ physiological response to a social evaluative stressor (i.e., the TSST) before and after receiving one of two anxiety interventions (CBT with relaxation training or CBT with imagery rescripting) or a self-help control group. Each consisted of 3-hour group sessions one time per week over five weeks. Counter to expectations, physiological (heart rate and blood pressure) response to the TSST did not differ before and after the intervention for either intervention group relative to the control group.

Hyett and colleagues (2018), on the other hand, did find selectively attenuated physiological reactivity following an imagery-based intervention compared with a verbally-based intervention. They assigned adult participants ($M_{age} = 35.22$ years) with social anxiety disorder to a single session of group imagery rescripting, group verbal restructuring, or a waitlist control condition. In each of the treatment conditions participants rescripted aversive autobiographical memories; in the imagery rescripting condition they did so using visualization and in the verbal restructuring condition they did so using verbal thought challenging. Before and after the intervention, participants experienced a stressor (i.e., the TSST) while HRV and GSR were recorded. Relative to individuals who received verbal restructuring or who were in the waitlist control condition, individuals who received imagery rescripting experienced significantly higher HRV during the TSST following the intervention. This suggests that imagery rescripting promoted more adaptive parasympathetic responding relative to verbally-based interventions. Of note, however, there were no mean level differences in GSR during the TSST post-intervention among conditions suggesting that these differences in physiological responding following
imagery- and verbally-based interventions may not hold for sympathetic indices. Given these mixed results, further research clarifying physiological response to imagery versus verbal processing is clearly needed, especially with adolescents who have yet to be studied in this context. Examination of adolescents’ physiological response to imagery- and verbally-based rumination and distraction, as was done in the present study, helps to fill this gap.

**Implications for imagery- and verbally-based rumination.** In adulthood, rumination is associated with lower HRV, or reduced parasympathetic response (Vögele et al., 2010; Williams et al., 2015; Woody et al., 2014; Woody et al., 2015), and increased GSR, or sympathetic response (Capobianco et al., 2018; Sigmon et al., 2000). The former finding has been replicated in a sample of adolescents (Ottaviani et al., 2017), who experienced lowered HRV when ruminating, but no research has examined GSR response to depressive rumination in adolescents. Although differences in HRV response to imagery versus verbal thought had not been examined until the present study, there is some evidence that imagery may result in higher GSR (Reyher & Smeltzer, 1968) and that imagery is generally more physiologically arousing than verbal thought (Vrana et al., 1989). Thus, it was expected that in the present study’s sample of adolescents, imagery-based rumination would result in lower HRV and higher GSR than verbally-based rumination.

**Implications for imagery- and verbally-based distraction.** Compared with rumination, distraction is associated with a more adaptive physiological response. In adulthood, distraction is related to lower GSR than rumination (Capobianco et al., 2018; Sigmon et al., 2000; Steinfurth et al., 2017), though results regarding HRV response to distraction are more mixed (e.g., LeMoult et al., 2017). In adolescence, there is also some research suggesting that distraction is associated with higher HRV as compared with rumination (Ottaviani et al., 2017) though no research has
evaluated adolescents’ GSR response to distraction. The current study filled this gap, evaluating parasymathetic and sympathetic response to imagery- and verbally-based distraction in adolescence. Given previous findings that imagery elicits a stronger physiological response compared with verbal thought, it was hypothesized that imagery-based distraction would result in higher HRV and lower GSR compared with verbally-based distraction.

**Gender.** There are not consistent differences between males and females in HRV, though when gender differences are found, females tend to have lower resting HRV (Young & Leicht, 2011) and respond to stress with larger decreases in HRV (Li et al., 2009) compared to males. In one of the only studies to date to examine gender differences in HRV response to rumination specifically, Ottaviani et al. (2009) did find that women experienced lower HRV during rumination compared to men. There is also some evidence that females respond to stress (e.g., Carrillo et al., 2001) and negative affect (e.g., Chentsova-Dutton & Tsai, 2007) with higher GSR than males, though these results are mixed (e.g., see also Kreibig, Wilhelm, Roth, & Gross, 2007). The current study helps to clarify gender differences in GSR and HRV response to rumination and distraction in both imagery- and verbal form. If differences were found in the present study, it was expected that females would experience lower HRV and higher GSR (i.e., a more maladaptive physiological response) than males and that these gender differences would be exaggerated in response to imagery-based rumination/distraction compared with verbally-based rumination/distraction.

**Cognition**

Cognitively, rumination is the retrieval and rehearsal of maladaptive cognitions in response to negative affect. Mood disorders in particular are characterized by biases toward, increased elaborations of, and difficulties disengaging from, negative information (e.g., Gotlib &
Joormann, 2010). Thus, rumination serves to activate and elaborate negatively valenced cognitions, leading to increased negative affect as well as a maladaptive physiological response, and as a result, increased risk for depression. Distraction on the other hand, involves retrieval or mental construction of cognitions that distract the individual from negative affect. Distraction serves to activate and hold in mind more neutral or positively valenced cognitions, interrupting or preventing cycles of rumination. In doing so, distraction reduces negative affect, allows for physiological recovery, and may reduce risk for depression.

Adolescence is a critical period for brain development, especially for those areas responsible for higher order cognitive functions (Spear, 2000). In particular, brain regions underlying executive functions of attention, abstract thought, organization, decision making, reward evaluation, and response inhibition experience substantial development throughout this period (Yurgelun-Todd, 2007). Such brain development likely allows for rumination to first occur in adolescence, as rumination requires sustained attention and abstract thought. At the same time, adolescents do not yet have fully developed cognitive capabilities, which may make it challenging to disengage from rumination, or employ distraction, which in itself requires shifting of attention.

Specific characteristics of cognition may make rumination especially affectively and/or physiologically impairing and distraction especially affectively and/or physiologically adaptive. In particular, higher realism and vividness of imagery relative to verbal thought may make imagery-based rumination more harming compared with verbally-based rumination and imagery-based distraction more helpful compared with verbally-based distraction. Next, research evaluating the realism and vividness of imagery and verbal thought are reviewed and implications of imagery- and verbally-based rumination and distraction are discussed.
Cognitive correlates of imagery versus verbal thought. Research with adults finds imagery to be higher in realism and vividness compared with verbal thought. This suggests that imagery may be more affectively and physiologically impactful than verbal thought in part because imagery is experienced as closer to real perception. Until the current study, no research had compared realism and vividness of imagery and verbal thought in adolescents, however.

Realism. First, imagery is perceived to be more realistic than verbal thought. Compared with verbal thought, imagery is consistently found to be more easily confused with reality and is rated as “more real” (see Holmes & Mathews, 2010 for review). In the first study to investigate how realistic images are compared with verbal thoughts, Hyman and Pentland (1996) presented undergraduates with false events from their childhood intermixed with several true events that they had obtained from participants’ parents. Undergraduates were randomly assigned to either repeatedly imagine or “think about” these events. Participants who imagined the false events were significantly more likely to believe the event had actually happened during their childhood (25%) compared with those who simply thought about the event (9%). Thus, the act of repeatedly imagining information appears to increase how real that information is perceived to be.

Two previously described studies (Holmes, Mathews, et al., 2008; Mathews et al., 2013) also included measures of realism. In Holmes, Mathews, et al. (2008), adult participants ($M_{age} = 48.8$ years) either imagined or verbally thought about negative pictures paired with word captions. In addition to rating their affective response to imagery versus verbal thought, participants rated the extent to which their mental combination of the picture and word caption reflected a real autobiographical memory. Across two studies, imagery was associated with greater similarity to an actual memory compared with verbal thought, both when participants
self-reported that they had combined the picture and word caption into an image (Study 1) and when they were instructed to combine the picture and word caption using imagery (Study 2). When asked to describe their thoughts/images aloud, Holmes and colleagues also found that participants’ descriptions of images more closely resembled a real memory compared with descriptions of constructed sentences.

Undergraduate participants in Mathews et al. (2013) were also presented with word captions paired with either a corresponding picture, instructions to imagine the word caption, or instructions to construct a descriptive sentence of the word caption. One day after the initial lab visit, participants were presented with all word captions a second time and asked whether each word caption had previously been presented with a corresponding picture or not. Across two experiments, Mathews et al. found that mental images were more frequently confused with the presentation of a real picture than mentally constructed descriptive sentences. This suggests that imagery is more likely to be confused with past events than verbal thought is.

Compared with verbal thought, imagery also results in a higher likelihood of interpreting future events as likely to occur, at least for adults (e.g., Holmes & Mathews, 2005). For example, studies with adult samples have found that imagining one political party winning an election was associated with increased probability estimates that that political party would in fact win the election (Carroll, 1978; Study 1), imagining a good college football season for a team increased predictions that that team would receive a major bowl bid (Carroll, 1978; Study 2), and imagining symptoms of an illness was associated with higher probability estimates of contracting that illness (Sherman, Cialdini, Schwartzman, & Reynolds, 1985).

Finally, neurocognitive research also supports the notion that imagery is experienced as more realistic than verbal thought. Specifically, the neural mechanisms underlying actual
perception appear to be more similar to those underlying imagery than those underlying verbal processing (see Heyes et al., 2013; Kosslyn et al., 2001 for reviews). Imagery is hypothesized to serve an emulative function in that similar processes are involved in imagining a scenario as are recruited when actually perceiving that scenario (Moulton & Kosslyn, 2012).

Using functional magnetic resonance imaging (fMRI), Ganis, Thompson, and Kosslyn (2004), for example, examined the overlap in brain activation between imagery and perception. Adult participants ($M_{age} = 21$ years) were assigned to either view pictures of objects (perception) or imagine previously studied drawings of the same objects (imagery). Ganis et al. found substantial overlap in activation during imagery and perception, especially in the frontal and parietal regions. In fact, the overall overlap in brain activation across the two conditions was 92%.

O’Craven and Kanwisher (2000) examined more specific patterns of brain activation between imagery and perception for specific types of stimuli. Adult participants (age range: 20-39 years) were scanned with fMRI while either viewing images of famous faces and familiar places (perception condition) or imagining those same faces or places with their eyes closed (imagery condition). Along with finding similar amounts of overall overlap in activation (on average 92% for places, 84% for faces) to Ganis et al. (2004), O’Craven and Kanwisher found selective activation of the fusiform face area (i.e., area of the brain responsible for face perception) both when participants viewed faces and imagined faces and selective activation of the parahippocampal place area (i.e., area of the brain that selectively responds to scenes/landscapes) both when participants viewed and imagined scenes with spatial layouts. Thus, imagery and perception do not just share general neural bases, but rather specific neural mechanisms based on the stimuli perceived or imagined.
**Vividness.** The vividness of imagery and verbal thought also may play a role in affective and physiological response to imagery- and verbally-based rumination and distraction. Although imagery has yet to be explicitly compared with verbal thought in terms of vividness, the vividness of imagery has been found to be associated with increased similarity between the imagery and real perception for adults (Dobson & Markham, 1993; Holmes & Mathews, 2010). Furthermore, more vivid imagery is associated with greater physiological and affective response compared with less vivid imagery in adult samples (Holmes & Mathews, 2010; Miller et al., 1987). Thus, it would be expected that like realism, vividness would enhance affective and physiological response to rumination and distraction. What is more, there is evidence that autobiographical memories become more vivid across childhood and adolescence (Heyes et al., 2013), suggesting that the role of vividness in ruminative and distracting cognition may be especially important to examine during adolescence.

**Implications for imagery- and verbally-based rumination.** Rumination involves repeatedly dwelling on negative cognitions. When ruminative cognitions are realistic and vivid, individuals who ruminate are recurrently exposed to cognitions that feel very “real” and intense. Evidence suggests that imagery is more realistic than verbal thought (e.g., Holmes & Mathews, 2010) and that when vivid, imagery elicits an amplified affective and physiological response compared to when less vivid (Holmes & Mathews, 2010; Miller et al., 1987). Thus, in the present study it was expected that vividness and realism would moderate the relation between rumination condition (imagery- and verbally-based) and maladaptive affective and physiological response, with a larger difference among conditions the more vivid and realistic ruminative cognitions were perceived to be.
Implications for imagery- and verbally-based distraction. Distraction, on the other hand, involves repeatedly dwelling on more neutral or positive cognitions. When distracting cognitions are realistic and vivid, individuals may be less preoccupied by negative affect and less likely to return to cycles of rumination. Given that imagery is more realistic and may be more vivid than verbal thought (e.g., Holmes & Mathews, 2010), vividness and realism were expected to also moderate the relation between distraction condition (imagery- and verbally-based) and adaptive affective and physiological response in the current study, with a larger difference among conditions the more vivid and realistic distracting cognitions were perceived to be.

Gender. Although gender differences in vividness and realism of imagery versus verbal thought have yet to be examined directly, there is some preliminary evidence that when gender differences in imagery abilities are present, females tend to have greater abilities than males (e.g., Kosslyn et al., 1990). This suggests that females may experience imagery as more vivid and realistic than do males.

The Current Study

The current study examined affective, physiological, and cognitive response to rumination and distraction in the form of imagery and verbal thought in adolescents. Rumination results in affective, physiological, and cognitive change that increases risk for depression. Little is known, however, about how dwelling on, or distracting in the form of, imagery or verbal thought may differ across these substrates. What is more, no research has been conducted on response to imagery- and verbally-based rumination and distraction in adolescence, a developmental period during which rumination emerges in earnest and early intervention is key.

This research addresses a substantial gap in the literature, assessing how imagery- and verbally-based rumination and distraction may differ. Primary Aims examined the relationship
between rumination style (imagery, verbal, both) and depressive symptoms (Aim 1) and evaluated affective (Aim 2), parasympathetic (Aim 3), and sympathetic (Aim 4) response to experimentally-induced imagery- and verbally-based rumination and distraction in adolescence.

One secondary aim and a set of secondary hypotheses also were explored. One secondary aim (Aim 5) evaluated realism and vividness as characteristics of ruminative and distracting cognition that may exaggerate differences between imagery- and verbally-based rumination and distraction. Gender differences and effects among those adolescents with elevated depressive symptoms also were tested as secondary hypotheses in the context of Aims 1-4. Examination of imagery- and verbally-based rumination and distraction has the potential to ultimately inform prevention and treatment of adolescent depression.

**Aim 1 (Trait Rumination): Examine Moderating Role of Rumination Style (Imagery, Verbal, Both) on Relation Between Trait Rumination and Depressive Symptom Severity**

Although research has traditionally conceptualized rumination as verbal (Fresco et al., 2002), recent research with adults has revealed evidence for rumination in imagery form. To review, researchers find that between 27.27% and 61.1% of individuals report imagery while ruminating (McLaughlin et al., 2007; Newby & Moulds, 2012; Speckens et al., 2007). Only one study to date (Lawrence et al., 2018) has examined how the relationship between rumination and depressive symptoms may differ depending on whether individuals experience imagery or verbal thought. In this study, depressive cognitive style (imagery, verbal, both) significantly moderated the relationship between rumination and depressive symptom severity such that those who ruminated in the form of imagery (whether in isolation or in combination with verbal rumination) were at higher risk than those who ruminated only verbally (Lawrence et al., 2018, Study 2).
When gender was considered, the moderation effect held only for females. For females exclusively, rumination was more strongly associated with depressive symptom severity for those women who experienced depressive cognition as imagery or both imagery and verbal thought compared with only verbal thought. For males, the association between rumination and depressive symptom severity was equally strong for all depressive cognitive styles (Lawrence et al., 2018).

The present study was well positioned to assess whether these findings replicated with an adolescent sample and whether the same patterns were observed when individuals reported on their tendency to ruminate in the form of imagery, verbal thought, or both, rather than their general predisposition to experience depressive cognition in these forms. In line with Lawrence et al. (2018), the following hypotheses were proposed:

**Hypothesis 1 (primary):** Prevalence of imagery-based, verbally-based, and both imagery- and verbally-based rumination styles would mirror those found in adult samples. Specifically, it was expected that approximately one-third of adolescents would report an imagery-based rumination style, one-third would report a verbally-based rumination style, and one-third would report having both an imagery- and verbally-based rumination style.

**Hypothesis 2 (primary):** Replicating Lawrence et al. (2018), it was hypothesized that rumination style (imagery, verbal, both) would moderate the relation between degree of trait rumination and severity of depressive symptoms, such that there would be a stronger relation between rumination and depression for adolescents who ruminated only in the form of imagery or in the form of both imagery and verbal thought as compared to adolescents who ruminated only verbally.
**Hypothesis 3 (secondary):** When the subsample of participants with clinically elevated depressive symptoms was considered, rumination style (imagery, verbal, both) would even more strongly moderate the relation between degree of trait rumination and severity of depressive symptoms.

**Hypothesis 4 (secondary):** When gender was considered, rumination style (imagery, verbal, both) would moderate the relation between degree of trait rumination and severity of depressive symptoms for females but not for males.

**Aim 2 (Affect): Compare Affective Response to Induced Imagery- and Verbally-Based Rumination and Distraction**

Affectively, rumination increases negative mood via perseveration on negative cognition. In adolescence, rumination predicts negative affect both when rumination is self-reported (e.g., Schwartz & Koenig, 1996) and experimentally-induced (e.g., Rood et al., 2012). Conversely, distraction relieves negative affect by directing attention to more neutral or positive cognition. Distraction has been shown to improve affect relative to rumination in adolescent samples (e.g., Park et al., 2004).

Holmes and Mathews (2010) suggest that at least in adulthood, imagery acts as an emotional amplifier. Negative imagery elicits greater negative affect than negative verbal thought, and positive imagery elicits greater positive affect than positive verbal thought. Imagery-based rumination may therefore lead to a more strongly negative affective response compared with verbally-based rumination, and imagery-based distraction may result in greater relief of negative affect than verbally-based distraction. In the only study to date to examine affective response to imagery- and verbally-based rumination and distraction, greater imagery during distraction was associated with greater affective relief, though rumination maintained
negative affect regardless of the degree of imagery and verbal thought experienced (Lawrence & Schwartz-Mette, 2018). No study, however, has examined affective response to experimentally-induced imagery or verbal thought during rumination and distraction with an adolescent sample. The current study addressed this gap. The following hypotheses were put forth:

**Hypothesis 5 (primary):** Affective reactivity (i.e., change in affect from post-Cyberball to post-rumination/distraction induction) would be exaggerated in the imagery conditions relative to verbal conditions. There would be a significant 2 (rumination, distraction) X 2 (imagery, verbal thought) interaction predicting affective reactivity. Compared to verbally-based rumination, imagery-based rumination would result in lower affect ratings. Compared to verbally-based distraction, imagery-based distraction would result in higher affect ratings.

**Hypothesis 6 (primary):** There would be less affective recovery (i.e., baseline affect subtracted from affect post-recovery) following imagery-based rumination compared to verbally-based rumination and greater affective recovery following imagery-based distraction compared to verbally-based distraction. There would be a significant 2 (rumination, distraction) X 2 (imagery, verbal thought) interaction predicting affective recovery. Compared to verbally-based rumination, imagery-based rumination would result in less affective recovery following rumination. Compared to verbally-based distraction, imagery-based distraction would result in greater affective recovery following distraction.

**Hypothesis 7 (secondary):** When the subsample of adolescents with clinically elevated depressive symptoms was considered, the 2 (rumination, distraction) X 2 (imagery,
verbal thought) interaction would more strongly predict affective reactivity and affective recovery.

**Hypothesis 8 (secondary):** When gender was considered, the 2 (rumination, distraction) X 2 (imagery, verbal thought) interaction would more strongly predict affective reactivity and affective recovery for females than for males.

**Aim 3 (Parasympathetic): Compare HRV Response to Induced Imagery- Versus Verbally-Based Rumination and Distraction**

Rumination is associated with reduced HRV, an index of parasympathetic response (e.g., Woody et al., 2015). Although associations between HRV and rumination have only recently been examined in adolescence (e.g., Vögele et al., 2010), rumination appears to prolong cardiovascular response and lower HRV (e.g., Brosschot, Gerin, & Thayer, 2006; Radstaak, Geurts, Brosschot, Cillessen, & Kompier, 2011). Conversely, low HRV is associated with increased activation in the amygdala and decreased activation in the prefrontal cortex, both of which impact the ability to disengage from rumination (Thayer et al., 2012; Woody et al., 2014). Relative to rumination, distraction promotes increases in HRV (e.g., Key et al., 2008).

Imagery may be especially physiologically impactful. Physiological reactivity to emotional stimuli is positively related to imagery ability (Miller et al., 1987), and imagining feared stimuli results in greater increases in heart rate compared with thinking about the same stimuli verbally (Vrana et al., 1986). To date, no research had evaluated HRV in response to imagery- and verbally-based rumination and distraction, however. The current study compared HRV response to these processes in adolescence. It was hypothesized that:

**Hypothesis 9 (primary):** HRV reactivity (i.e., mean HRV change during the rumination/distraction induction) would be exaggerated in the imagery conditions relative
to the verbal conditions. There would be a significant 2 (rumination, distraction) \( \times 2 \) (imagery, verbal thought) interaction predicting HRV reactivity. Compared to verbally-based rumination, imagery-based rumination would result in lower HRV. Compared to verbally-based distraction, imagery-based distraction would result in higher HRV.

**Hypothesis 10 (primary):** There would be less HRV recovery (i.e., baseline HRV subtracted from mean HRV during recovery) following imagery-based rumination compared to following verbally-based rumination and greater HRV recovery following imagery-based distraction compared to following verbally-based distraction. There would be a significant 2 (rumination, distraction) \( \times 2 \) (imagery, verbal thought) interaction predicting HRV recovery. Compared to verbally-based rumination, imagery-based rumination would result in less HRV recovery. Compared to verbally-based distraction, imagery-based distraction would result in greater HRV recovery.

**Hypothesis 11 (secondary):** When the subsample of adolescents with clinically elevated depressive symptoms was considered, the 2 (rumination, distraction) \( \times 2 \) (imagery, verbal thought) interaction would more strongly predict HRV reactivity and HRV recovery.

**Hypothesis 12 (secondary):** When gender was considered, the 2 (rumination, distraction) \( \times 2 \) (imagery, verbal thought) interaction would more strongly predict HRV reactivity and HRV recovery for females than for males.

**Aim 4 (Sympathetic): Compare GSR Response to Induced Imagery- Versus Verbally-Based Rumination and Distraction**

Rumination also is associated with increases in GSR, an index of sympathetic response (e.g., Sigmon et al., 2000; Steinfurth et al., 2017). Although no research has examined GSR
response to rumination in adolescence, rumination has been shown to result in higher GSR response (Sigmon et al., 2000; Steinfurth et al., 2017) and less GSR recovery (Capobianco et al., 2018) relative to distraction in adulthood. As noted previously, imagery results in a larger physiological response compared to verbal thought. Specific to GSR, Reyher and Smeltzer (1968) found a larger GSR response to imagery relative to verbal thought, though Baker and Jessup (1980) and Hyett et al. (2018) did not replicate these differences. The current study was the first to compare GSR response to imagery- and verbally-based rumination and distraction. The following hypotheses were put forth:

**Hypothesis 13 (primary):** GSR reactivity (i.e., mean GSR change during the rumination/distraction induction) would be exaggerated in the imagery conditions compared to the verbal conditions. There would be a significant 2 (rumination, distraction) X 2 (imagery, verbal thought) interaction predicting GSR reactivity. Compared to verbally-based rumination, imagery-based rumination would result in higher GSR. Compared to verbally-based distraction, imagery-based distraction would result in lower GSR.

**Hypothesis 14 (primary):** There would be less GSR recovery (i.e., baseline GSR subtracted from mean GSR during recovery) following imagery-based rumination compared to following verbally-based rumination and greater GSR recovery following imagery-based distraction compared to following verbally-based distraction. There would be a significant 2 (rumination, distraction) X 2 (imagery, verbal thought) interaction predicting GSR recovery. Compared to verbally-based rumination, imagery-based rumination would result in less GSR recovery. Compared to verbally-based distraction, imagery-based distraction would result in more GSR recovery.
**Hypothesis 15 (secondary):** When the subsample of adolescents with clinically elevated depressive symptoms was considered, the 2 (rumination, distraction) X 2 (imagery, verbal thought) interaction would more strongly predict GSR reactivity and GSR recovery.

**Hypothesis 16 (secondary):** When gender was considered, the 2 (rumination, distraction) X 2 (imagery, verbal thought) interaction would more strongly predict GSR reactivity and GSR recovery for females than for males.

**Aim 5 (Cognitive): Examine Realism and Vividness as Cognitive Factors that May Contribute to Differences in Affective and Physiological Response to Imagery- and Verbally-Based Rumination/Distraction**

Rumination involves repeated rehearsal of maladaptive, negative cognitions. One would expect that the more realistic and vivid these ruminative cognitions are, the more affectively and physiologically impactful they would be after repeated rehearsal. Conversely, distraction involves repeated rehearsal of more adaptive, neutral or positive cognitions. The more vivid and realistic these distracting cognitions are, the more effective they may be in promoting adaptive affective and physiological response. Given that imagery is rated as higher in realism and vividness compared with verbal thought, it was expected that imagery/vividness would moderate the relation between condition and affective/physiological reactivity and recovery, with larger differences among conditions the more vivid and realistic one’s cognitions are. The following hypotheses were made:

**Hypothesis 17 (secondary):** Realism would moderate the relation between rumination/distraction induction condition and affective reactivity. There would be larger
differences among conditions in affective reactivity the more realistic adolescents reported their cognitions to be.

**Hypothesis 18 (secondary):** Vividness would moderate the relation between rumination/distraction induction condition and affective reactivity. There would be larger differences among conditions in affective reactivity the more vivid adolescents reported their cognitions to be.

**Hypothesis 19 (secondary):** Realism would moderate the relation between rumination/distraction induction condition and HRV reactivity. There will be larger differences among conditions in HRV reactivity the more realistic adolescents reported their cognitions to be.

**Hypothesis 20 (secondary):** Vividness would moderate the relation between rumination/distraction induction condition and HRV reactivity. There would be larger differences among conditions in HRV reactivity the more vivid adolescents reported their cognitions to be.

**Hypothesis 21 (secondary):** Realism would moderate the relation between rumination/distraction induction condition and GSR reactivity. There would be larger differences among conditions in GSR reactivity the more realistic adolescents reported their cognitions to be.

**Hypothesis 22 (secondary):** Vividness would moderate the relation between rumination/distraction induction condition and GSR reactivity. There would be larger differences among conditions in GSR reactivity the more vivid adolescents reported their cognitions to be.
CHAPTER 2

METHOD

Participants

Adolescents ($N = 145$; age range: 13-17 years; $M_{age} = 15.44$ years; see Table 1 for demographic characteristics of sample) were recruited from the surrounding community of a mid-sized New England university (population approximately 150,000) and from a database of adolescents who had participated in prior and/or ongoing studies (see Appendices I, J, K, L for recruitment materials). Initial power analyses using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) indicated that a sample of 128 participants was sufficiently powered (.80) to detect differences between rumination/distraction conditions based on an expected effect size of .25. Data from an additional 17 participants were collected to account for the potential need to eliminate physiological data due to artifacts and/or equipment malfunction. Higher order interactions were considered exploratory, as the present sample was underpowered to detect smaller effects. Adolescents’ parent(s)/guardian(s) gave informed consent and adolescents provided assent prior to participation.
### Table 1

**Demographic Characteristics of Sample**

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Procedure

Participants completed a laboratory session consisting of questionnaire completion, baseline assessment, Cyberball (i.e., a negative mood induction), an original rumination/distraction induction paradigm, and a recovery period. Physiological data and affect ratings were obtained throughout (see Figure 1), and participants made subjective experience ratings (realism, vividness) following the rumination/distraction induction. Participants were compensated $30 for their participation in the study, which took approximately 1.25 hours.

Figure 1. Study procedure. 1, 2, 3, and 4 mark affect ratings.

**Questionnaire assessments.** In the first part of the study, participants completed questionnaires online using Qualtrics©.
1) **Demographics and basic information (Appendix A).** Items assessed participants’ date of birth, age, gender identity, race, and ethnicity. Participants were screened for relevant cardiovascular conditions and use of medications that may impact cardiovascular function.

2) **Trait rumination (Appendix C).** Participants completed the 22-item Ruminative Responses Scale (RRS; Nolen-Hoeksema & Morrow, 1991) assessing the degree to which one dwells on negative affect when feeling down or depressed. The RRS has demonstrated strong reliability in previous studies with adolescents (α = .91; Cox, Funasaki, Smith, & Mezulis, 2012) as well as in the current study (α = .94).

3) **Rumination style (Appendix D).** To assess rumination style, participants completed a 3-item adaption of the Sensory Properties of Depressive Thoughts Questionnaire (Moritz et al., 2014). Participants first read a definition of rumination. They then self-reported whether they tend to ruminate in the form of imagery, verbal thought, or both imagery and verbal thought. Two additional items asked when they ruminated, how often their rumination took the form of imagery, and how often their rumination took the form of verbal thought. An alpha is not reported as internal consistency of items was not expected given that participants could report that they often engaged in rumination as imagery and verbal thought, or only as imagery or only as verbal thought. Instead, two one-way ANOVAs were conducted to assess validity of the measure. There was a significant effect of rumination style (imagery, verbal, both) on the frequency of verbally-based rumination reported, $F(2, 141) = 17.06, p < .001, \eta^2 = 0.20$. Adolescents who endorsed a verbally-based rumination style or a both imagery- and verbally-based rumination style reported significantly greater verbal rumination than adolescents who endorsed an
imagery-based rumination style \((ps < .05)\). There also was a significant effect of rumination style (imagery, verbal, both) on the frequency of imagery-based rumination reported, \(F(2, 141) = 19.70, p < .001, \eta^2_p = 0.22\). Adolescents who endorsed an imagery-based rumination style or a both imagery- and verbally-based rumination style reported significantly greater imagery-based rumination than adolescents who endorsed a verbally-based rumination style \((ps < .05)\). These findings lend evidence to the validity of this original measure of rumination style.

4) **Severity of depressive symptoms (Appendix B).** Participants rated the 20 items of the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) to indicate how often within the last week they experienced affective, somatic, interpersonal, cognitive, and behavioral symptoms of depression. The CES-D demonstrated good to excellent reliability in previous studies with adolescents \((\alpha = .87-.92;\) Roberts, Andrews, Lewinsohn, & Hops, 1990) and in the current study \((\alpha = .93)\).

**Induction.** In the second part of the study, participants were outfitted with non-invasive sensors to measure electrical activity of the heart \((i.e.,\) electrocardiogram; ECG) and galvanic skin response \((i.e.,\) GSR). Participants completed a baseline HRV and GSR assessment. Then, they played Cyberball to induce negative affect followed by a task designed to induce rumination or distraction in the form of imagery or verbal thought. Finally, participants experienced a recovery period. The baseline assessment, Cyberball, rumination/distraction induction, and recovery period were all presented on the computer using E-Prime 2.0 software.

**Baseline assessment.** To capture baseline affect, HRV, and GSR and to allow for acclimation to the sensors, participants sat comfortably at a computer with uncrossed legs and watched a 7-minute neutral film about United States National Parks. Similar videos of landscape
scenes from National Parks have previously been used to establish a physiological baseline (e.g., Woody et al., 2015).

**Cyberball.** Following baseline assessment, all participants experienced an experimental manipulation of peer rejection to induce negative affect. Participants played “Cyberball” (Williams, Cheung, & Choi, 2000), a virtual ball-throwing game in which participants “play catch” with two unknown peers on the computer who are really preprogramed computer player confederates. After several rounds of equal play, the peers appear to exclude the participant by throwing the ball to only one another. Cyberball reliably induces negative affect (e.g., Wesselmann, Wirth, Mroczek, & Williams, 2012) and has previously been shown to induce negative affect and subsequent rumination in an older adolescent sample (Wesselmann, Ren, Swim, & Williams, 2013). Peer rejection was selected as a negative mood induction given the salience of peer rejection in adolescence (e.g., Prinstein & Aikins, 2004).

**Rumination/distraction induction.** Next, participants were randomly assigned to rumination/distraction induction condition in a 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects design.

Imagery instructions. To induce rumination/distraction in the form of imagery, participants first received instructions intended to help the adolescent practice deliberately generating mental imagery (adapted from Holmes et al., 2006; Holmes, Mathews, et al., 2008). Participants were asked to imagine (1) a lemon and what a lemon looks like when you shine a bright light on it, (2) cutting a lemon with a knife and smelling the zest/juice, and (3) holding a lemon slice close to their eye and squeezing it. For each practice item, participants rated their imagery’s vividness from 1 (not at all) to 9 (extremely clear as in vision) to help the participants focus on making their imagery as vivid as possible. Previous research using these instructions
has found them to lead participants to reliably use imagery on subsequent tasks (Holmes et al., 2006; Holmes, Mathews, et al., 2008).

Verbal thought instructions. To induce participants to engage in rumination/distraction in the form of verbal thought, adolescents received equivalent verbalize instructions intended to help the participant practice deliberately generating grammatically correct sentences in one’s mind (again, adapted from Holmes et al., 2006; Holmes, Mathews, et al., 2008). Participants were asked to make a grammatically correct sentence in their mind combining (1) a picture of a lemon with the word “yellow,” (2) a picture of a lemon with the word “refreshing,” and (3) a picture of a lemon slice with the word “squeeze.” For each practice item, participants rated how easy it was to make the sentence in their mind from 1 (extremely difficult) to 9 (extremely easy). As with the imagery instructions, previous research has found these instructions to lead participants to reliably use verbal processing on subsequent tasks (Holmes et al., 2006; Holmes, Mathews, et al., 2008).

After receiving initial instructions (imagery instructions, verbal thought instructions), adolescents completed either a rumination or distraction induction. During the rumination/distraction induction, participants completed 6 blocks of 1 minute of rumination/distraction followed by 1 minute of rest. Before each block, participants were prompted to either “make mental images” or “make sentences” depending on condition (see Figure 2 for example block).
### Figure 2. Rumination/distraction procedure block. Repeated six times for each participant such that each participant was presented with 24 total rumination/distraction prompts.

To introduce the rumination/distraction induction, participants were instructed as follows:

*For the next few minutes, try your best to focus your attention on each of the ideas on the screen. Read each item slowly and silently to yourself. As you read the items, use your [imagination/concentration] to focus your mind on each of the ideas. Spend a few moments [imagining/concentrating on] each item. Please continue until you receive the next instructions.*

Rumination induction. Participants in the rumination condition were presented with 24 prompts shown to reliably induce rumination in adolescents (e.g., *[Think about/Imagine] the kind of person you think you should be*; Hilt & Pollak, 2012; Park et al., 2004) and to be equally likely to elicit imagery or verbal thought (Lawrence & Schwartz-Mette, 2018). Each prompt remained on the screen for 15 seconds such that each block of rumination prompts lasted 1 minute. To induce rumination in the form of imagery, participants were cued to “make mental images” before each block of prompts, and each prompt began with “Imagine.” To induce rumination in

<table>
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<th>Prompt</th>
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the form of verbal thought, participants were cued to “make sentences” before each block of prompts, and each prompt began with “Think about.”

Distraction induction. In contrast to rumination, distraction draws attention away from stressful events and is considered an adaptive alternative to rumination (e.g., Joormann & Siemer, 2004). Participants in the distraction conditions were presented with 24 prompts designed to distract the participant from negative affect (e.g., [Think about/Imagine] the items on your grocery list.). Again, prompts were previously shown to be equally likely to elicit imagery or verbal thought (Lawrence & Schwartz-Mette, 2018). Each prompt remained on the screen for 15 seconds such that each block of distraction prompts lasted 1 minute. To induce distraction in the form of imagery, participants were cued to “make mental images” before each block of prompts, and each prompt began with “Imagine.” To induce distraction in the form of verbal thought, participants were cued to “make sentences” before each block of prompts, and each prompt began with “Think about.”

Recovery period. Finally, participants watched a different 7-minute neutral film about United States National Parks to recover.

Physiological recording. Physiological data were collected using a MindWare Mobile Acquisition Unit (MindWare Technologies LTD, Gahanna, Ohio) and Biolab 3.3.1 software.

HRV. With instruction from the experimenter, the participant applied a 3-lead electrocardiograph (ECG) (electrode placement below the right clavicle, below the left lower rib, and below the right lower rib) to capture continuous HRV at a sampling rate of 100 Hz. ECG data were collected using MindWare disposable 1.5 inch ECG electrodes with 7% chloride wet gel. Data were cleaned and ensembled, and parameters were calculated (including automated R peak detection) using MATLAB code written by Dr. Greg Siegle (used with permission). Each
participant’s data were visually inspected by the author for physiological feasibility and to ensure accurate R peak detection. Heart rates outside of 60 to 120 beats per minute were further inspected and adjustments were made to eliminate erroneous R peaks. Continuous wavelet transforms were applied to allow for analysis of nonstationary signals, and the power density in the high frequency (.18-.40 Hz) band of HRV was calculated to isolate parasympathetic influence. Each data point (i.e., 1 sec) of HRV data was compared with its surrounding data points. Any data point that fell +/- 1.5 SD away from the surrounding data points was rescaled to reflect the mean value of the data points surrounding it.

**GSR.** The experimenter applied two electrodes to the participant’s non-dominant hand (electrode placement on the thenar and hypothenar eminence) to measure GSR. GSR data were collected using MindWare disposable 1.5 inch by 1 inch GSR electrodes with 0.5% chloride wet gel. GSR data were cleaned and smoothed using MATLAB software developed by Dr. Greg Siegle (used with permission). Each participant’s data were visually inspected by the author to ensure physiological feasibility. GSR data were eliminated if mean GSR fell under 3 or over 35 microsiemens, if there was a change of over 20 microseemens, or if GSR dropped below 1 at any point during a given period (baseline, Cyberball, rumination/distraction induction, recovery). GSR data also were eliminated during the rumination/distraction induction if there were 6 or more minutes during which GSR changed 6 or more microsiemens within 3 seconds or dropped 10 or more microseimens within a minute. Each GSR data point that fell +/- 1.5 SD away from the surrounding data points was rescaled to its surrounding data points.

**Affect ratings.** At four time points (see Figure 1) participants were prompted on the computer screen to rate their affect on a VAS ranging from sad (1) to happy (100) (see Appendix E). Capturing affect ratings allowed comparison between rumination conditions in terms of
change in affect. A single VAS was used to ensure as little disruption as possible between study tasks.

**Subjective experience ratings.** Following the rumination/distraction induction, participants rated each of the following statements on a scale from 1 (*not at all*) to 9 (*totally*). Items were based on questions used in Holmes et al. (2008) to assess participants’ experience during a cognitive bias modification task.

1) *How much did you find yourself thinking in mental images?*

2) *How much did you find yourself thinking in words or sentences?*

3) *How much did you find yourself thinking in a manner that neither seemed like having mental images nor verbal thoughts?* (*if participants indicate a 5 or higher they were prompted to describe their thoughts in a free response text box).*

4) *How much did your thoughts/mental images seem like a real memory of events that you actually experienced?*

5) *How much did your thoughts/mental images appear as if they were happening to you, that is, that you were involved in them?*

6) *How vivid were your thoughts/mental images?*

**Debriefing.** Lastly, participants were debriefed regarding the purposes of the study. Follow-up risk assessment was conducted with any participant who reported elevated depressive symptoms. All participants were provided with a list of resources for mental health services in the community and the parents/guardians of participants with elevated depressive symptoms were informed that their child may be in distress and were provided with the list of community resources as well.
CHAPTER 3
RESULTS

Overall Analysis Approach

Descriptive analyses were first conducted to provide information on study variables. Participants in each condition also were compared on baseline demographics, affect, and physiology, and manipulation checks were conducted to ensure that Cyberball and the rumination/distraction induction had their intended effects. Then, analyses relevant to each aim were conducted. In line with recommendations from Laborde, Mosley, and Thayer (2017), participants’ baseline, reactivity, and recovery scores were analyzed. Baseline was defined as response during the baseline period. Baseline affect was measured directly after the baseline period and baseline HRV and GSR were measured by averaging physiological response from the last 5 minutes of the baseline period³. Reactivity was defined as the difference between participants’ responses to the rumination/distraction induction and their responses to Cyberball. Affective reactivity was calculated by subtracting the affect rating following Cyberball from the affect rating following the rumination/distraction induction. HRV and GSR reactivity were calculated by subtracting the first second of HRV and GSR data from each subsequent second of HRV and GSR data during the rumination/distraction induction and computing mean HRV and GSR change during the rumination/distraction induction period. Recovery was defined as the difference between recovery and baseline. Affective recovery was calculated by subtracting the affect rating following the recovery period from the affect rating following the baseline period. HRV and GSR recovery were calculated by subtracting mean HRV and GSR during the recovery period from mean HRV and GSR during the baseline period.

³ The first two minutes were eliminated to allow for acclimation to wearing the sensors.
Within primary Aims 1-4, analyses were first conducted with the overall sample (primary); then, secondary analyses were conducted with the subsample of adolescents with elevated depressive symptoms (i.e., a CES-D score ≥ 16), and taking gender into account. Gender analyses were considered exploratory given that the present study was under-powered to detect three-way interactions and because there were unequal numbers of males and females within each condition.

Adolescents were screened for cardiovascular and neurological conditions and use of medications that may impact physiological response. No participants reported relevant cardiovascular or neurological conditions. T-tests were conducted to compare mean HRV and GSR during each study segment (baseline, Cyberball, rumination/distraction induction, recovery) for participants taking and not taking medications. No significant differences were found for any study variable (all p < .05); thus, all participants were retained in the final sample. When gender was included in analyses, only adolescents who identified as male or female were considered given insufficient numbers of adolescents who endorsed each gender identity.

Study variables were examined for missing data, issues with skew and kurtosis, and outliers. Given low levels of missing data overall, missing values were omitted from analyses. Skew and kurtosis of primary study variables were assessed in the overall sample, within each condition, and in the subsample of adolescents with elevated depressive symptoms. Baseline GSR (skew = 1.54) and CES-D total scores (skew = 0.91) were both positively skewed in the overall sample. No significant issues with skew or kurtosis were found in the subsample of adolescents with elevated depressive symptoms. In the case of ANOVA models, GSR and CES-D total scores were similarly skewed in each condition, and ANOVA models are generally robust to violations of normality (Schmider, Ziegler, Danay, Beyer, & Bühner, 2010). As such,
data were not transformed. In the case of regression models, when variables were found to be skewed, analyses were conducted with original data and after applying a square root transformation to the skewed variables. Given that patterns of results were similar, and that regression also has been shown to be robust to violations of normality (Box, 2005), analyses using the non-transformed data are presented. Where relevant, any differences in results based on use of transformed and non-transformed data are reported.

Cases were defined as univariate outliers if scores fell more than ±3 standard deviations from the mean. As recommended by Tabachnick and Fidell (2007), univariate outliers were winsorized to reflect a score ±1 point from the next most extreme score; physiological data were winsorized to be 10% greater/less than the next most extreme value. In the case of ANOVA models, the file also was split by condition, and scores that fell more than ±3 standard deviations from the mean of each condition were treated as outliers and winsorized as above. In the case of regression models, multivariate outliers were examined by calculating studentized residuals and leverage to identify cases that qualified as multivariate outliers with undue influence. To account for multivariate outliers, analyses were first conducted with and without the outlier. If results were the same, the outlier was retained. If results differed, the outlier was eliminated. Outliers were examined both in the overall sample and in the subsample of adolescents with elevated depressive symptoms. In the context of addressing each aim, additional specific information is provided on missing data, the analysis approach taken, and the number of outliers identified and winsorized.

Descriptive Analyses

Analysis strategy. First, descriptive analyses were performed, and correlations among primary study variables were calculated. Means and standard deviations for primary study
variables are presented in Table 2. Descriptive statistics are presented prior to any adjustments to outliers. A series of 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVAs were used to assess random allocation to conditions.

No univariate outliers were identified on the CES-D or RRS. Outliers on baseline affect ($n=1$), baseline HRV ($n=1$), and baseline GSR ($n=2$) were winsorized. When examined by condition, there was one outlier on the CES-D within the verbal rumination condition; this outlier also was winsorized.

Descriptive statistics and random allocation to conditions. Adolescents reported a moderate level of depressive symptoms overall ($M=14.66$, $SD=11.38$). A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA was conducted to determine whether there were baseline differences among conditions in terms of depressive symptoms. No difference in depressive symptom severity was found among conditions as evidenced by a nonsignificant interaction [$F(1,141)=1.46$, $p=.23$, $\eta^2=.01$] and nonsignificant main effects of rumination/distraction [$F(1,141)=1.22$, $p=.27$, $\eta^2=.01$] and imagery/verbal thought [$F(1,141)=0.53$, $p=.47$, $\eta^2<.01$]. Of the total sample, 38.62% ($n=56$) presented with elevated depressive symptoms (as defined by a CES-D score of 16 or greater; Lewinsohn, Seeley, Roberts, & Allen, 1997). Adolescents with elevated depressive symptoms were approximately equally distributed among conditions: imagery-based rumination ($n=13$), verbally-based rumination ($n=13$), imagery-based distraction ($n=15$), verbally-based distraction ($n=15$).

Adolescents also reported a moderate tendency to engage in rumination in response to depressed mood ($M=43.61$, $SD=13.65$). Again, the degree to which adolescents reported ruminating did not differ among conditions [interaction: $F(1,141)=1.76$, $p=.19$, $\eta^2=.01$;
main effect of rumination/distraction: $F(1,141) = 2.18, p = .14, \eta^2 = 0.02$; main effect of imagery/verbal thought: $F(1,141) = 1.56, p = .21, \eta^2 = 0.01$. When asked about their rumination style, the majority of the sample (59.5%) reported experiencing rumination in the form of both imagery and verbal thought, 29.9% reported ruminating only verbally, and 13.2% reported ruminating only in the form of imagery. A chi-square independence test was conducted to test whether adolescents in each condition differed in rumination style; the likelihood of reporting a verbally-based, imagery-based, or both verbally- and imagery-based rumination style did not differ by condition, $\chi^2(2, N = 144) = 1.28, p = .53$.

Next, baseline affect was examined. Adolescents reported moderately positive baseline affect ($M = 76.71$, $SD = 17.60$). The interaction among conditions was not a significant predictor of baseline affect [$F(1,133) = 0.00, p = .99, \eta^2 < 0.01$] nor were the main effect of rumination/distraction [$F(1,133) = 0.28, p = .60, \eta^2 < 0.01$] or the main effect of imagery/verbal thought [$F(1,133) = 0.27, p = .60, \eta^2 < 0.01$]. Thus, adolescents appeared to experience similar baseline affect across conditions.

Finally, baseline physiology was examined. Adolescents in each condition did not differ in baseline HRV [interaction: $F(1,129) = 0.19, p = .68, \eta^2 < 0.01$; main effect of rumination/distraction: $F(1,129) = 0.27, p = .61, \eta^2 < 0.01$; main effect of imagery/verbal thought: $F(1,129) = 0.06, p = .81, \eta^2 < 0.01$] or baseline GSR [interaction: $F(1,92) = 0.22, p = .64, \eta^2 < 0.01$; main effect of rumination/distraction: $F(1, 92) = 1.27, p = .26, \eta^2 = 0.01$; main effect of imagery/verbal thought: $F(1, 92) = 3.90, p = .05, \eta^2 = 0.04$]. Again, adolescents experienced similar baseline physiology across conditions.

A chi-square independence test also revealed that adolescents in each condition did not differ in gender [$\chi^2(3, N = 145) = 3.85, p = .28$] and a 2 (rumination, distraction) X 2 (imagery,
verbal thought) between subjects ANOVA confirmed that adolescents in each condition did not differ in age [interaction: $F(1,141) = 0.25, p = .62, \eta^2 < 0.01$; main effect of rumination/distraction: $F(1,141) = 0.00, p = .96, \eta^2 < 0.01$; main effect of imagery/verbal thought: $F(1,141) = 0.02, p = .88, \eta^2 < 0.01$]. Thus, participants appear to have been randomly allocated to conditions as adolescents did not differ in depressive symptom severity, trait rumination, rumination style, baseline affect, baseline HRV, baseline GSR, gender, or age.

Table 2

*Means and Standard Deviations for Study Variables by Condition*

<table>
<thead>
<tr>
<th></th>
<th>Imagery-based</th>
<th>Verbally-based</th>
<th>Imagery-based</th>
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<tr>
<td><strong>Total sample</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$(N = 145)$</td>
<td>rumination</td>
<td>rumination</td>
<td>distraction</td>
<td>distraction</td>
</tr>
<tr>
<td>$(n = 37)$</td>
<td>$(n = 37)$</td>
<td>$(n = 36)$</td>
<td>$(n = 35)$</td>
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<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
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<td><strong>Self-report measures</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CES-D</td>
<td>14.66 (11.38)</td>
<td>14.03 (11.71)</td>
<td>13.46 (9.58)</td>
<td>13.83 (10.55)</td>
</tr>
<tr>
<td>RRS</td>
<td>43.61 (13.65)</td>
<td>42.08 (14.29)</td>
<td>41.92 (11.98)</td>
<td>42.42 (13.66)</td>
</tr>
<tr>
<td>Rumin. style</td>
<td>29.9% verbal</td>
<td>29.7% verbal</td>
<td>29.7% verbal</td>
<td>27.8% verbal</td>
</tr>
<tr>
<td></td>
<td>13.1% image</td>
<td>10.8% image</td>
<td>21.6% image</td>
<td>8.3% image</td>
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<tr>
<td></td>
<td>56.6% both</td>
<td>59.5% both</td>
<td>48.6% both</td>
<td>61.1% both</td>
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Table 2 Continued.

<table>
<thead>
<tr>
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<th>Baseline</th>
<th>Cyberball</th>
<th>Reactivity</th>
<th>Recovery</th>
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<tr>
<td></td>
<td>76.71 (17.60)</td>
<td>75.24 (16.94)</td>
<td>76.43 (19.05)</td>
<td>76.76 (16.42)</td>
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<tr>
<td></td>
<td>62.10 (22.03)</td>
<td>59.89 (25.81)</td>
<td>61.74 (23.21)</td>
<td>59.36 (17.43)</td>
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<td>-0.05 (19.10)</td>
<td>1.88 (20.68)</td>
<td>-0.60 (21.47)</td>
<td>4.36 (14.11)</td>
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<td>-5.35 (17.62)</td>
<td>-8.31 (18.14)</td>
<td>-4.86 (19.21)</td>
<td>-3.16 (12.70)</td>
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<table>
<thead>
<tr>
<th>Parasympathetic Response (HRV)</th>
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<th>Reactivity</th>
<th>Recovery</th>
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<tr>
<td></td>
<td>3.71 (1.21)</td>
<td>3.59 (1.26)</td>
<td>3.73 (1.20)</td>
<td>3.79 (0.97)</td>
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<td>3.58 (1.21)</td>
<td>3.50 (1.29)</td>
<td>3.64 (1.03)</td>
<td>3.60 (1.14)</td>
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<td>-0.09 (0.92)</td>
<td>-0.14 (0.95)</td>
<td>0.01 (1.04)</td>
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<td>0.05 (0.52)</td>
<td>0.05 (0.47)</td>
<td>0.06 (0.56)</td>
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<table>
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<th>Reactivity</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.53 (5.43)</td>
<td>9.37 (6.10)</td>
<td>6.65 (3.55)</td>
<td>10.06 (6.57)</td>
</tr>
<tr>
<td></td>
<td>-0.45 (1.54)</td>
<td>-0.09 (1.59)</td>
<td>-0.39 (1.68)</td>
<td>-0.92 (1.40)</td>
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<tr>
<td></td>
<td>3.51 (2.99)</td>
<td>3.57 (3.04)</td>
<td>4.26 (3.20)</td>
<td>2.34 (2.80)</td>
</tr>
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</table>

Correlations among primary study variables are presented in Table 3. As expected, higher depressive symptom severity was associated with greater trait rumination ($r = .78, p < .01$). Higher depressive symptom severity also was correlated with lower baseline affect ($r = -.40, p < .01$), lower affect post-Cyberball ($r = -.29, p < .01$), greater reductions in affect during the rumination/distraction induction (i.e., affective reactivity; $r = -.18, p = .03$), and lower baseline HRV ($r = -.19, p = .03$). Higher baseline affect was associated with higher affect post-Cyberball
(r = .43, p < .01) and less affective recovery (r = -.40, p < .01). Higher baseline HRV was associated with higher HRV during Cyberball (r = .88, p < .01) and less HRV recovery (r = -.26, p < .01). Higher baseline GSR was associated with higher GSR during Cyberball (r = .85, p < .01) and less GSR recovery (r = -.25, p = .02).

Table 3

Correlations Among Study Variables

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<td>1. CES-D</td>
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<td>-.29*</td>
<td>-.18*</td>
<td>-.02</td>
<td>-.19*</td>
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<td>.06</td>
<td>.07</td>
<td>.03</td>
<td>.11</td>
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<td>-.16</td>
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<td>-.15</td>
<td>-.09</td>
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<td>.16</td>
<td>-.01</td>
<td>-.05</td>
<td>.00</td>
<td>.02</td>
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<td>.00</td>
<td>-.40*</td>
<td>.02</td>
<td>.03</td>
<td>-.12</td>
<td>.07</td>
<td>.01</td>
<td>-.11</td>
<td>-.02</td>
<td>-.18</td>
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<tr>
<td>4. Cyberball affect</td>
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<td>-.03</td>
<td>.06</td>
<td>.01</td>
<td>-.04</td>
<td>-.08</td>
<td>.08</td>
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<td>.01</td>
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<td>-.01</td>
<td>-.12</td>
<td>.02</td>
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<td>-.01</td>
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<td>-.03</td>
<td>-.08</td>
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*p < .05.

**Manipulation check.**

**Cyberball.** To test whether Cyberball had its intended effect as a negative mood induction, a series of paired samples t-tests was conducted. Baseline affect, HRV, and GSR were compared with affect following Cyberball and HRV and GSR during Cyberball. As expected, adolescents experienced significant decreases in affect [t(135) = 7.91, p < .001, d = 0.73], significant decreases in HRV [t(132) = 2.49, p = .014, d = 0.11], and significant increases in GSR [t(95) = -12.96, p < .001, d = 0.72], suggesting that Cyberball was effective.

**Rumination/distraction induction.** Across conditions, adolescents reported moderate amounts of imagery (M = 6.05, SD = 2.11) and verbal thought (M = 6.84, SD = 2.11) during the rumination/distraction induction. Imagery during the rumination/distraction induction was negatively correlated with verbal thought during the rumination/distraction induction as would
be expected ($r = .21, p = .01$). A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA revealed a significant main effect of imagery/verbal thought such that adolescents in the imagery conditions ($M = 6.70, SD = 1.84$) reported significantly greater imagery than adolescents in the verbal conditions ($M = 5.40, SD = 2.16$), $F(1,136) = 15.26, p < .01, \eta^2_p = 0.10$. Adolescents in the verbal conditions ($M = 7.14, SD = 2.00$) also reported greater verbal thought than adolescents in the imagery conditions ($M = 6.54, SD = 2.21$), though this difference was only marginally significant, $F(1,136) = 2.82, p = .095, \eta^2_p = 0.02$. Thus, the rumination/distraction induction appeared to have its intended effects, though the imagery induction may have been stronger than the verbal thought induction.

**Aim 1 (Trait Rumination): Examine Moderating Role of Rumination Style (Imagery, Verbal, Both) on Relation Between Trait Rumination and Depressive Symptom Severity**

**Analysis strategy.** Frequencies were used to evaluate the prevalence of rumination styles, and one-way ANOVAs and a chi-square test of independence were used to test whether adolescents differed in depressive symptom severity, trait rumination, or gender based on their rumination style. Moderated regression analyses were then conducted to test whether rumination style moderated the relation between trait rumination and depressive symptom severity. Models were run with the overall sample, the subsample with elevated depressive symptoms, and gender included.

No adolescents were missing data on the CES-D or RRS but one participant did not endorse a rumination style; this participant was excluded from analyses. As previously noted, no univariate outliers were identified for CES-D or RRS total scores. There was one outlier on the CES-D when considered within each rumination style (i.e., within the group that identified as imagery-based ruminators); this outlier was winsorized. No multivariate outliers were detected.
Prevalence of rumination styles. The prevalence of adolescents’ rumination styles was first examined (H1; primary). Of the total sample, 29.7% reported a verbally-based rumination style, 13.1% an imagery-based rumination style, and 56.6% a both imagery- and verbally-based rumination style. When asked to rate the degree to which they experience images or words when ruminating in general, adolescents reported similar amounts of imagery ($M = 2.92$, $SD = 1.22$) and verbal thought ($M = 3.09$, $SD = 1.20$). A chi-square test of independence revealed no gender differences in rumination style, $\chi^2(6) = 2.48$, $p = 0.75$. A series of one-way ANOVAs found that adolescents who reported an imagery-based, verbally-based, or both imagery- and verbally-based rumination style did not differ in severity of depressive symptoms, $F(2, 141) = 1.92$, $p = .15$, $\eta^2_p = 0.03$, though there was a significant effect of rumination style on trait rumination, $F(2, 141) = 3.72$, $p = .03$; $\eta^2_p = 0.05$; individuals with a both imagery- and verbally-based rumination style reported ruminating more than individuals with an imagery-based rumination style ($p = .03$, $d = 0.72$).

Moderating role of rumination style. Next, rumination style was tested as a potential moderator of the relation between trait rumination and severity of depressive symptoms (H2; primary). On Step 1, main effects of trait rumination (centered at the grand mean) and rumination style ([0 0] = verbal rumination style, [1 0] = imagery rumination style, [1 1] = both rumination style; represented by two dummy codes) were entered. On Step 2, the interactions between trait rumination and rumination styles were entered.

The overall model was significant [$R^2 = .63$, $F(5, 138) = 46.34$, $p < .01$]; rumination style significantly moderated the relation between trait rumination and depressive symptom severity as evidenced by a significant increase in variance explained on Step 2, $\Delta R^2 = .02$, $\Delta F(2, 138) = 4.29$, $p = .016$. Trait rumination was significantly associated with depressive symptom severity
for all rumination styles: imagery-based ($b = 0.96$, $p < .001$, 95% CI [0.65, 1.27], $SE = .16$, $sr^2 = .10$), verbally-based ($b = 0.48$, $p < .001$, 95% CI [0.31, 0.64], $SE = .085$, $sr^2 = .08$), and both imagery- and verbally-based ($b = 0.69$, $p < .001$, 95% CI [0.58, 0.79], $SE = .06$, $sr^2 = .41$). The relation between trait rumination and depressive symptom severity was significantly stronger for individuals who reported an imagery-based rumination style compared with a verbally-based rumination style ($b = 0.49$, $p = .007$, 95% CI [0.13, 0.84], $SE = .18$, $sr^2 = .02$) and a both imagery- and verbally-based rumination style compared with a verbally-based rumination style ($b = .21$, $p = .04$, 95% CI [0.01, 0.41], $SE = .10$, $sr^2 = .01$). The strength of this relation did not differ between individuals who reported that their rumination style was imagery-based or both imagery- and verbally-based ($b = 0.28$, $p = .10$, 95% CI [-0.05, 0.60], $SE = .17$, $sr^2 = .01$). Thus, trait rumination was found to be most highly associated with depressive symptom severity for individuals who reported ruminating in the form of imagery, whether in isolation or in combination with verbally-based rumination (see Figure 3).

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4 When this model was run with CES-D scores square root transformed to correct for positive skew, the relation between trait rumination and depressive symptom severity was significantly stronger for individuals who reported an imagery-based compared with verbally-based rumination style ($b = 0.05$, $p = .04$, 95% CI [0.002, 0.10], $SE = .03$, $sr^2 = .01$) but the difference between individuals who reported a both imagery- and verbally-based rumination style compared with a verbally-based rumination style did not emerge as statistically significant ($b = 0.02$, $p = .14$, 95% CI [-0.01, 0.05], $SE = .02$, $sr^2 = .01$).
Figure 3. Rumination style significantly moderated the relation between trait rumination and depressive symptom severity. There was a significantly stronger association between the constructs for individuals who reported an imagery-based, or both imagery- and verbally-based, rumination style compared with a verbally-based rumination style.

The same moderation model was examined with the subsample of adolescents with elevated depressive symptoms (H3; secondary). The overall model was significant \([R^2 = .66, F(5, 50) = 19.40, p < .01]\) and there was a marginally significant increase in variance in depressive symptom severity explained on Step 2 in this subsample \([\Delta R^2 = .04, \Delta F(2, 50) = 2.74, p = .07]\). As with the total sample, trait rumination was significantly associated with depressive symptom severity for all rumination styles (imagery-based: \(b = 0.86, p < .001, 95\% \ CI [0.51, 1.22], \ SE = .18, sr^2 = .16\); verbally-based: \(b = 0.38, p = .001, 95\% \ CI [0.16, 0.61], \ SE = .11, sr^2 = .08\); both imagery- and verbally-based: \(b = 0.59, p < .001, 95\% \ CI [0.42, 0.76], \ SE = .09, sr^2 = .32\).
interaction between trait rumination and the dummy code representing the comparison between imagery-based and verbally-based rumination styles was significant ($b = 0.48, p = .03, 95\% CI [0.06, 0.90], SE = .21, sr^2 = .04$). The interactions between trait rumination and the dummy codes representing the comparisons between both imagery- and verbally-based and verbally-based rumination styles ($b = 0.20, p = .16, 95\% CI [-0.08, .49], SE = .14, sr^2 = .01$) and between both imagery- and verbally-based and imagery-based rumination styles ($b = 0.28, p = .17, 95\% CI [-0.12, 0.6], SE = .20, sr^2 = .01$) were not significant. The relation between trait rumination and depressive symptom severity was significantly stronger for depressed adolescents with an imagery-based rumination style compared with a verbally-based rumination style, neither of which differed from depressed adolescents with a both imagery- and verbally-based rumination style (see Figure 4).
Figure 4. Rumination style was a marginally significant moderator of the relation between trait rumination and depressive symptom severity for the subsample of adolescents with clinically elevated depressive symptoms. The constructs were more strongly associated for depressed adolescents with an imagery-based rumination style compared with a verbally-based rumination style.

The impact of gender on the moderating role of rumination style was considered (H4; secondary). On Step 1, main effects of trait rumination (centered at the grand mean), rumination style ([0 0] = verbal rumination style, [1 0] = imagery rumination style, [1 1] = both rumination style; represented by two dummy codes), and gender (dummy coded: 0 = female, 1 = male) were entered. On Step 2, two-way interactions were entered. On Step 3, three-way interactions were entered. Although the overall model was significant [$R^2 = .62, F(11, 122) = 18.44, p < 0.01$], there was not a significant increase in variance explained on Step 3, $\Delta R^2 = .01, \Delta F(2, 122) =$
1.31, \( p = 0.27 \). Rumination style does not appear to function differently as a moderator between trait rumination and depressive symptom severity for male and female adolescents.

**Aim 2 (Affect): Compare Affective Response to Induced Imagery- and Verbally-Based Rumination and Distraction**

**Analysis strategy.** To test affective response to imagery- and verbally-based rumination and distraction, a series of 2 (rumination, distraction) \( \times 2 \) (imagery, verbal thought) between subjects ANOVAs were conducted predicting affective reactivity and affective recovery. Planned contrasts were made between imagery- and verbally-based rumination and between imagery- and verbally-based distraction. Bonferroni corrections were applied to account for multiple comparisons. Affective reactivity was defined as the difference between the affect rating post-rumination/distraction induction and the affect rating post-Cyberball. Zero represents no affect change from Cyberball. Positive values represent improvements in affect relative to Cyberball. Negative values represent decrements in affect relative to Cyberball. Affective recovery was defined as the difference between the affect rating post-recovery and the affect rating post-baseline. Zero represents recovery to baseline affect. Positive values represent improvements in affect relative to baseline. Negative values represent decrements in affect relative to baseline.

Affect ratings were treated as missing if participants did not provide a rating or if they clicked outside of the VAS scale (baseline affect: \( n = 2 \); Cyberball affect: \( n = 1 \); affective reactivity: \( n = 2 \); affective recovery: \( n = 7 \)). An additional six adolescents’ affective data were eliminated due to observed difficulties understanding the VAS ratings (e.g., clicking on labels for the VAS scale rather than the scale itself). Affect data for the remaining adolescents were then examined for outliers. Univariate outliers (baseline affect: \( n = 1 \), affective reactivity: \( n = 1 \);
affective recovery: \( n = 3 \) were winsorized. Additional cases identified as outliers when affective recovery was examined by condition also were winsorized (verbally-based rumination condition: \( n = 1 \); imagery-based distraction condition: \( n = 1 \); verbally-based distraction condition: \( n = 1 \)). Within the sample of adolescents with elevated depressive symptoms there was one univariate outlier for affective recovery, which also was winsorized.

**Affective response to, and recovery from, rumination/distraction.** First, affective reactivity was compared among conditions (H5; primary). A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA was conducted predicting affective reactivity. The interaction between rumination/distraction conditions and imagery/verbal thought conditions was not a significant predictor of affective reactivity \([F(1,133) = 1.39, p = .24, \eta^2_p = 0.01]\). The main effect of rumination/distraction also was not significant \([F(1,133) = 0.17, p = .68, \eta^2_p < 0.01]\) but the main effect of imagery/verbal thought was marginally significant \([F(1,133) = 3.61, p = .06, \eta^2_p = 0.03]\); adolescents in the imagery-based conditions provided higher affect ratings than adolescents in the verbally-based conditions (see Figure 5). Of note, a non-significant interaction does not confirm that an interaction is not present in the population (Faraway, 2015; Fox, 2008; Searle, 2006). Thus, it has been recommended that simple main effects analyses be conducted regardless of whether the intervention effect was significant (Faraway, 2015). In this case, there was a significant difference between adolescents in the imagery- and verbally-based distraction conditions \((p = .03, d = 0.60)\). Adolescents in the imagery-based distraction condition experienced greater improvement in affect compared with adolescents in the verbally-based distraction condition, whose affect actually worsened.
Affective Reactivity by Condition

Figure 5. Affective reactivity differed by condition. There was a significant pairwise comparison between imagery- and verbally-based distraction conditions. Adolescents in the imagery-based distraction condition experienced significantly more improved affect than adolescents in the verbally-based distraction condition, whose affect actually worsened. Zero represents no affect change from Cyberball. Positive values reflect improvements in affect relative to Cyberball. Negative values indicate decrements in affect relative to Cyberball. Error bars represent 95% CI. *p < .05.
Affective recovery following the rumination/distraction induction was then examined (H6; primary). A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA was conducted, in this model predicting affective recovery. Affective recovery did not differ by condition. Affective recovery was not predicted by the interaction between rumination/distraction conditions and imagery/verbal thought conditions \( F(1,128) = 0.16, p = .69, \eta^2 < 0.01 \), the main effect of rumination/distraction \( F(1,128) = 1.29, p = .26, \eta^2 = 0.01 \), or the main effect of imagery/verbal thought \( F(1,128) < 0.01, p = .96, \eta^2 < 0.01 \) (see Figure 6). Imagery- and verbally-based rumination and imagery- and verbally-based distraction resulted in similar affective recovery.
Affective Recovery by Condition

![Bar chart showing affective recovery by condition.]

Figure 6. Affective recovery following the rumination/distraction induction did not differ by condition. Zero represents no change in affect from baseline. Positive values reflect improvements in affect relative to baseline. Negative values indicate decrements in affect relative to baseline. Error bars represent 95% CI.

Next, affective reactivity and recovery were compared among conditions for the subsample of adolescents with clinically elevated depressive symptoms (H7; secondary). First, affective reactivity was examined. A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA predicting affective reactivity revealed no significant differences among conditions in depressed adolescents’ affective reactivity [interaction: $F(1,49) = 0.95, p = .66, \eta^2_p < 0.01$; main effect of rumination/distraction: $F(1,49) = 0.01, p = .91, \eta^2_p < 0.01$; main
effect of imagery/verbal thought: $F(1,49) = 2.16, p = .15, \eta_p^2 < 0.01$] (see Figure 7). The pairwise comparison between imagery- and verbally-based distraction did not reach the threshold of statistical significance in this subsample ($p = .16$) though the direction of effects was the same as in the overall sample.

**Elevated Depressive Symptom Subsample:**

Affective Reactivity by Condition

*Figure 7.* Affective reactivity did not differ by condition for adolescents with elevated depressive symptoms. Zero represents no affect change from Cyberball. Positive values reflect improvements in affect relative to Cyberball. Negative values indicate decrements in affect relative to Cyberball. Error bars represent 95% CI.
Then, affective recovery following the rumination/distraction induction was examined in this subsample. A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA predicting affective recovery also revealed a non-significant interaction \( [F(1,47) = 0.57, p = .45, \eta^2 = 0.01] \) and non-significant main effect of imagery/verbal thought \( [F(1,47) = 0.41, p = .84, \eta^2 < 0.01] \) though the main effect of rumination/distraction was significant \( [F(1,47) = 4.97, p = .03, \eta^2 = 0.10] \) (see Figure 8). Adolescents with elevated depressive symptoms in the rumination conditions experienced significantly less affective recovery than those in the distraction conditions.
For adolescents with elevated depressive symptoms, affective recovery was greater for those in the distraction conditions than those in the rumination conditions. Zero represents no affect change from baseline. Positive values reflect improvements in affect relative to baseline. Negative values indicate decrements in affect relative to baseline. Error bars represent 95% CI. *p < .05.

Gender was then considered (H8; secondary). A 2 (rumination, distraction) X 2 (imagery, verbal thought) X 2 (male, female) between subjects ANOVA was conducted predicting affective reactivity. The three-way interaction was not significant \(F(1,120) = 0.28, p = .60, \eta^2\)
< 0.01] nor were any two-way interactions or main effects (all $p$s > .05). Thus, patterns of affective reactivity did not significantly differ by gender (see Figure 9).

Affective Reactivity by Condition by Gender

![Graph showing affective reactivity by condition for females and males.](image)

Figure 9. No significant gender differences were found in affective reactivity by condition. Zero represents no affect change from Cyberball. Positive values reflect improvements in affect relative to Cyberball. Negative values indicate decrements in affect relative to Cyberball. Error bars represent 95% CI.

A parallel 2 (rumination, distraction) X 2 (imagery, verbal thought) X 2 (male, female) between subjects ANOVA was conducted predicting affective recovery. Again, the three-way interaction with gender was not significant [$F(1,115) = 0.39, p = .54, \eta^2_p < 0.01$] nor were any
two-way interactions or main effects (all $p > .05$). Thus, there were no significant gender differences in affective recovery by condition (see Figure 10).

Affective Recovery by Condition by Gender

![Affective Recovery by Condition by Gender](image)

*Figure 10.* No significant gender differences were found in affective recovery by condition. Zero represents no affect change from baseline. Positive values reflect improvements in affect relative to baseline. Negative values indicate decrements in affect relative to baseline. Error bars represent 95% CI.

**Aim 3 (Parasympathetic): Compare HRV Response to Induced Imagery- Versus Verbally-Based Rumination and Distraction**

**Analysis strategy.** To test HRV response to imagery- and verbally-based rumination and distraction, a series of 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects
ANOVAs was conducted predicting HRV reactivity and HRV recovery. Planned contrasts were made between imagery- and verbally-based rumination and between imagery- and verbally-based distraction. Bonferroni corrections were applied to account for multiple comparisons. HRV reactivity was defined as mean HRV change during the rumination/distraction induction. A benefit of applying a wavelet transform is that power is allowed to vary over time, which provides the opportunity to examine HRV data continuously. Thus, to calculate mean HRV change during the rumination/distraction induction, the first second of HRV data during the rumination/distraction induction was subtracted from each subsequent second of HRV, resulting in continuous HRV change throughout the rumination/distraction induction period. Continuous HRV during the rumination/distraction induction was then plotted across time to visualize HRV change by condition (see Figure 11). Consistent condition-related differences were observed so HRV change during the rumination/distraction induction was averaged across time such that HRV reactivity reflected mean HRV change. Zero represents no HRV change. Positive scores reflect increases in HRV across the rumination/distraction induction and negative scores indicate decreases in HRV across the rumination/distraction induction. HRV recovery was defined as the difference between mean HRV during recovery and mean HRV during baseline. Zero represents recovery to baseline HRV. Positive scores reflect higher HRV during recovery relative to baseline. Negative scores indicate lower HRV during recovery relative to baseline.
Consistent condition related differences were observed.

Physiological data were not collected for 11 adolescents due to technical difficulties (i.e., MindWare Mobile Acquisition Unit malfunctions, E-Prime malfunctions). One additional adolescent’s data were not preserved given the adolescent’s failure to follow procedural directions. For the remaining 133 adolescents, HRV data were sufficiently clean to retain for analyses. No univariate outliers were identified for HRV reactivity, but two outliers were found for HRV recovery, which were winsorized. When examined by condition, two outliers were found for HRV recovery (imagery-based rumination: \( n = 1 \); imagery-based distraction: \( n = 1 \)). These outliers were winsorized. Within the subsample of adolescents with elevated depressive symptoms, there was one univariate outlier on HRV reactivity, which also was winsorized.
**HRV response to, and recovery from, rumination/distraction.** First, conditions were compared on HRV reactivity (H9; primary). A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA was conducted predicting HRV reactivity. Main effects of rumination/distraction \([F(1,129) = 0.10, p = .76, \eta^2 < 0.01]\) and imagery/verbal thought \([F(1,129) = 1.47, p = .23, \eta^2 = 0.21]\) were not significant. There was a significant interaction among conditions \([F(1,129) = 4.55, p = .04, \eta^2 = 0.03]\) (see Figure 12). Simple main effects analysis revealed that adolescents in the imagery-based distraction condition experienced significantly higher HRV compared with adolescents in the verbally-based distraction condition \((p = .02, d = 0.65)\). Adolescents in the imagery-based rumination condition experienced similar maintenance of HRV compared with adolescents in the verbally-based rumination condition \((p = .52, d = 0.15)\).
HRV Reactivity by Condition

Figure 12. HRV reactivity differed significantly by condition. HRV increased significantly more for adolescents in the imagery-based distraction condition relative to adolescents in the verbally-based distraction condition ($p = .02$, $d = 0.65$), whose HRV decreased. Adolescents in the imagery- and verbally-based rumination conditions did not differ in HRV reactivity ($p = .52$, $d = 0.15$). Zero represents no change in HRV relative to the beginning of the rumination/distraction induction. Positive values reflect increases in HRV across the rumination/distraction induction. Negative values indicate decreases in HRV across the rumination/distraction induction. Error bars represent 95% CI. *$p < .05$. 
Next, HRV recovery was examined (H10; primary). A parallel 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA was conducted predicting HRV recovery. Neither the interaction \(F(1,129) = 0.09, p = .76, \eta^2 < 0.01\) nor the main effects of rumination/distraction \(F(1, 129) = 0.06, p = .81, \eta^2 < 0.01\) or imagery/verbal thought \(F(1, 129) = 0.42, p = .52, \eta^2 < 0.01\) was significant in predicting HRV recovery (see Figure 13). Thus, HRV recovery was similar across conditions.
Figure 13. HRV recovery was similar for all conditions. Zero represents recovery to baseline HRV. Positive values reflect higher HRV relative to baseline. Negative values indicate lower HRV relative to baseline. Error bars represent 95% CI.

The subsample of adolescents with clinically elevated depressive symptoms was then considered (H11; secondary). Using a 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA, HRV reactivity was examined. No statistically significant differences were found among conditions for HRV reactivity in this subsample [interaction: $F(1,47) = 1.87$, $p = .18$, $\eta^2_p = 0.04$; main effect of rumination/distraction: $F(1,47) = 1.87$, $p = .18$, $\eta^2_p = 0.04$; main effect of imagery/verbal thought: $F(1,47) = 0.08$, $p = .78$, $\eta^2_p < 0.01$ (see Figure 14).
Elevated Depressive Symptom Subsample:

HRV Reactivity by Condition

Figure 14. For adolescents with elevated depressive symptoms, HRV reactivity did not statistically differ by condition. Zero represents no change in HRV relative to the beginning of the rumination/distraction induction. Positive values reflect increases in HRV across the rumination/distraction induction. Negative values indicate decreases in HRV across the rumination/distraction induction. Error bars represent 95% CI.

HRV recovery did differ significantly by condition for adolescents with elevated depressive symptoms. A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA was conducted predicting HRV recovery. Main effects were not significant
[rumination/distraction: $F(1,47) = 3.36, p = .07, \eta^2_p = 0.07$; imagery/verbal thought: $F(1,47) = 1.24, p = .27, \eta^2_p = 0.03$], but there was a significant interaction [$F(1,47) = 4.10, p = .049, \eta^2_p = 0.08$] (see Figure 15). Simple main effects analysis revealed that for adolescents with elevated depressive symptoms, imagery-based distraction actually resulted in significantly less HRV recovery relative to verbally-based distraction ($p = .03, d = 0.92$), while adolescents in the imagery- and verbally-based rumination conditions recovered similarly ($p = .53, d = 0.25$).
Elevated Depressive Symptom Subsample:

HRV Recovery by Condition

Figure 15. HRV recovery differed by condition for adolescents with elevated depressive symptoms. Adolescents in the imagery-based distraction condition experienced less HRV recovery than adolescents in the verbally-based distraction condition ($p = .03$, $d = 0.92$). Adolescents in the imagery- and verbally-based rumination conditions experienced similar HRV recovery ($p = .53$, $d = 0.25$). Zero represents recovery to baseline HRV. Positive values reflect higher HRV relative to baseline. Negative values indicate lower HRV relative to baseline. Error bars represent 95% CI. *$p < .05$. 
Finally, gender was added to the models (H12; secondary). A 2 (rumination, distraction) X 2 (imagery, verbal thought) X 2 (male, female) between subjects ANOVA was conducted predicting HRV reactivity. The three-way interaction was not significant [$F(1,116) = 0.15, p = .70, \eta^2 < 0.01$] nor were any two-way interactions (all $ps > .05$). The main effect of imagery/verbal thought did remain significant [$F(1,116) = 4.29, p = .04, \eta^2 = 0.04$] such that imagery resulted in higher HRV overall (see Figure 16). Patterns of HRV reactivity were similar for male and female adolescents.
HRV Reactivity by Condition by Gender

Figure 16. No significant gender differences were found in HRV reactivity by condition. Zero represents no change in HRV relative to the beginning of the rumination/distraction induction. Positive values reflect increases in HRV across the rumination/distraction induction. Negative values indicate decreases in HRV across the rumination/distraction induction. Error bars represent 95% CI. * $p < .05$.

A parallel 2 (rumination, distraction) X 2 (imagery, verbal thought) X 2 (male, female) between subjects ANOVA was conducted predicting HRV recovery. Again, no significant gender differences were found. The three-way interaction [$F(1,116) = 0.23, p = .64, \eta^2_p < 0.01$], two-way interactions (all $ps > .05$), and main effects (all $ps > .05$) all were not statistically
significant (see Figure 17). Thus, patterns of HRV recovery were similar for males and female adolescents.

**Figure 17.** No gender differences were found in HRV recovery by condition. Zero represents recovery to baseline HRV. Positive values reflect higher HRV relative to baseline. Negative values indicate lower HRV relative to baseline. Error bars represent 95% CI.

**Aim 4 (Sympathetic): Compare GSR Response to Induced Imagery- Versus Verbally-Based Rumination and Distraction**

**Analysis strategy.** To test GSR response to imagery- and verbally-based rumination and distraction, GSR reactivity and recovery were compared using a series of 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVAs. Planned contrasts were
made between imagery- and verbally-based rumination and between imagery- and verbally-based distraction. Bonferroni corrections were applied to account for multiple comparisons. GSR reactivity was computed by calculating mean GSR change during the rumination/distraction induction. As with HRV, the first second of GSR data during the rumination/distraction induction was subtracted from each subsequent second of GSR. Continuous GSR change during the rumination/distraction induction was plotted across time (see Figure 18). Again, consistent condition-related differences were found so GSR change during the rumination/distraction induction was averaged, resulting in a single GSR reactivity score. Zero represents no GSR change. Positive scores reflect increases in GSR. Negative scores indicate decreases in GSR. GSR recovery was calculated by computing the difference between mean GSR during recovery and mean GSR during baseline. Zero represents recovery to baseline. Positive scores reflect higher GSR during recovery than during baseline. Negative scores indicate lower GSR during recovery relative to baseline.
Consistent GSR condition-related differences were observed.

As noted previously, physiological data were not collected for 12 adolescents due to technical difficulties and/or problems following procedural directions. Additional GSR data were eliminated due to issues with the data (see Method section). In total, 49 adolescents were missing data for baseline GSR, 28 adolescents were missing data for GSR during Cyberball, 22 adolescents were missing data for GSR during the rumination/distraction induction, and 50 adolescents were missing data for the recovery period. No univariate outliers were found for GSR reactivity, but one outlier was identified for GSR recovery, which was winsorized. When outliers were considered by condition, one outlier was found for GSR recovery in the verbally-based distraction condition, which also was winsorized.
**GSR response to, and recovery from, rumination/distraction.** GSR reactivity was first compared across conditions (H13; primary). Using a 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA, GSR reactivity was assessed. No significant effects were found [interaction: \( F(1,119) = 2.35, p = .13, \eta^2 = 0.02 \); main effect of rumination/distraction: \( F(1,119) = 2.21, p = .14, \eta^2 = 0.02 \); main effect of imagery/verbal thought: \( F(1,119) = 0.18, p = .67, \eta^2 < 0.01 \)] (see Figure 19). Although the same pattern of results was found as with affective and HRV data, with imagery-based distraction resulting in a more adaptive GSR response (i.e., lower GSR) than verbally-based distraction, this difference did not reach the threshold of statistical significance.
No statistically significant differences were found in GSR reactivity by condition. Zero represents no change in GSR relative to the beginning of the rumination/distraction induction. Positive values reflect increases in GSR across the rumination/distraction induction. Negative values indicate decreases in GSR across the rumination/distraction induction. Error bars represent 95% CI.

GSR recovery was evaluated next (H14; primary). A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA predicting GSR recovery was conducted. Again, no effects emerged as statistically significant [interaction: $F(1,91) = 0.30, p = .59, \eta^2 < 0.01$; main effect of rumination/distraction: $F(1,91) = 2.13, p = .15, \eta^2 = 0.02$; main effect of
imagery/verbal thought: \( F(1,91) = 2.74, p = .10, \eta^2_p = 0.03 \) (see Figure 20). GSR recovery was similar across conditions.

![GSR Recovery by Condition](image)

**Figure 20.** No statistically significant differences were found in GSR recovery by condition. Zero represents recovery to baseline GSR. Positive values reflect higher GSR relative to baseline. Negative values indicate lower GSR relative to baseline. Error bars represent 95% CI.

Analyses were then conducted with only adolescents experiencing elevated depressive symptoms (H15; secondary). When a 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA was conducted predicting GSR reactivity, the interaction \( F(1,45) = 1.03, p = .32, \eta^2_p = 0.02 \) and the main effect of imagery/verbal thought \( F(1,45) = 0.02, p = .90, \)
ηp² < 0.01] were not significant but there was a significant main effect of rumination/distraction
[F(1,45) = 7.24, p = .01, ηp² = 0.14] (see Figure 21). For adolescents with elevated depressive
symptoms, rumination resulted in significantly greater increases in GSR than distraction,
regardless of whether in imagery or in verbal form.
Figure 21. The main effect of rumination/distraction significantly predicted GSR reactivity such that adolescents in the distraction conditions experienced greater decreases in GSR relative to adolescents in the rumination conditions. Zero represents no change in GSR relative to the beginning of the rumination/distraction induction. Positive values reflect increases in GSR across the rumination/distraction induction. Negative values indicate decreases in GSR across the rumination/distraction induction. Error bars represent 95% CI.

GSR recovery was then examined in this subsample using a 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA predicting GSR recovery. Although the
main effect of rumination/distraction was not significant \[F(1,30) = 2.55, p = .12, \eta_p^2 = 0.08\],
there was a significant main effect of imagery/verbal thought \[F(1,30) = 5.21, p = .03, \eta_p^2 = 0.15\] that was qualified by a marginally significant interaction \[F(1,30) = 3.04, p = .09, \eta_p^2 = 0.09\] (see Figure 22). Simple main effects analyses revealed a significant difference in GSR recovery for adolescents with elevated depressive symptoms in the imagery- and verbally-based distraction conditions \((p = .01, d = 1.28)\). Adolescents in the imagery-based distraction condition experienced greater GSR recovery than adolescents in the verbally-based distraction condition.
Elevated Depressive Symptom Subsample:

GSR Recovery by Condition

Figure 22. There was a significant difference in GSR recovery for adolescents with elevated depressive symptoms in the imagery- and verbal-based distraction conditions such that adolescents in the imagery-based distraction condition recovered more than adolescents in the verbally-based distraction condition. Zero represents recovery to baseline GSR. Positive values reflect higher GSR relative to baseline. Negative values indicate lower GSR relative to baseline. Error bars represent 95% CI. *$p < .05$. 
Potential gender differences in GSR reactivity and recovery were then explored (H16; secondary). A 2 (rumination, distraction) X 2 (imagery, verbal thought) X 2 (male, female) between subjects ANOVA was first conducted predicting GSR reactivity. The three-way interaction was not significant \([F(1,106) = 0.71, p = .40, \eta^2 < 0.01]\) nor were any two-way interactions \((ps > .05)\) or main effects \((ps > .05)\). There were no statistically significant gender differences in GSR reactivity across conditions (see Figure 23).

**GSR Reactivity by Condition by Gender**

![GSR Reactivity by Condition by Gender](image)

*Figure 23.* No significant gender differences were found in GSR reactivity by condition. Zero represents no change in GSR relative to the beginning of the rumination/distraction induction. Positive values reflect increases in GSR across the rumination/distraction induction. Negative values indicate decreases in GSR across the rumination/distraction induction. Error bars represent 95% CI.
A 2 (rumination, distraction) X 2 (imagery, verbal thought) X 2 (male, female) between subjects ANOVA also was conducted predicting GSR recovery. Again, the three-way interaction \[F(1,81) = 0.17, p = .68, \eta^2 < 0.01\], two-way interactions \((ps > .05)\), and main effects \((ps > .05)\) were not significant (see Figure 24). GSR recovery was similar for male and female adolescents across conditions.

**GSR Recovery by Condition by Gender**

![GSR Recovery by Condition by Gender](image)

*Figure 24.* No significant gender differences were found in GSR recovery by condition. Zero represents recovery to baseline GSR. Positive values reflect higher GSR relative to baseline. Negative values indicate lower GSR relative to baseline. Error bars represent 95% CI.
Aim 5 (Cognitive): Examine Realism and Vividness as Cognitive Factors that May Contribute to Differences in Affective and Physiological Response to Imagery- and Verbally-Based Rumination/Distraction

Analysis strategy. First, descriptive analyses were conducted to evaluate mean levels of realism and vividness reported in each condition and 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVAs were tested to evaluate whether conditions differed in realism and vividness. Then, realism and vividness were tested as moderators of the relations between condition and affective, HRV, and GSR reactivity. To do so, a series of moderated regression analyses was conducted. In each model, main effects of rumination/distraction (0 = rumination, 1 = distraction), imagery/verbal thought (0 = imagery, 1 = verbal thought), and realism or vividness (centered at the grand mean) were entered. On Step 2, two-way interactions were entered. On Step 3, the three-way interaction was entered. Affective, HRV, and GSR reactivity were tested as dependent variables in separate models. Hypotheses relevant to Aim 5 were considered exploratory as the present study was underpowered to detect three-way effects.

Five adolescents were missing ratings for realism and vividness. No outliers were identified for realism or vividness ratings both in the overall sample and within each condition. No multivariate outliers were identified in any model.

Descriptive analyses and differences among conditions. Overall, adolescents reported that their cognitions during the rumination/distraction induction were moderately realistic ($M = 6.01, SD = 2.24$) and vivid ($M = 6.66, SD = 1.73$) (see Table 4). A 2 (rumination, distraction) X 2 (imagery, verbal thought) between subjects ANOVA predicting vividness revealed a significant main effect of imagery/verbal thought such that adolescents in the imagery conditions reported significantly higher vividness than adolescents in the verbal conditions, $F(1,136) = 5.84, p = .02,$
\( \eta^2 = 0.04 \). A parallel between subjects ANOVA predicting realism did not find condition-related differences \((p < .05)\).

Table 4

*Mean Vividness and Realism by Condition*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Imagery-based rumination</th>
<th>Verbally-based rumination</th>
<th>Imagery-based distraction</th>
<th>Verbally-based distraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sample</td>
<td>6.01 (2.24)</td>
<td>6.03 (2.25)</td>
<td>5.69 (2.48)</td>
<td>6.43 (2.03)</td>
</tr>
<tr>
<td>Realism</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vividness</td>
<td>6.66 (1.73)</td>
<td>7.03 (1.29)</td>
<td>6.40 (1.82)</td>
<td>7.00 (1.70)</td>
</tr>
</tbody>
</table>

**Moderating role of realism and vividness.** In separate models, realism and vividness were tested as potential moderators of the relation between condition and affective, HRV, and GSR reactivity. First, the moderating roles of realism (H17; secondary) and vividness (H18; secondary) on the relation between condition and affective reactivity were tested. Neither overall model was significant [realism: \( R^2 = .07, F(7, 129) = 1.34, p = .24 \); vividness: \( R^2 = .04, F(7, 129) = 0.79, p = .60 \)] and neither realism nor vividness were significant moderators as evidenced by non-significant increases in variance explained on Step 3 [realism: \( \Delta R^2 = .01, \Delta F(1, 129) = 0.93, p = .34 \); vividness: \( \Delta R^2 = .04, \Delta F(1,129) = 0.08, p = .78 \)]. The relation between condition and affective reactivity does not appear to vary based on how realistic or vivid cognitions were perceived to be.

The moderating roles of realism (H19; secondary) and vividness (H20; secondary) on the relation between condition and HRV reactivity were then tested. Although overall models were
significant [realism: $R^2 = .11, F(7, 125) = 2.20, p = .04$] or marginally significant [vividness: $R^2 = .10, F(7,125) = 1.92, p = .07$], increases in variance explained on Step 3 were not significant in either model [realism: $\Delta R^2 < .01, \Delta F(1, 125) = 0.06, \ p = .80$; vividness: $\Delta R^2 < .01, \Delta F(1, 125) = 0.17, p = .68$]. There were significant main effects of realism ($b = .09, p = .02, 95\% \ CI [0.02, 0.16], SE = .04, sr^2 = .04$) and vividness ($b = 0.11, p = .02, 95\% \ CI [0.01, 0.20], SE = .05, sr^2 = .04$) such that higher realism and vividness were associated with greater increases in HRV during the rumination/distraction induction regardless of condition. Again, the relation between condition and HRV reactivity did not vary based on the degree of realism or vividness participants reported, though higher realism and vividness overall were associated with higher HRV.

Finally, realism (H21; secondary) and vividness (H22; secondary) were evaluated as moderators of the relation between condition and GSR reactivity. Overall models were not significant [realism: $R^2 = .10, F(7, 115) = 1.76, p = .10$; vividness: $R^2 = .10, F(7, 115) = 1.72, p = .11$] and realism was not a significant moderator given a non-significant increase in variance explained on Step 3, $\Delta R^2 = .01, \Delta F(1, 115) = 1.43, p = .24$. There was a marginally significant main effect of realism ($b = -.12, p = .06, 95\% \ CI [-0.24, 0.01], SE = .06, sr^2 = .03$); higher realism was associated with lower GSR. Regardless of condition, increased realism resulted in adaptive decreases in GSR.

Vividness was, however, a significant moderator of the relation between condition and GSR reactivity (see Figure 25). There was a significant increase in variance explained on Step 3, $\Delta R^2 = .04, \Delta F(1, 115) = 4.87, p = .03$, suggesting that vividness impacted differences in GSR reactivity among conditions. The association between vividness and GSR reactivity significantly differed based on whether adolescents were induced to ruminate in the form of imagery or verbal
thought. In particular, increased vividness was associated with lower GSR for adolescents in the verbally-based rumination condition \((b = -0.34, p = .03, 95\% \ CI [-0.63, -0.04], SE = .15, r^2 = .04)\) but was not significantly associated with GSR for adolescents in the imagery-based rumination condition \((b = 0.26, p = .24, 95\% \ CI [-0.18, 0.70], SE = .22, r^2 = .01)\). Thus, verbally-based rumination may be especially impairing when lower in vividness.

**Figure 25.** Vividness significantly moderated the relation between condition and GSR reactivity. Vividness was associated with decreases in GSR for adolescents in the verbally-based, but not imagery-based, rumination conditions.
CHAPTER 4
DISCUSSION

Much of what the field knows about rumination has been confined to knowledge about one form of rumination, dwelling in the form of verbal thought. More recently, evidence has emerged that rumination can in fact take the form of imagery (Lawrence & Schwartz-Mette, 2018; McLaughlin et al., 2007; Newby & Moulds, 2012; Speckens et al., 2007) and that ruminating in the form of imagery may be even more maladaptive than ruminating in the form of verbal thought (Lawrence et al., 2018). Until the present study, however, no research had evaluated how imagery- and verbally-based rumination may differentially relate to depressive symptoms or how response to imagery- and verbally-based rumination may differ. The present study addressed this gap, examining whether rumination style (imagery, verbal thought, both) impacted the strength of the rumination-depression relation (Aim 1) and whether induced imagery- and verbally-based rumination resulted in differential affective (Aim 2), parasympathetic (Aim 3), sympathetic (Aim 4), and cognitive (Aim 5) response.

Evidence-based interventions targeting rumination likewise have been largely verbal in focus. In CBT approaches to intervention, clients are guided through verbal cognitive restructuring or verbal distraction as a means of interrupting cycles of rumination. Although relatively nascent, research has begun to evaluate the merits of imagery- versus verbally-based interventions. In the few studies that have directly compared imagery- and verbally-based treatment techniques, imagery-based interventions have been shown to be more effective (Blackwell et al., 2015; Jacob et al., 2011; Renner et al., 2017; Torkan et al., 2014). Until the present study, however, no research had compared experimentally-induced imagery- and verbally-based distraction as alternatives to rumination. The current investigation evaluated
whether imagery- and verbally-based distraction resulted in differential affective (Aim 2), parasympathetic (Aim 3), sympathetic (Aim 4), and cognitive (Aim 5) responses.

Additionally, the present study contributed new information on imagery- and verbally-based rumination and distraction during adolescence, a time when rumination emerges (Nolen-Hoeksema, 1998), risk for depression increases (Costello et al., 2003), and early intervention is vital. Imagery- and verbally-based rumination and distraction were compared in the overall sample of community adolescents (primary), in the subsample of adolescents with elevated depressive symptoms (secondary), and by gender (secondary). Doing so allowed for a more nuanced understanding of how imagery- and verbally-based rumination and distraction impact adolescents. First, findings are discussed within each aim. Then, overall discussion is provided, integrating across all aims to draw conclusions about imagery- and verbally-based rumination and distraction.

Aim 1 (Trait Rumination): Examine Moderating Role of Rumination Style (Imagery, Verbal, Both) on Relation Between Trait Rumination and Depressive Symptom Severity

It is well-established that increased trait rumination is associated with higher depressive symptom severity both in adults (e.g., Lyubomirsky & Tkach, 2004; Nolen-Hoeksema et al., 2008; Smith & Alloy, 2009; Thomsen, 2006) and in adolescents (e.g., Abela & Hankin, 2011; Hankin, 2008; Park et al., 2004). Nearly all research evidencing this relation has conceptualized rumination as purely verbal, however. The present study examined rates of imagery-, verbally-, and both imagery- and verbally-based rumination styles, as well as whether rumination style impacted the strength of this association between trait rumination and depressive symptoms in an adolescent sample.
Previous studies have found that between 27.27% and 61.1% of adults report ruminating in the form of imagery (McLaughlin et al., 2007; Newby & Moulds, 2012; Speckens et al., 2007). It was hypothesized that prevalence rates would be similar in adolescents (H1; primary). Results extended these prevalence estimates. Nearly 70% of adolescents reported ruminating in the form of imagery at least some of the time, with 13.1% reporting that they ruminated exclusively in the form of imagery. Rates of imagery-, verbally-, and both imagery- and verbally-based rumination styles did not differ by gender.

It was not surprising that adolescents ruminated in the form of imagery even more frequently than adults. Previous research has found that adolescents may be more likely to process, and more adept at processing, information in the form of imagery relative to adults (Heyes et al., 2013; Kosslyn et al., 1990). If adolescents are more likely to engage in imagery-based processing than adults, it would follow that they also may be more likely to ruminate in the form of imagery. Another possibility is that the increasing influence of social media and exposure to imagery-based communication has led to greater imagery-based processing in younger generations. Additional research both evaluating longitudinal changes in imagery-based rumination within person and examining potential differences in imagery-based rumination related to media exposure could provide additional information on how rumination in the form of imagery develops and is maintained. Regardless, the fact that the vast majority of adolescents reported ruminating in the form of imagery, either in isolation or in combination with verbal rumination, further emphasizes the need to consider both imagery- and verbally-based rumination in research and clinical contexts.

The current study not only evaluated prevalence of rumination styles but also tested the moderating role of rumination style on the rumination-depression relation. Lawrence et al.
(2018) found that the association between trait rumination and depressive symptom severity was stronger for adults who reported experiencing depressive cognition as imagery, or both imagery and verbal thought, compared with only verbal thought (Lawrence et al., 2018; Study 2). Thus, in the current sample of adolescents, it was hypothesized that rumination style (imagery, verbal, both) would moderate the association between trait rumination and severity of depressive symptoms, with a stronger relation for adolescents who reported an imagery-, or both imagery- and verbally-based, rumination style compared with a verbally-based rumination style (H2; primary).

Results supported this hypothesis. The relation between trait rumination and depressive symptom severity was significantly stronger for adolescents who reported ruminating in the form of imagery, or both imagery and verbal thought, compared with verbal thought alone. Although response to imagery- and verbally-based rumination may not differ in the short term (see Aims 2-4), imagery-based rumination may have a cumulative effect over time, increasing depressive symptom severity. It is also possible that an underlying third variable, such as having an imagery-based processing style in general, may make some adolescents more likely to experience imagery-based rumination, putting those adolescents at higher risk for depression. Relations among imagery-based processing, rumination, and depression, have yet to be examined, however. The findings from the present study do indicate that imagery-based rumination is not only prevalent but has particularly strong ties with depressive symptoms as well.

As expected, similar results were found for the subsample of adolescents with elevated depressive symptoms (H3; secondary). Trait rumination was more strongly associated with depressive symptom severity when adolescents with elevated depressive symptoms reported an
imagery-based rumination style compared with a verbally-based rumination style, though neither group differed from those adolescents who reported a both imagery- and verbally-based rumination style. This suggests that imagery-based rumination is problematic regardless of how severe one’s depressive symptoms are.

Gender differences were not found in the moderating role of rumination style as hypothesized (H4; secondary). Previous work has shown depressive cognitive style to moderate the rumination-depression relation only for females (Lawrence et al., 2018). In this sample, the three-way interaction among gender, trait rumination, and rumination style did not significantly predict depressive symptom severity. Rumination style may therefore function similarly for male and female adolescents. Of note, however, there were unequal samples of males and females in the present study with fewer males than females. Within each gender there may have been insufficient numbers of adolescents with each rumination style to detect a potential three-way interaction. Additional research with larger samples of equal numbers of male and female adolescents is needed.

Results from the present study confirm that rumination is far from exclusively verbal. Findings from Aim 1 suggest that the majority of adolescents ruminate in the form of imagery at least some of the time and that imagery-based rumination may be especially highly associated with depression. By excluding imagery-based ruminators from research on rumination and by neglecting to ask about rumination in imagery form in therapy, the field is likely missing important information regarding the risk that dwelling on imagery may pose, dampening clinicians’ ability to intervene effectively.
Aim 2 (Affect): Compare Affective Response to Induced Imagery- and Verbally-Based Rumination and Distraction

Rumination is thought to be associated with depression in part because it functions to maintain and/or increase negative affect. In line with this assertion, previous research has found that in adolescents, rumination intensifies negative affect (Schwartz & Koenig, 1996; Rood et al., 2012), whereas distraction relieves negative affect (Park et al., 2004). A parallel line of research has shown imagery to serve as an emotional amplifier, with negative imagery eliciting greater negative affect than negative verbal thought and positive imagery eliciting greater positive affect than positive verbal thought (see Holmes & Mathews, 2010 for review). Thus, it was hypothesized that imagery-based rumination would result in greater increases in negative affect relative to verbally-based rumination and that imagery-based distraction would provide greater affective relief relative to verbally-based distraction (H5; primary).

Counter to this hypothesis, imagery- and verbally-based rumination did not differ in terms of affective reactivity. In both conditions, negative affect was similarly maintained relative to affect post-Cyberball. Although it was expected that imagery-based rumination would result in greater negative affect than verbally-based rumination given that imagery has been shown to be more affectively arousing than verbal thought in other contexts (Holmes & Mathews, 2010), the current study’s finding is in line with the only other study to compare affective response to imagery- and verbally-based rumination (Lawrence & Schwartz-Mette, 2018). In Lawrence and Schwartz-Mette’s (2018) study with undergraduates who were induced to ruminate, neither the degree to which they experienced imagery nor verbal thought was associated with the amount of affect change they experienced during rumination. Thus, it may be that imagery-based rumination maintains negative affect similarly to verbally-based rumination.
It is also possible that the lack of a difference in affective reactivity in response to imagery- and verbally-based rumination was due to the choice of rumination prompts. Prior research comparing affective response to imagery and verbal thought used emotionally laden stimuli (i.e., imagery/verbal stimuli that were positively or negatively valenced; Holmes & Mathews, 2005; Holmes, Mathews, et al., 2008; Mathews et al., 2013). The rumination and distraction prompts used in the present study were instead emotionally neutral, as intended by Nolen-Hoeksema. The idea that imagery-based rumination would result in greater negative affect than verbally-based rumination because negative imagery has been shown to result in greater negative affect than negative verbal thought may therefore not translate. In fact, when affective responses to benign imagery and verbal thought have been compared in the past (Holmes & Mathews, 2005), affective reactivity did not differ. It is therefore also possible that affective response to imagery- and verbally-based rumination did not differ in the present study, not because imagery- and verbally-based rumination similarly maintain negative affect, but rather because the rumination prompts used were neutral rather than negative. Given that rumination is conceptualized as a response to negative affect and/or negative life events, additional work comparing affective response to more negatively-valenced imagery- and verbally-based rumination is needed.

Affective response to imagery- and verbally-based distraction also was compared. In line with hypotheses, imagery-based distraction was significantly more effective in providing affective relief relative to verbally-based distraction. Following Cyberball, affect improved only for those adolescents assigned to distract themselves in the form of imagery. Affect actually worsened for those adolescents who engaged in verbal distraction. Again, this result was consistent with findings from the only previous study to compare imagery and verbal thought.
during distraction. Lawrence and Schwartz-Mette (2018) found that greater imagery during distraction was associated with greater affective relief.

This finding is noteworthy given that cognitive behavioral interventions are typically verbal in focus. In the context of treating depression, relieving negative affect is especially important. Based on findings from the current study, imagery-based strategies may be most efficient in doing so. Importantly, the distraction prompts used in the present study also were previously shown to be emotionally neutral (Lawrence & Schwartz-Mette, 2018), in line with Nolen-Hoeksema’s traditional rumination/distraction induction. Thus, it was not that imagery-based distraction prompts were simply more positive than verbally-based distraction prompts; rather the act of constructing a mental image in response to distracting stimuli was more powerful in improving affect relative to forming a verbal mental sentence about those same distracting stimuli. One possibility is that imagery may require greater cognitive load and concentration than does verbal thought. If so, imagery could provide more effective distraction whereas verbal thought may allow for rumination to continue concurrently. Additional research on the effort required to distract oneself in the form of imagery and verbal thought would be needed to confirm this hypothesis, however.

A second possibility is that because of the ties imagery shares with real perception (Dobson & Markham, 1993; Holmes & Mathews, 2010), imagery-based distraction may elicit the same affective response felt during a real experience. For example, the distraction prompt, *Think about/imagine as many different pizza toppings as you can,* may be more likely to elicit the same positive affect experienced during a fun outing to a pizza parlor when imagined versus when thought about verbally. Again, this supposition has yet to be tested empirically.
Affective recovery was then compared following imagery- and verbally-based rumination and distraction. Adolescents in all conditions experienced similar affective recovery, despite the hypothesis that imagery-based rumination would result in less affective recovery than verbally-based rumination and that imagery-based distraction would result in more affective recovery than verbally-based distraction (H6; primary). In all conditions, adolescents returned to approximately their baseline affect. The rumination/distraction induction used in the present study was only 12 minutes long. Adolescents in all conditions may have had sufficient time to affectively recover relative to this short period of rumination/distraction. Rumination is unlikely to cease after such a short time in the environment. In fact, Nolen-Hoeksema coined the term ruminative response style because of the tendency to consistently respond to negative effect with rumination. It is therefore possible that affective recovery following imagery- and verbally-based rumination and distraction in the real world would differ when rumination and distraction are more prolonged.

To begin to elucidate whether imagery- and verbally-based rumination and distraction function differently when adolescents experience clinical levels of depressive symptomatology, parallel analyses were run examining affective reactivity and recovery in the subsample of adolescents with elevated depressive symptoms. As predicted, similar patterns of results were found in this subsample as were observed in the overall sample (H7; secondary), although differences among conditions did not reach the threshold of statistical significance. There was similar maintenance of negative affect for adolescents in the imagery- and verbally-based rumination conditions. Affective improvement was documented only for adolescents in the imagery-based distraction condition whereas affect worsened for adolescents in the verbally-based distraction condition, but again, these differences were not statistically significant. In terms of affective recovery, the main effect of rumination/distraction was significant.
Adolescents in the rumination conditions experienced less affective recovery relative to adolescents in the distraction conditions, but no differences in affective recovery were found based on whether those conditions were imagery- or verbally-based.

It is not surprising that the main effect of rumination/distraction emerged as significant in this subsample. Previous work has shown that differences in response to rumination and distraction using Nolen-Hoeksema’s induction may only emerge when individuals are depressed or are experiencing depressed mood (Lyubomirsky & Nolen-Hoeksema, 1995; Nolen-Hoeksema & Morrow, 1993). It was, however, unexpected that differences in affective response to imagery- and verbally-based distraction were not statistically significant in this subsample. Only one prior study (Sloftsra et al., 2017) has examined how depression impacts affective response to imagery and verbal thought. In their adult sample, processing a negative autobiographical memory in the form of imagery resulted in greater negative affect than processing the memory in the form of verbal thought, but only for those adults with low levels of depressive symptoms. Thus, it may be that imagery- and verbally-based distraction result in differential affective response for adolescents with low but not high depressive symptoms. Additional analyses would need to be conducted with the subsample of adolescents with minimal depressive symptoms to determine if this is the case.

Another possibility is that the lack of a statistically significant difference between imagery- and verbally-based distraction in the subsample of adolescents with elevated depressive symptoms was due to insufficient statistical power. This may be more likely as the magnitude of affective change in response to imagery- and verbally-based distraction was similar in this subsample relative to the overall sample, but there were fewer adolescents who met criteria as having elevated depressive symptoms. Studies with larger samples of adolescents experiencing
clinical depression could aid in clarifying how affective response to imagery- and verbally-based distraction may differ based on depressive symptomatology.

Lastly, gender differences in affective reactivity and recovery were examined. Larger differences in affective reactivity and recovery were predicted among conditions for females than for males (H8; secondary), but no significant gender differences in affective response were obtained. Typically, gender is found to moderate the relation between rumination and depressed mood such that there is a stronger association between the constructs for females than for males (Hankin & Abramson, 2001; Nolen-Hoeksema, 1994). This could suggest that rumination results in greater negative affect for females than for males, which overtime, exacerbates depressive symptoms. In line with this hypothesis, adult females have been shown to experience greater negative affect during rumination than adult males (Mor & Winquist, 2002). Importantly, however, gender differences in affective response to induced rumination are not consistently found in adolescents (Park et al., 2004). It may be that as adolescence progresses and gender differences begin to emerge in the degree to which individuals ruminate and in their risk for depression, gender differences also become apparent in affective response to rumination. The present study was underpowered to detect developmental differences within the span from 13- to 17-years-old, however.

Importantly, there also has been no research examining gender differences in affective response to imagery and verbal thought. The current study did not find differences in how male and female adolescents responded affectively to imagery and verbal thought, at least in the form of rumination and distraction. As noted, however, the present study had unequal numbers of males and females and may have been underpowered to detect possible gender effects; additional
research on gender differences in affective response to imagery- and verbally-based rumination and distraction is therefore needed.

Overall, imagery-based rumination appears to result in similar affective reactivity and recovery compared with verbally-based rumination. Interestingly, imagery-based distraction was found to be particularly effective in relieving negative affect compared with verbally-based distraction. This pattern was consistent in the overall sample, for adolescents with elevated depressive symptoms, and for both genders, though the effect was statistically significant only in the overall sample, potentially due to insufficient power to detect small effects in these subsamples.

**Aim 3 (Parasympathetic): Compare HRV Response to Induced Imagery- Versus Verbally-Based Rumination and Distraction**

Rumination is associated with reduced HRV, a sign of lower parasympathetic response and poor internal emotion regulation (Brosschot et al., 2006; Radstaak, et al., 2011; Vögele et al., 2010; Woody et al., 2015). Although no research has compared HRV reactivity to imagery and verbal thought, some studies have found imagery to result in exaggerated physiological arousal relative to verbal thought (Reyher & Smeltzer, 1968; Vrana et al., 1989). Therefore, it was hypothesized that HRV reactivity would be greater in imagery conditions relative to verbal conditions such that imagery-based rumination would result in lower HRV than verbally-based rumination, and imagery-based distraction would result in higher HRV than verbally-based distraction (H9; primary).

In line with findings for affect, this hypothesis was only partially supported. Imagery-based rumination resulted in similar HRV reactivity relative to verbally-based rumination. In both conditions, HRV was maintained following Cyberball. This suggests that parasympathetic
response to rumination is similar regardless of whether rumination takes imagery or verbal form. Rumination may prolong parasympathetic response and lead to internal dysregulation because of its perseverative internal focus, rather than the specific content of the ruminative cognitions. Simply continuing to think about the negative experience of Cyberball may have been enough to maintain reduced HRV, regardless of whether adolescents were assigned to dwell in the form of imagery or verbal thought.

There is also no research directly comparing HRV in response to imagery and verbal thought. It is possible that HRV response to imagery and verbal thought is equivalent, which might explain why HRV response to imagery- and verbally-based rumination was similar. When imagery and verbal thought are compared on other physiological indices, however, imagery is found to be more physiologically activating (e.g., Vrana et al., 1989), suggesting that this explanation is less likely.

HRV response to distraction did vary depending on whether adolescents distracted themselves in the form of imagery or verbal thought. HRV was significantly higher for adolescents in the imagery-based distraction condition relative to adolescents in the verbally-based distraction condition. HRV increased for adolescents in the imagery-based distraction condition but decreased for adolescents in the verbally-based distraction condition. Thus, imagery-based distraction appears to promote a more adaptive parasympathetic response relative to verbally-based distraction.

Again, imagery-based distraction may allow for greater increases in HRV than verbally-based distraction in part because it may require more cognitive effort. If so, imagery-based distraction may better prevent continued perseveration on the negative experience of Cyberball, allowing for greater emotion regulation and increases in HRV. Verbally-based distraction may
instead require less cognitive load, allowing for concurrent ruminaton, which could explain why decreases in HRV were observed for adolescents in this condition.

It is also possible that imagery-based distraction increases HRV because it provides affective relief. As affect improves in the imagery-based distraction condition there may be less of a demand for emotion regulation, allowing for HRV to stabilize and return to baseline. Given that affect worsened in the verbally-based distraction condition, adolescents may continue to require regulatory capabilities, resulting in lower HRV. In other words, it may be that affect and parasympathetic response interact to promote a more adaptive response to imagery-based distraction and a less adaptive response to verbally-based distraction.

HRV recovery was then compared across conditions. Counter to the hypothesis that imagery-based rumination would impede HRV recovery relative to verbally-based rumination and that imagery-based distraction would promote HRV recovery relative to verbally-based distraction (H10; primary), HRV recovery was similar in all conditions. On average, adolescents recovered to their baseline HRV regardless of whether they ruminated or distracted themselves in imagery or verbal form.

At least in response to the brief rumination/distraction induction used, the differential HRV reactivity found in response to imagery- and verbally-based distraction may be short-lived. As noted previously, the 12-minute rumination/distraction induction may not have been powerful enough to see differences in HRV response to imagery- and verbally-based distraction persist through the recovery period. It remains unknown whether HRV recovery following imagery- and verbally-based rumination and distraction differ when these processes are long-lasting, as might occur when adolescents are in their real environment.
Similar results regarding HRV reactivity and recovery were expected in the subsample of adolescents with elevated depressive symptoms, though it was predicted that the differences among conditions would be magnified (H11; secondary). As expected, adolescents in the imagery-based rumination condition experienced lower HRV than adolescents in the verbally-based rumination condition, and adolescents in the imagery-based distraction condition experienced higher HRV than adolescents in the verbally-based distraction condition. These differences were not statistically significant, however. The fact that differences among conditions were not statistically significant in this subsample of adolescents with elevated depressive symptoms was most likely due to the smaller sample of adolescents who met criteria for inclusion in this set of analyses. A larger sample of adolescents with clinical depression would be needed to determine whether conditions are in fact not statistically different from one another, or whether imagery- and verbally-based rumination and distraction differ in HRV response for depressed adolescents as well.

One finding that was notably counter to expectations was that within this subsample, differences among conditions in HRV recovery were statistically significant, but in the opposite direction of the hypothesized effect. Adolescents in the imagery- and verbally-based rumination conditions recovered similarly, but adolescents in the imagery-based distraction condition experienced less HRV recovery than adolescents in the verbally-based distraction condition. Although unexpected, it is possible that this finding may actually lend additional support to the efficacy of imagery-based distraction. Once imagery-based distraction ceased and adolescents with depressive symptoms were left to recover, they may have returned to thinking about the negative experience of Cyberball, resulting in a rebound reduction in HRV during the recovery period. Verbally-based distraction may have allowed for more concurrent reflection on Cyberball
during the actual distraction period, lessening the impact once distraction ended. Given that no differences in recovery was found among conditions for any other outcome variable, however, this single finding should be interpreted with caution.

Lastly, gender was added to the model. It was hypothesized that differences among conditions in HRV reactivity would be larger for females than for males (H12; secondary). Instead, no gender differences were found. A similar pattern of HRV reactivity was observed across conditions for both males and females as was detected in the overall samples, but no differences among conditions were statistically significant. HRV recovery also was consistent across all conditions for both male and female adolescents. The previous caution regarding unequal samples of males and females and potential lack of power to find three-way effects remains. It is also noteworthy that consistent gender differences in HRV are not always found in youth (Silvetti, Drago, & Ragonese, 2001), suggesting that a lack of gender differences was not unlikely.

Taken together, imagery- and verbally-based rumination resulted in comparable HRV reactivity and recovery, whereas imagery-based distraction promoted more adaptive HRV reactivity than verbally-based distraction. Although this pattern was observed in the overall sample, the subsample of adolescents with elevated depressive symptoms, and for both females and males, differences between imagery- and verbally-based distraction were again statistically significant only in the overall sample. HRV recovery was largely similar across all conditions. The only exception was in the subsample of adolescents with elevated depressive symptoms; adolescents with elevated depressive symptoms in the imagery-based distraction condition experienced less HRV recovery than adolescents with elevated depressive symptoms in the verbally-based distraction condition.
Aim 4 (Sympathetic): Compare GSR Response to Induced Imagery- Versus Verbally-Based Rumination and Distraction

Rumination also is associated with increased GSR, which reflects higher sympathetic activation and is conceptualized as heightened emotional arousal (Backs & Boucsein, 2000; Critchley et al., 2000; Hansen & Sawatzky, 2008; Jansen et al., 1995; Sigmon et al., 2000; Steinfurth et al., 2017). There is mixed evidence, however, regarding whether GSR response to imagery versus verbal thought differs. Reyher and Smeltzer (1968) documented larger GSR reactivity in response to imagery versus verbal thought, whereas Baker and Jessup (1980) found the opposite effect. Given that past research more consistently finds imagery to result in a larger physiological response compared to verbal thought, greater GSR reactivity was expected in the imagery conditions relative to the verbal conditions such that imagery-based rumination would result in higher GSR than verbally-based rumination and imagery-based distraction would result in lower GSR than verbally-based distraction (H13; primary).

Counter to this hypothesis but consistent with results regarding affective and HRV reactivity, GSR reactivity did not differ between imagery- and verbally-based rumination. Adolescents who were induced to ruminate in imagery or in verbal form experienced similar maintenance of GSR activation. Thus, sympathetic response to imagery- and verbally-based rumination appears to be similar. If GSR is posited to serve as a marker of emotional arousal, it makes sense that if imagery- and verbally-based rumination similarly maintain self-reported affect following Cyberball, they also would similarly maintain GSR activation. Additionally, there was mixed evidence regarding whether imagery and verbal thought resulted in differential GSR response (Baker & Jessup, 1980; Reyher & Smeltzer, 1968), making it potentially less likely to find differences in GSR reactivity during imagery- and verbally-based rumination.
As noted when discussing previous findings, imagery- and verbally-based rumination may be problematic because of their perseverative nature, rather than whether those perseverative cognitions take imagery or verbal form. Continuing to process the negative experience of Cyberball may maintain sympathetic arousal (as it does affective and HRV arousal) because thinking about Cyberball elicits the same sympathetic response as that experienced during Cyberball. Another possibility is that affective response during the rumination/distraction induction drove sympathetic response. The act of perceiving one’s own negative affect may have led to increased sympathetic response and overall maintenance of GSR. Given that affective response to imagery- and verbally-based rumination did not differ, it would follow that GSR response to imagery- and verbally-based rumination also would not vary.

GSR reactivity in response to imagery- and verbally-based distraction also was not significantly different. The pattern of GSR reactivity was in line with that found for HRV and affect, with imagery-based distraction resulting in a more adaptive response (i.e., lower GSR) than verbally-based distraction. This difference was not, however, large enough to reach statistical significance after Bonferroni corrections were applied.

One possibility is that differences in sympathetic response to imagery- and verbally-based distraction may not be as exaggerated as differences in parasympathetic or affective response. It may be that imagery-based distraction promotes adaptive emotion regulation (as indexed by HRV) and perceptions of affective improvement, while sympathetic arousal may take longer to recover following Cyberball. This would be counter to existing evidence that in general, sympathetic change occurs more rapidly than parasympathetic change (e.g., Gordan, Gwathmey, & Xie, 2015), however.
In addition, it is noteworthy that in the current study, GSR was conceptualized as an index of emotional arousal but has also been interpreted as a marker of attention in prior studies (Critchley et al., 2000). Thus, it is possible that differences among conditions were partially obscured because imagery- and verbally-based distraction, by requiring adolescents to draw their attention away from Cyberball, required similar attentional demands. This seems less likely, however, given that similar patterns of effects were found for affect ratings and HRV, which may be less susceptible to attentional demands.

Finally, given that similar patterns were found for GSR, HRV, and affect change during imagery- versus verbally-based distraction, an additional possibility is that the difference in statistical significance for GSR findings was due to lack of power. There was approximately twice as much GSR reactivity data missing compared with HRV or affective reactivity data, lowering the potential to find small effects. Thus, differences in GSR reactivity during imagery- and verbally-based distraction may emerge as statistically significant with a larger sample, though additional research is needed to test this.

GSR recovery also was consistent across conditions despite the prediction that imagery-based rumination would result in less GSR recovery relative to verbally-based rumination, and imagery-based distraction would result in more GSR recovery relative to verbally-based distraction (H14; primary). No differences in sympathetic activation during recovery were found among conditions. Adolescents were able to recover to approximately baseline GSR regardless of whether they ruminated or distracted themselves in imagery or verbal form.

This finding is in line with results previously described for HRV and affective recovery. In general, adolescents in all conditions recovered to baseline. As noted, it may be that Cyberball was not aversive enough or that the 12-minute rumination/distraction induction used in the
present study was not long enough to result in persistent sympathetic change that would continue through the recovery period. Adolescents who have a ruminative response style may ruminate for longer periods of time in their real environments, which may prolong GSR activation and result in less GSR recovery. Adolescents who tend to distract themselves in response to negative affect also may experience a more adaptive and prolonged GSR response in their real lives. Physiological response to imagery- and verbally-based rumination and distraction has yet to be studied in an ecologically valid context, however.

The same models were then re-examined with the subsample of adolescents with elevated depressive symptoms. Similar patterns were expected, though differences among conditions were hypothesized to be greater (H15; secondary). Adolescents with elevated depressive symptoms in the distraction conditions experienced significantly greater reductions in GSR than adolescents in the rumination conditions, but there were no significant differences based on whether rumination and distraction were in imagery or verbal form. Although mean level differences in GSR change were in the expected directions (i.e., greater increases in GSR for adolescents in the imagery-based rumination condition than adolescents in the verbally-based rumination condition, and greater decreases in GSR for adolescents in the imagery-based distraction condition than adolescents in the verbally-based distraction condition), these differences were not statistically significant.

Again, a main effect of rumination/distraction predicting GSR reactivity was found for the subsample of adolescents with elevated depressive symptoms but not for the overall sample. As previously described, prior research has established that Nolen-Hoeksema’s rumination/distraction induces rumination for those individuals already depressed or experiencing negative affect. Although Cyberball was intended to induce negative affect in all
participants, it is possible that negative affect was only sufficiently high to induce full rumination in those participants who were already depressed.

As in the overall sample, GSR response to imagery- and verbally-based distraction was not statistically different in this subsample but was in the expected direction, with imagery-based distraction resulting in greater decreases in GSR than verbally-based distraction. This would suggest that imagery and verbally-based rumination and imagery and verbally-based distraction may result in similar sympathetic response regardless of how depressed an adolescent is. A larger sample of clinically depressed adolescents is needed to determine whether sympathetic response to imagery- and verbally-based distraction is meaningfully different, which could begin to inform whether imagery-based interventions are more effective than verbally-based interventions in treating clinical depression in this age group.

In line with hypotheses but inconsistent with findings examining affect and HRV, there were significant differences in GSR recovery based on the condition adolescents with elevated depressive symptoms were in. Adolescents in the imagery- and verbally-based rumination condition experienced similar GSR recovery, whereas adolescents in the imagery-based distraction condition experienced significantly greater GSR recovery than adolescents in the verbally-based distraction condition. For adolescents experiencing elevated depressive symptoms, imagery-based distraction provided greater relief of sympathetic activation than verbally-based distraction. This finding lends further support to the idea that imagery-based distraction does provide additive benefit over verbally-based distraction for depressed adolescents, despite the fact that GSR reactivity did not significantly differ for adolescents in the imagery- and verbally-based distraction conditions. It may be that these differences are not initially evident during distraction, but that for adolescents with elevated depressive symptoms,
distraction in the form of imagery relative to verbal thought begins to lower sympathetic activation as time goes on. One reason that this finding emerged only for depressed adolescents may be that imagery-based distraction is especially different from their typical ruminative styles of processing negative experiences, whereas nondepressed adolescents may employ distraction more regularly.

Finally, gender hypotheses were tested. Differences in GSR reactivity and recovery by condition were expected to be larger for females than for males (H16; secondary). However, no gender differences were found in GSR reactivity or recovery. This lack of a significant gender effect may again have been due to the imbalance of males and females or insufficient power to detect small, three-way effects. It is also possible that male and female adolescents respond similarly sympathetically to imagery- and verbally-based rumination and distraction. Previous research has not always found consistent gender differences in GSR (Carrillo et al., 2001; Chentsova-Dutton & Tsai, 2007; Kreibig et al., 2007) and no research has evaluated gender differences in GSR response to imagery and verbal thought. A third option is that gender differences in sympathetic response to imagery- and verbally-based rumination and distraction may emerge across development, as females continue to ruminate more than males over the transition to adulthood. Longitudinal research is needed to examine this possibility.

Taken together, imagery- and verbally-based rumination appear to elicit a similar sympathetic response, as evidenced by the lack of statistically significant differences in GSR reactivity and recovery experienced by adolescents in each condition. Although imagery-based distraction resulted in greater mean level reductions in GSR than verbally-based distraction, differences between these conditions were not statistically significant as they were for affect and HRV. Analyses conducted with the subsample of adolescents with elevated depressive symptoms
revealed similar patterns, though imagery-based distraction did result in significantly greater sympathetic recovery relative to verbally-based distraction. Thus, imagery-based distraction may provide an especially effective means of lowering emotional arousal over time, especially for depressed adolescents. No gender differences in sympathetic response were found.

**Aim 5 (Cognitive): Examine Realism and Vividness as Cognitive Factors that May Contribute to Differences in Affective and Physiological Response to Imagery- and Verbally-Based Rumination/Distraction**

Rumination and distraction both involve retrieval and rehearsal of cognitions, though ruminative cognitions tend to be negatively valenced, whereas distracting cognitions tend to be neutral or positively valenced. Imagery is perceived to be more realistic than verbal thought (e.g., Heyes et al., 2013; Kosslyn et al., 2001; Hyman & Pentland, 1996), and the more vivid imagery is, the more likely it is to be associated with real perception (Dobson & Markham, 1993; Holmes & Mathews, 2010). Realism and vividness may therefore explain potential differences between imagery- and verbally-based rumination and distraction. It was hypothesized that realism and vividness would independently moderate relations among rumination/distraction induction conditions and affective (H17; H18; secondary), HRV (H19; H20; secondary), and GSR (H21; H22; secondary) reactivity. Differences among conditions were expected to be larger the more realistic and vivid cognitions were perceived to be.

On a mean level, imagery was more vivid but similarly realistic compared with verbal thought. Counter to predictions, neither realism nor vividness impacted the strength of associations between condition and affective or HRV reactivity. Although realism also did not impact the association between condition and GSR reactivity, vividness was a significant moderator of this relation. Higher vividness was associated with greater reductions in GSR for
adolescents in the verbally-based but not imagery-based rumination condition. Thus, although imagery- and verbally-based rumination were largely found to result in a similarly maladaptive response across outcomes, lower vividness of verbal ruminative cognitions could lead verbally-based rumination to be more impairing, at least sympathetically. It may be that by increasing the vividness of verbal thought, those thoughts become more distracting and therefore help to relieve sympathetic activation. It is also possible that verbal thoughts are perceived as more vivid as they become increasingly problem-solving oriented, a more adaptive alternative to rumination that also may lower sympathetic response.

It does appear, however, that there are unstudied factors that lead imagery-based distraction to result in a more adaptive affective and parasympathetic response than verbally-based distraction as neither vividness nor realism explained why distraction in imagery and verbal form differed in affective and HRV response. Use of first-person pronouns and/or first-person perspective could be one such factor. If individuals use first-person pronouns and/or experience imagery from a first-person perspective, they may feel more involved in their cognitions and therefore may experience heightened response relative to engaging in third-person processing, which may allow for more distance form their own cognitions.

Another variable that has not yet been studied in this context is visual imagery ability. Miller and colleagues (1987) found that physiological arousal differed between emotional imagery (e.g., fear versus anger inducing imagery) only for those individuals with high imagery abilities. Thus, it is possible that differences between imagery- and verbally-based rumination and imagery- and verbally-based distraction emerge only when individuals are capable of forming a vivid mental image (i.e., have high imagery abilities). Additionally, visual imagery ability could predict rumination style. Individuals who have high imagery abilities may more
readily gravitate towards imagery-based styles of processing, both putting them at risk for imagery-based rumination and making them more capable of potentially engaging in adaptive imagery-based distraction. No research has evaluated the role of visual imagery abilities in this way, however.

In sum, it remains largely unknown what factors lead imagery- and verbally-based rumination to be similarly impairing, but imagery-based distraction to be more effective than verbally-based distraction in promoting adaptive affective, parasympathetic, and potentially, sympathetic responses. Vividness and realism of cognitions largely did not appear to influence differences in response to imagery- and verbally-based rumination and distraction, with the exception of vividness impacting sympathetic response to verbally-based rumination. Thus, additional research is needed to identify why imagery-based distraction may be especially beneficial.

**General Discussion**

**Imagery- and Verbally-Based Rumination**

Imagery-based rumination resulted in similar affective, HRV, and GSR response compared to verbally-based rumination. In both forms, rumination largely maintained affective and physiological response to Cyberball. These findings lend support to the perseverative cognition hypothesis, that rumination exerts its negative influence through perseverative focus, rather than the specific content of ruminative cognitions (e.g., Brosschot et al., 2006). Perseveration is likely to interfere with opportunities for problem solving or even behavioral activation, regardless of whether it takes the form of imagery or verbal thought. Thus, rumination may maintain affective and physiological activation, and contribute to risk for depression,
because of its perseverative nature. It may not matter whether ruminative cognitions are imagery- or verbally-based.

It was surprising, however, that imagery-based rumination was not even more affectively and physiologically impactful relative to verbally-based rumination, given that imagery has been shown to be more affectively and physiologically arousing than verbal thought. In fact, the findings from the current study are in opposition to Borkoveck’s cognitive avoidance model (Sibrava & Borkovec, 2006), which posits that individuals avoid the emotional salience of imagery by worrying in verbal form. One possibility was that dwelling on imagery during rumination reduced its impact through repeated rehearsal of mental images. Imaginal exposure exercises, for example, become less anxiety provoking through repetition (e.g., Minnen & Foa, 2006); thus, repeatedly dwelling on imagery during rumination may similarly reduce imagery’s emotional and physiological impact. This may not be the most likely explanation, however, as when physiological response to the rumination/distraction induction was plotted continuously over time (see Figures 11, 18), reductions in physiological activation were not observed over the course of the rumination/distraction induction as would be expected if habituation had occurred.

There also may be a methodological reason that differences in affective response to imagery- and verbally-based rumination were not found. The rumination prompts used in both the current study and in Lawrence and Schwartz-Mette (2018) were intentionally emotionally neutral. Nolen-Hoeksema specifically designed this rumination/distraction induction to be neutral such that rumination would emerge for those individuals who were already experiencing negative affect (either due to depressive symptoms or a negative mood induction as employed in the current study; Nolen-Hoeksema & Morrow, 1993). Previous work comparing affective response to imagery and verbal thought has instead compared emotionally valenced stimuli
(Holmes & Mathews, 2005; Holmes, Mathews, et al., 2008; Mathews et al., 2013). There may therefore be differences between imagery- and verbally-based rumination in reality, as rumination is often prompted by a negative trigger or prolonged depressed mood, rather than the brief negative mood induction used in the present study (i.e., Cyberball).

This latter explanation is supported by the current study’s finding that trait rumination was more highly associated with depressive symptom severity when adolescents ruminated in the form of imagery compared with verbal thought. It could be that rumination in real life is more negatively valenced than rumination traditionally induced in the lab, leading to these differences in imagery- and verbally-based rumination. It also is possible that the effects of imagery- and verbally-based rumination are cumulative such that the differential impact of ruminating in the form of imagery or verbal thought emerge over time as individuals continue to ruminate in imagery or verbal form. This may not have been captured by the 12-minute rumination/distraction induction used in the present study.

Overall, it is clear from the current study’s findings that imagery-based rumination is just as impairing, if not more impairing, than verbally-based rumination. When considering rumination, researchers and clinicians should evaluate for perseverative cognition in both imagery and verbal form. Neglecting to do so could fail to capture the majority of adolescents who engage in imagery-based rumination at least some of the time, hampering both research and clinical efforts to identify and treat rumination.

**Imagery- and Verbally-based Distraction**

Imagery-based distraction improved affect, increased HRV, and reduced GSR more so than verbally-based distraction, though differences in sympathetic response were not statistically significant. Thus, imagery-based distraction appears to be more effective than verbally-based
distraction. This lends support to the idea that imagery-based treatments may provide a more impactful means of intervening, relieving negative affect, and promoting a more adaptive physiological response relative to verbally-based treatments.

One reason imagery-based distraction may be better at providing affective and physiological relief than verbally-based distraction is that imagery is closely tied with real perception (Kosslyn et al., 2001). Imagery may be more likely to elicit the emotion tied with a real experience compared with verbal thought. Consider, for example, why it may be more common to laugh or cry in response to watching a movie relative to reading a book. It is unclear why this effect would not also translate to differences between imagery- and verbally-based rumination, however.

It is also possible that, as noted previously, imagery may require higher cognitive load than verbal thought given its multisensory nature. If generating and maintaining a mental image is more taxing than generating a verbal thought, imagery may be a more effective means of distraction whereas verbal thought may allow rumination to continue concurrently. Again, this has yet to be tested empirically.

Additionally, imagery-based distraction may be more amenable to individuals relative to verbally-based distraction. Previous studies reported that therapists preferred incorporating imagery-based techniques in treatment (Arntz et al., 2007), that adding imagery-based treatment techniques to interventions lowered client dropout rates (Arntz et al., 2007), and that 90.5% of participants report that they would use imagery rescripting again (Moritz et al., 2018). This may be because imagery-based techniques are effective in reducing depressive symptoms, but also suggests that participants find imagery-based interventions to be relatively enjoyable and potentially easy. Thus, imagery-based distraction may have been more effective in promoting an
adaptive affective and physiological response than verbally-based distraction in part because individuals found imagery-based distraction to be a more agreeable means of distraction following Cyberball.

One final note is that these differences in response to imagery- and verbally-based distraction emerged using an adolescent sample. One common criticism of cognitive interventions for youth is that such interventions rely on youths’ verbal abilities, making them ill-suited for younger children. Imagery-based interventions could potentially be applied across the developmental lifespan, providing relief for youth who may not have the verbal abilities to engage in more traditional verbally-based cognitive interventions. The current study would need to be replicated with younger populations and with more in-depth imagery-based interventions than simple distraction to provide further clarity on whether imagery-based treatments also are effective for younger children, however.

Results from the present investigation suggest that imagery-based distraction is more effective than verbally-based distraction. Taken together with prior research suggesting that imagery-based interventions may result in greater clinical improvement than verbally-based interventions (e.g., Arntz, 2012), researchers and clinicians should consider use of imagery-based interventions when developing and evaluating treatments. Although imagery-based distraction was employed in the current study, it is likely that imagery could be used more broadly in intervention packages. By doing so, we may be able to treat mental health disorders more effectively.

**Recovery**

Affective, HRV, and GSR recovery were largely similar across conditions. It may be that response to imagery- and verbally-based rumination and distraction is short-lived. This appears
unlikely given that the current study found that on a trait level, imagery-based rumination was more highly associated with depression than verbally-based rumination, suggesting that differential response to imagery- and verbally-based rumination may have long standing implications. Instead, this result may most likely be due to the fact that the rumination/distraction induction was short (i.e., only 12 minutes) and that the sample was a community sample of relatively healthy adolescents. Outside of a research context, it is unlikely that when adolescents get caught in cycles of ruminative thought, that these periods last only 12 minutes and then cease. Rather, Nolen-Hoeksema coined the term ruminative response style to describe individuals who continually respond to negative affect with rumination. Thus, differences in affective and physiological recovery following imagery- and verbally-based rumination and distraction may in fact differ, if rumination is more prolonged or when more severely depressed adolescents engage in rumination. Future research is needed to examine these possibilities, however.

**The Role of Depression**

In a series of secondary analyses, the role of depression was examined. Rumination style moderated the relation between trait rumination and depressive symptom severity similarly for adolescents who had elevated depressive symptoms and in the overall sample. Patterns of affective, HRV, and GSR response to imagery- and verbally-based rumination and distraction also were largely similar in the subsample of adolescents with elevated depressive symptoms as they were in the overall sample. This suggests that imagery- and verbally-based rumination and distraction may function similarly regardless of how depressed adolescents are.

Although patterns of effects were similar in the subsample of adolescents with elevated depressive symptoms and in the overall sample, at times, differences among conditions emerged
as statistically significant only in the overall sample. It may be that the hypothesized findings did not reach the threshold for statistical significance in this subsample because of cognitive load involved in generating and maintaining imagery. Generating vivid imagery may be more challenging in individuals with depression, resulting in dampened affective, HRV, and GSR responses relative to conditions requiring verbal thought. In fact, prior research has indicated that this may be the case, as adults with depression have been shown to experience greater difficulties generating vivid, positive mental imagery relative to non-depressed adults (e.g., Morina et al., 2011). Given that the magnitude of affective, HRV, and GSR change was equivalent to, or larger than, those documented in the overall sample, however, differences in whether effects were statistically significant were more likely due to the fact that there were fewer adolescents with elevated depressive symptoms, reducing statistical power to find even small effects.

It was noteworthy, however, that main effects of rumination/distraction emerged as significant only for adolescents with elevated depressive symptoms. This is in line with past research finding that Nolen-Hoeksema’s rumination/distraction induction works only when individuals are depressed or currently experiencing negative affect (Lyubomirsky & Nolen-Hoeksema, 1995; Nolen-Hoeksema & Morrow, 1993). Cyberball may not have been powerful enough to elicit consistent and long-lasting negative affect to induce depressive rumination in those adolescents who were not already depressed. Additional research with a larger population of clinically depressed adolescents could help to further clarify whether patterns of affective and physiological response to imagery- and verbally-based rumination and distraction are in fact similar among depressed and non-depressed adolescents.
Gender

Potential gender differences were also examined in a series of secondary analyses. No statistical differences between males and females in the role of rumination style or affective, HRV, or GSR response to induced imagery- and verbally-based rumination and distraction were documented. Visual inspection of mean level affective, HRV, and GSR reactivity and recovery also revealed largely similar patterns in response to imagery- and verbally-based rumination and distraction among males and females. Thus, imagery- and verbally-based rumination and distraction may function similarly in male and female adolescents. This was in line with previous findings that gender differences in affective response to rumination may not yet have materialized in adolescence (Park et al., 2004).

Just as gender differences in rumination and depression arise over the course of adolescence, it may be that gender differences in how rumination style impacts the rumination-depression relation become apparent only as adolescence progresses. In particular, as females continue to ruminate more so than males, they may begin to have more consistent styles of rumination (i.e., ruminate predominately in the form of imagery or predominately in the form of verbal thought), which could exaggerate differences between these styles. This idea is supported by the fact that in this sample of adolescents, 56.6% reported ruminating in both imagery and verbal form. Previous studies with adults found lower rates of adults ruminating in both forms (i.e., in Lawrence et al., 2018, only 37.3% of the sample reported a both imagery- and verbally-based depressive cognitive style). Thus, as rumination style becomes more stable, and females ruminate more than males, differences in response to imagery- and verbally-based rumination may emerge more so for females than for males. Longitudinal research is needed to examine this question empirically, however.
As noted in previous sections, the current sample was underpowered to detect small gender effects. Thus, although no significant differences between genders were found in the present study, it is possible that small differences between males and females are in fact present. Larger samples of individuals of all gender identities are needed to fully explore potential gender differences in affective and physiological response to imagery- and verbally-based rumination and distraction.

**Limitations and Future Directions**

The current study adds valuable information on response to imagery- and verbally-based rumination and distraction in adolescence but it is not without limitations that warrant further investigation. First, Cyberball was used as a negative mood induction, a paradigm which could have induced depressed affect and/or a stress response. Similarly, participants rated their affect on a single VAS ranging from sad to happy, which again, could have captured a number of different emotional states. Future research using a more specific mood induction as well as more nuanced measures of affect could aid in clarifying affective response to imagery- and verbally-based rumination and distraction.

Second, the induction used to elicit imagery- and verbally-based rumination and distraction was short in duration and did not induce purely imagery- or verbally-based rumination or distraction. In fact, most adolescents experienced degrees of both imagery and verbal thought during the rumination/distraction induction. This may suggest that a more powerful manipulation is needed to deduce whether response to imagery- and verbally-based rumination and to imagery- and verbally-based distraction differs. The fact that differences still emerged among conditions, however, would indicate that differences between entirely imagery-based or entirely verbally-based rumination and distraction may be even more exaggerated.
Furthermore, it is interesting that the majority of adolescents reported a both imagery- and verbally-based rumination style and continued to ruminate in both imagery and verbal form during the rumination/distraction induction. This suggests that rumination style may be a particularly stable trait, such that the manipulation could not force adolescents to completely deviate from how they ruminate in general. Future research evaluating how affective, physiological, and cognitive response to rumination differs based on adolescents’ own rumination style, rather than attempting to induce them to ruminate in a form different from their own, could be especially valuable.

Third, distraction was used as an analog for intervention in the current study. Examining distraction allowed for an equivalent comparison to rumination and is certainly used as a skill in therapeutic contexts. Conclusions drawn may or may not extend to all types of imagery- and verbally-based interventions, however. Typically, cognitive interventions for depression involve identifying maladaptive cognitions, evaluating whether those cognitions are accurate and helpful, and then changing those cognitions to be more accurate and helpful. Thus, comparing response to imagery and verbal forms of more comprehensive cognitive interventions (e.g., cognitive restructuring) and evaluating how those interventions impact depressive symptoms over time could have even higher clinical utility.

Additionally, it is important to note that it is possible that having an imagery-based processing style in general puts some individuals at higher risk for having an imagery-based rumination style, and therefore a higher likelihood of experiencing elevated depressive symptoms. The likelihood of having an imagery-based processing style also may be increasing over time, as individuals are exposed to greater imagery in their day-to-day lives through venues such as social media. The current study did not include a measure of processing style, however.
In fact, no research to date has examined imagery-based processing (e.g., a general tendency to encode/retrieve information in imagery form) and its associations with rumination and depression. Thus, future research should evaluate whether an underlying imagery- or verbally-based processing style helps account for differences in response to imagery- and verbally-based rumination and distraction, and whether rates of imagery-based processing are increasing across time.

Finally, research with a larger sample of youth is needed to fully understand imagery- and verbally-based rumination. The current study was underpowered to detect many smaller effects, especially when response was evaluated within the subsample of adolescents with elevated depressive symptoms and when three-way interactions with gender or vividness/realism were explored. It is promising that the patterns observed were largely in line with hypotheses. There would be greater confidence in these effects if the sample had been sufficiently powered to detect whether they were statistically significant. A larger sample, or longitudinal design, could provide the additional benefit of examining developmental differences, allowing for a better understanding of how imagery- and verbally-based rumination and distraction impact adolescents as the frequency of rumination increases and risk for depression becomes higher.

**Final Conclusions**

Despite the field’s historic focus on verbally-based rumination and verbally-based distraction, the current study found imagery-based rumination to be just as impactful and imagery-based distraction to be even more effective. Efforts to develop and test imagery-based interventions could improve efficacy of treatments for depression. Such imagery-based interventions hold especially great promise for adolescents, for whom early and effective intervention is key.


Moritz, S., Ahlf-Schumacher, J., Hottenrott, B., Peter, U., Franck, S., Schnell, T., ... Jelinek, L. (2018). We cannot change the past, but we can change its meaning: A randomized controlled trial on the effects of self-help imagery rescripting on depression. *Behaviour Research and Therapy, 104*, 74–83.


CHAPTER 6

APPENDICES

APPENDIX A: DEMOGRAPHIC QUESTIONNAIRE

Date of birth (mm/dd/yyyy) _______
Age _______
Grade_______

Gender
Male  Female  Transgender  Other

For the next two questions, check all categories that apply:

1. What is your ethnicity?
   _____ Hispanic or Latino       _____ Not Hispanic or Latino

2. What is your race?
   _____ American Indian / Alaskan Native       _____ Black or African American
   _____ Asian       _____ White
   _____ Native Hawaiian or Other Pacific Islander

Is English your first language?
I. Yes
II. No
III. If no, what is? _____________

Do you have any problems seeing or with your vision (e.g., color blindness)?
   Yes
   No
If yes, please briefly describe: ______________
Are these problems corrected with glasses?
Yes  No

Do you have a history of diabetes, heart disease, hypertension, or any other cardiovascular condition?
Yes  No
If yes, please briefly describe: ______________

Do you currently take tricyclic antidepressants, antipsychotic agents, antihistamines, beta-blockers, or any other medication known to impact cardiovascular functioning?
Yes  No
If yes, please briefly describe: ______________
APPENDIX B: CENTER FOR EPIDEMIOLOGIC STUDIES

DEPRESSION SCALE (CES-D)

Below is a list of ways you might have felt or behaved. Please circle the number that indicates how often you have felt this way during the past week.

1. I was bothered by things that didn’t usually bother me.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rarely or none</td>
<td>Some or a little</td>
<td>Occasionally or a moderate amount of time</td>
<td>Most or all of the time</td>
</tr>
<tr>
<td>(less than 1 day)</td>
<td>(1-2 days)</td>
<td>(3-4 days)</td>
<td>(5-7 days)</td>
</tr>
</tbody>
</table>

2. I did not feel like eating; my appetite was poor.

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3. I felt that I could not shake off the blues even with help from my family and friends.

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4. I felt I was just as good as other people.

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5. I had trouble keeping my mind on what I was doing.

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6. I felt depressed.

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7. I felt that everything I did was an effort.

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8. I felt hopeful about the future.

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9. I thought my life had been a failure.

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10. I felt fearful.

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11. My sleep was restless.

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12. I was happy.

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13. I talked less than usual.

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15. People were unfriendly.

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16. I enjoyed life.

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17. I had crying spells.

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18. I felt sad.

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19. I felt that people dislike me.

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20. I could not get “going.”

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APPENDIX C: RUMINATIVE RESPONSES SCALE (RRS)

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you almost never, sometimes, often, or almost always think or do each one when you feel down, sad, or depressed. Please indicate what you generally do, not what you think you should do.

1 almost never 2 sometimes 3 often 4 almost always

1. think about how alone you feel
2. think “I won’t be able to do my job if I don’t snap out of this”
3. think about your feelings of fatigue and achiness
4. think about how hard it is to concentrate
5. think “What am I doing to deserve this?”
6. think about how passive and unmotivated you feel.
7. analyze recent events to try to understand why you are depressed
8. think about how you don’t seem to feel anything anymore
9. think “Why can’t I get going?”
10. think “Why do I always react this way?”
11. go away by yourself and think about why you feel this way
12. write down what you are thinking about and analyze it
13. think about a recent situation, wishing it had gone better
14. think “I won’t be able to concentrate if I keep feeling this way.”
15. think “Why do I have problems other people don’t have?”
16. think “Why can’t I handle things better?”
17. think about how sad you feel.
18. think about all your shortcomings, failings, faults, mistakes
19. think about how you don’t feel up to doing anything
20. analyze your personality to try to understand why you are depressed
21. go someplace alone to think about your feelings
22. think about how angry you are with yourself
Sometimes, when people feel sad, blue, or depressed they ruminate about how they feel. Ruminating is when people think over and over again about how sad, blue, or depressed they feel and wonder repeatedly about what caused them to feel this way.

When people ruminate, they can think over and over again in words (like sentences in your mind) or in mental images (like a picture or movie in your mind).

When you ruminate, do you tend to think more in words/sentences, in mental images, or in both?

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<thead>
<tr>
<th></th>
<th>Words</th>
<th>Images</th>
<th>Both</th>
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<tbody>
<tr>
<td>1</td>
<td>Almost never</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sometimes</td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>About half the time</td>
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<td>4</td>
<td>Most of the time</td>
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<tr>
<td>5</td>
<td>Almost always</td>
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When you ruminate, how often does it seem like you are replaying words/sentences in your mind?

1  Almost never
2  Sometimes
3  About half the time
4  Most of the time
5  Almost always

When you ruminate, how often does it seem like you are replaying images in your mind?

1  Almost never
2  Sometimes
3  About half the time
4  Most of the time
5  Almost always
We are interested in knowing about your current mood. Please mark an ‘X’ on the line below to indicate how you feel right now. Use the labels above the line to help you in your judgment.
BIOGRAPHY OF THE AUTHOR

Hannah R. Lawrence graduated from Davidson College in 2012 with a Bachelor’s degree in Psychology. She earned her Master’s degree in Clinical Psychology in 2016 from the University of Maine. She will complete her predoctoral internship at Alpert Medical School of Brown University in Providence, RI (2019-2020).

Her program of research examines the role of imagery in the etiology and treatment of depression. She has a particular interest in examining maladaptive imagery-based cognition, such as imagery-based rumination and suicidal ideation, and evaluating and developing imagery-based treatments for depressed and/or suicidal youth. She is a candidate for the Doctor of Philosophy degree in Clinical Psychology from the University of Maine in August 2020.