INFLEXIBILITY AND VULNERABILITY TO DEPRESSION

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By
Jonathan P. Stange
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Examining Committee Members:

Lauren B. Alloy, Ph.D., Doctoral Advisory Committee Chair, Department of Psychology
Richard G. Heimberg, Ph.D., Department of Psychology
Philip Kendall, Ph.D., Department of Psychology
Deborah Drabick, Ph.D., Department of Psychology
Tania Giovannetti, Ph.D., Department of Psychology
Robert Weisberg, Ph.D., Department of Psychology

ABSTRACT

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Dissertation Advisory Committee Chair: Lauren B. Alloy, Ph.D.

Although existing research has evaluated various cognitive, behavioral, physiological, and environmental risk factors for depression (Johnson, Cuellar, & Miller, 2009), previous studies have typically focused on the *content* of cognitive styles and coping styles when evaluating vulnerability to depression (e.g., Alloy et al., 2006; Compas et al., 2009). However, recent research has suggested that the ability to *flexibly* engage in different thoughts, strategies, and behaviors that fit situational demands may be most indicative of psychological health (Bonanno & Burton, 2013; Fresco, Williams, & Nugent, 2006a; Kashdan & Rottenberg, 2010). Existing studies have typically evaluated inflexibilities in isolation without examining commonalities among these factors, and few studies have evaluated inflexibilities as prospective predictors of depression within a vulnerability-stress framework. Thus, the present study was designed to examine (1) which forms of cognitive, behavioral, and psychophysiological inflexibility confer vulnerability to depressive symptoms, particularly when individuals are confronted with life stressors, (2) whether elevations in depressive symptoms prospectively predict decreases in coping flexibility and explanatory flexibility and increases in rumination, and (3) the extent to which explanatory and coping flexibilities are associated with other cognitive, behavioral, and physiological indices of flexibility. A sample of 187 university students completed a multi-wave study, which included a baseline assessment of components of cognitive, behavioral, and autonomic flexibility and symptoms of depression, and four follow-up waves (once every three weeks) assessing the occurrence of negative life events, event-specific explanatory and coping flexibilities, and symptoms of depression. Hierarchical linear modeling was used to test the hypotheses that baseline inflexibilities would predict prospective symptoms of depression, particularly when individuals encountered high levels of negative life events relative to their own mean level of events. Partial support for these hypotheses was found. Deficits in set-shifting predicted greater prospective symptoms of depression. Extreme attributions, brooding, and deficits in cognitive inhibition, autonomic reactivity and recovery interacted with negative life events to predict prospective symptoms of depression. Additionally, elevations in depressive symptoms predicted prospective increases in the use of rumination, but did not predict reductions in explanatory or coping flexibilities. Extreme pessimistic attributions were associated with set-shifting deficits and lack of autonomic flexibility, whereas coping flexibility was associated with greater autonomic flexibility. Overall, the results suggest that assessing components of inflexibility may help to identify individuals who are vulnerable to experiencing depression. They also suggest that enhancing flexibility is a possible mechanism by which interventions (e.g., mindfulness training) may reduce vulnerability to depression.

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CHAPTER 1

INTRODUCTION

Major Depressive Disorder (MDD) is the most common mental disorder, with an estimated lifetime prevalence of 16.6% (Kessler et al., 2005). It is associated with tremendous impairment and considerable comorbidity with other psychiatric conditions, resulting in major personal, economic, and societal costs (Kessler et al., 2006; Kessler & Wang, 2009). This study evaluated and compared inflexible cognitive, behavioral, and psychophysiological factors thought to be associated with depression, and that also may constitute vulnerabilities to depression, particularly in combination with life stressors.

Negative Life Events as a Proximal Cause of Depression

Over the past several decades, life stress has been identified as a potent factor that increases the likelihood of developing psychopathology, including MDD (Alloy, Abramson, Raniere, & Dyller, 1999; Monroe et al., 2009). Indeed, stressful life events often immediately precede episodes of depression and appear to play a proximal role in the development of depressive symptoms (Monroe et al., 2009). However, because not all individuals experience depression following stressful events, research also has focused on distal factors (i.e., moderators) that confer particular risk to depression in the face of stressful events (Ingram & Luxton, 2005).

Theoretical Relevance of Inflexibility in Depression

Depression is characterized by cognitive and behavioral loss of flexibility in several ways (Kashdan & Rottenberg, 2010). First, the major symptoms of depression imply emotional inflexibility in that individuals show low mood or loss of interest across multiple domains of life. Depressed individuals exhibit less context-appropriate emotional reactivity to positive and negative stimuli and display unresponsive facial expressiveness and gaze which disrupts social interactions (Rottenberg & Gotlib, 2004), leading researchers to suggest that depression is characterized by insensitivity to emotional context (Rottenberg, 2005; Rottenberg, Gross, & Gotlib, 2005). Depression also often is characterized by rumination, a perseverative thinking style in which individuals attempt to understand the causes of their depressed mood (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Rumination involves an inflexible and passive focus on depressed mood across contexts in which other coping strategies (e.g., distraction, problem-solving) might be more effective, and has been linked to cognitive inflexibility and perseverative errors on performance tasks (Davis & Nolen-Hoeksema, 2000). Finally, negative attributional style also has been associated with depression and is characterized by a rigid, stereotyped way of attributing the causes of negative events to personally-relevant factors with stable and global implications and negative consequences (Abramson, Metalsky, & Alloy, 1989; Alloy et al., 2008).

Inflexibility as a Vulnerability to Depression

Coping Flexibility. Coping has been well-researched because of its relationship with psychological adjustment. Two major functions of coping have been hypothesized: problem management (problem-focused coping) and emotion regulation (emotion-focused coping) of difficult situations (Lazarus & Folkman, 1984). Previous research has indicated that these two types of coping strategies may be effective in certain types of situations, but may actually elicit distress in others (Cheng, 2001). Problem-focused coping may be most effective in situations that are controllable because problem-solving enables the individual to identify solutions and hence to potentially gain control over the stressful event (Cheng, Hui, & Lam, 1999). In contrast, emotion-focused coping may be most effective for events that are uncontrollable and hence require adjustment to the situation rather than attempts to fix it (Holmes & Stevenson, 1990). Thus, effective coping may be best characterized by flexible deployment of coping strategies that match situational demands (Bonanno & Burton, 2013; Cheng, 2001). Coping flexibility thereby may impact depression as a consequence of the effectiveness of the chosen coping response. Only recently has coping flexibility been evaluated as a correlate of adjustment. Coping flexibility has been shown to predict decreases in anxiety and increases in quality of life across time (Cheng, 2001). Pertinent to the proposed study, coping flexibility also is cross-sectionally negatively associated with depressive symptoms (Cheng, 2001; Fresco et al., 2006a; Zong et al., 2010), and may attenuate the relationship between life stress and prospective levels of depression (Lam & McBride-Chang, 2007).

Explanatory Flexibility. Explanatory flexibility is defined as the degree to which individuals perceive multiple perspectives when explaining the causes of negative life events (Fresco et al., 2006a). Whereas cognitive theories of depression posit that attributing the causes of negative events to internal, stable, and global factors confers risk for depression (Abramson, Seligman, & Teasdale, 1978; Abramson, Metalsky, & Alloy, 1989), explanatory flexibility theory posits that it is not simply the content of such attributions, but the flexibility with which individuals determine the causes of events, that confers risk for or resilience against depression (Moore & Fresco, 2007). Individuals with high explanatory flexibility are likely to effectively balance their interpretation of events with previous and current contextual information, which results in variability in the perceived causes of negative events, allowing for more adaptive responses to stressors.

Although explanatory flexibility is thought to be adaptive, some controversy exists regarding the constructs that underlie variability in attributions. Although attributional variability could represent adaptive and flexible deployment of inferences, it may overlap with the tendency to make "extreme" attributions, which conversely has been proposed as an index of rigid, extreme thinking (e.g., Teasdale et al., 2001; Stange et al., 2013a). Extreme attributions are evaluated by summing the number of responses made using the endpoints of Likert scales on measures of cognitive style (e.g., the cause of event "leads to problems in all other areas of my life" or "will never again be present"). Thus, individuals who make extreme responses at both ends of the response scale may demonstrate variability in their attributions that is captured by the computation of individuals' explanatory flexibility scores (Stange, Alloy, & Fresco, under review).

Individuals who make extreme attributions may be cognitively reactive to life events, making all-or-nothing explanations for events, rather than making more moderate inferences after considering multiple possible causes and relevant contextual information. Extreme response styles on other measures also have been associated with intolerance of ambiguity, cognitive inflexibility, simplistic thinking, and taking a shorter time to complete measures (e.g., Naemi, Beale, & Payne, 2009), and among individuals with bipolar spectrum disorders, extreme attributions are associated with personality disorders that are characterized by emotional reactivity (Stange et al., 2015). Thus, the tendency to make extreme responses on attributional measures may represent relatively automatic schematic processing that is uncorrected by deliberate reappraisal in more moderate terms (Teasdale et al., 2001). This extreme automatic processing could interfere with the ability to make contextually-appropriate attributions about the causes of stressful events. Thus, it is not clear whether explanatory flexibility or extreme attributions are a superior measure of flexible attributional style and a stronger vulnerability factor for depression.

Explanatory flexibility has been shown to buffer against the effects of negative life events in prospectively predicting depressive symptoms (Fresco, Rytwinski, & Craighead, 2007). Explanatory flexibility also is attenuated in treatment-seeking patients with MDD relative to controls (Lackner, Moore, Minerovic, & Fresco, under review). In contrast, greater explanatory flexibility predicted a *longer* duration of depression among adults with bipolar depression (Stange et al., 2013b). Bipolar individuals with greater explanatory flexibility endorsed more extreme optimistic and pessimistic attributions (Stange et al., 2013b), and more extreme attributions were associated with a longer course of current depressive episodes (Stange et al., 2013a), greater likelihood of another prospective onset of depression (Stange et al., 2015), more lifetime episodes of depression (Stange et al., 2013c), and a greater likelihood of having a history of a suicide attempt and experiencing the onset of suicidal ideation (Stange et al, 2014a).

Rumination. Rumination, and particularly brooding, the tendency to repetitively and passively think through the causes and consequences of one's dysphoric mood to better understand it (Treynor, Gonzalez, & Nolen-Hoeksema, 2003; Nolen-Hoeksema et al., 2008) is moderately correlated with depression and has been shown to confer vulnerability to the onset and recurrence of depression, including resulting in greater stress-reactivity to life events in the form of depression (e.g., Abela & Hankin, 2011; Nolen-Hoeksema, 2000; Stange, Hamilton, Abramson, & Alloy, 2014b). Rumination is associated with cognitive inflexibility (e.g., Davis & Nolen-Hoeksema, 2000) and is considered an inflexible style of responding to dysphoric mood (e.g., Aldao, Sheppes, & Gross, in press). However, few studies have compared the extent to which rumination confers vulnerability to depression relative to other components of inflexibility, a gap that the present study aims to fill.

Cognitive Flexibility. Cognitive flexibility is a component of executive functioning and is central to effective emotion regulation and cognitive control (Miyake et al., 2000; Joormann & Siemer, 2011; Joormann & Vanderlind, 2014; Kashdan & Rottenberg, 2010), which are implicated in depression. Cognitive flexibility involves two primary components: inhibition (the ability to prevent the processing of material irrelevant to a task at hand) and set-shifting (switching between mental sets by activating relevant material and disengaging from irrelevant material) (Miyake et al., 2000; De Raedt & Koster, 2010). Both components are central to the ability to maintain and shift attention, which are prerequisites for self-control and goal-directed behavior (Goldberg, 2001; Lyon & Krasnegor, 1995). Thus, basic executive control may underlie other types of cognitive and behavioral flexibility (Kashdan & Rottenberg, 2010). Cognitive flexibility appears to be decreased among individuals with MDD, particularly with respect to negatively-valenced stimuli (Deveney & Deldin, 2006; Murphy et al., 1999, 2012). Additionally, cognitive flexibility with affective material, or the ability to attend to and disengage from emotional material effectively, may be central to effective emotion regulation and is associated with trait resilience, reappraisal ability and low levels of rumination (Genet & Siemer, 2011; Genet, Malooly, & Siemer, 2013; Malooly, Genet, & Siemer, 2013). Furthermore, because rumination has been associated with inhibition and set-shifting errors (Davis & Nolen-Hoeksema, 2000), it is possible that cognitive inflexibility may underlie ineffective cognitive emotion-regulation strategies and may contribute to risk for depression in this manner (e.g., Malooly et al., 2013; Pe et al., 2013a).

Autonomic Flexibility. One promising process that may underlie cognitive and behavioral forms of flexibility is cardiac vagal control (CVC) (Kashdan & Rottenberg, 2010). CVC is thought to be a physiological index of emotion regulation capacity because it is controlled by many of the brain structures associated with regulation of the autonomic nervous system (e.g., prefrontal cortex), which provide parasympathetic input to the heart through the vagus nerve (Thayer & Lane, 2009). It also reflects an integration of cognitive and emotional processes in cortical and sub-cortical brain areas, the goal of which is to cope effectively with changing environmental circumstances (Kashdan & Rottenberg, 2010). CVC is indexed through respiratory sinus arrhythmia (RSA), or variability in heart rate during the respiratory cycle (Beauchaine, 2001; Porges, 1995). Poor resting CVC is associated with many negative indexes of emotion regulation (Beauchaine, 2015), including higher emotional arousal in response to stressors and lower coping effectiveness (Fabes & Eisenberg, 1997), as well as inflexible deployment of attention and poorer executive functioning (Seuss, Porges, & Plude, 1994). Additionally, individuals with MDD have lower resting CVC (Rottenberg, 2007) and a less dynamic CVC response to stressors (Rottenberg et al., 2007a). Attenuated vagal withdrawal to a sad film and attenuated vagal recovery following a sad film is associated with a worse course of MDD (Rottenberg et al., 2005). Therefore, it appears that CVC is a biological process that is relevant to emotion regulation and adaptive coping. However, surprisingly little work has been conducted evaluating CVC prospectively as a risk factor for depression (Kashdan & Rottenberg, 2010; Rottenberg et al., 2005), nor whether low CVC could confer vulnerability to depression when individuals encounter life stressors (for an exception that provides support for this hypothesis in a cross-sectional study, see McLaughlin et al., 2015). Existing research also has not compared CVC to other measures specific to cognitive and behavioral flexibility. Thus, the specific role of CVC as a precursor to depression remains unclear.

Consistent with literature suggesting that depression is characterized by emotion context insensitivity, in addition to problems with parasympathetic flexibility, a related literature also has suggested that depressed individuals may show hyporeactivity of the sympathetic nervous system, characterized by attenuated heart rate reactivity (i.e., increases in heart rate) and attenuated recovery (i.e., decreases in heart rate) following exposure to stimuli that require mobilization of resources for coping (Bernston, Cacioppo, & Quigley, 1991; Rottenberg, 2005). However, whether inflexible heart rate reactivity or recovery in the context of sad stimuli (i.e., attenuated reactivity or recovery when these are the adaptive responses) could confer vulnerability to future symptoms of depression is not known.

Status of Inflexibility as a Causal Factor in Depression. The above review highlights several important measures of flexibility that may hold promise for the prediction of depression. However, little work has been done to (1) evaluate these factors prospectively as predictors of depression in the context of life stress, and (2) integrate these factors to examine which are the strongest predictors of depression (Kashdan & Rottenberg, 2010). Therefore, the proposed study aims to compare and evaluate these flexibilities in the context of life stress using a multi-method, multi-wave, idiographic approach to predict which individuals experience increases in depressive symptoms over time.

In addition, although explanatory and coping flexibilities are thought to be relatively stable over time, they may also fluctuate to some extent as a function of current mood state, becoming less flexible when individuals are depressed (e.g., Fresco, Heimberg, Abramowitz, & Bertram, 2006b). Thus, there is likely to be a reciprocal, transactional relationship between depression and explanatory and coping inflexibilities and rumination, such that they exacerbate one another. To evaluate this, the present study tested the model in both directions using a multi-wave longitudinal design to determine the prospective temporal relationships between these flexibilities and depressive symptoms.

The Current Study

The current study implemented a prospective multi-wave design to evaluate cognitive, behavioral and psychophysiological inflexibilities as risk factors for depressive symptoms among college students in the context of naturally-occurring life stress. This multi-wave approach allowed for powerful tests of inflexibilities as risk factors for depression in the context of life stress measured with an idiographic (person-centered) approach. It also enabled tests to disentangle the directionality of the relationship between depressive symptoms and inflexible cognition and behavior.

Aims and Hypotheses

Primary Aim 1. The first primary aim of the study was to evaluate which measures of inflexibility interact with life events to predict depressive symptoms, using an idiographic approach to stress measurement. Given research suggesting that each of the hypothesized measures of inflexibility is associated with depression, I hypothesized that each measure would moderate the relationship between negative life events and depressive symptoms, such that life events would predict depression more strongly among individuals with less flexibility than among individuals with more flexibility.

Primary Aim 2. The second primary aim of the study was to evaluate whether depressive symptoms predicted decreased explanatory and coping flexibilities and increased use of brooding. This aim will extend previous work comparing other forms of inflexibility in MDD vs. healthy individuals (Fresco et al., 2006b; Rottenberg et al., 2005) by testing the potentially transactional relationship between depressive symptoms and flexibilities using a cross-lagged design. Given cross-sectional evidence that depression is associated with inflexibility, I hypothesized that depressive symptoms will prospectively predict increases in brooding and decreases in explanatory and coping flexibilities for actual life events.

Secondary Aim. The secondary aim of the study was to examine which measure of flexibility predicted the most variance in residual depressive symptoms at follow-up. Given research suggesting that rumination mediates the relationship between negative cognitive styles and depression (Spasojevic & Alloy, 2001; Roelofs et al., 2008; Lo, Ho, & Hollon, 2008), I hypothesized that rumination would be the strongest predictor of depressive symptoms among the multiple measures of flexibility assessed in this study.

Exploratory Aim. An exploratory aim of the study was to evaluate psychophysiological and behavioral correlates (e.g., RSA, cognitive flexibility, flexible affective processing) of coping flexibility and explanatory flexibility. This extends previous literature by elucidating processes associated with these adaptive traits.

CHAPTER 2

METHOD

Participants and Procedure

Participants were undergraduate students at Temple University, age 18 to 65. For inclusion, participants were fluent in English and had normal or corrected-to-normal vision. Participants were excluded if they failed to meet these inclusion criteria or had (a) a history of epilepsy or head trauma (which may result in health risks or interfere in attentional processing required for the behavioral tasks, respectively), or (b) a cardiac device that would interfere with the measurement of respiratory sinus arrhythmia (e.g., a cardiac pacemaker). No participants screened for the study met exclusionary criteria. Participants were not excluded on the basis of gender, ethnicity/race, or other demographic variables.

Participants were recruited from undergraduate psychology classes using the department's online listing of studies, and from the general student body via flyers posted around campus. Students either received psychology course credit or were compensated in cash for participation ($25 for Time 1 assessment and $10 for each Time 2-5 assessment completed, with a $10 bonus if all four follow-up assessments were completed). Follow-up visits took place remotely for the comfort of participants, although participants were invited to complete follow-up assessments in the lab if this was preferable (no participants chose to use this option). To further increase retention, participants received up to two reminder calls and e-mails within three days of the due date of their scheduled follow-up assessment.

Individuals who indicated interest in participating in the study either contacted the PI (in the case of recruitment from flyers) or signed up for time slots directly online (if recruited from online listing of studies). All participants spoke English fluently and had normal or corrected-to-normal vision. At the Time 1 assessment, all participants completed informed consent approved by the Temple University Institutional Review Board. The experimenter described the purpose and procedures involved in study participation, potential risks, assurances of confidentiality, and allowed opportunity for the potential participant to ask any questions about the study. They also completed a battery of tasks that included all of the instruments detailed below.

Every three weeks after Time 1, participants completed a follow-up assessment that included measures of current symptoms of depression, use of rumination in the prior three weeks, life events experienced in the prior three weeks, and questions about perceived explanations about the causes of the events and strategies used to cope with these events. At the last assessment, participants also completed an interview to confirm life events reported at Times 1-5.

A total of 190 participants were originally enrolled in the study. Although the study originally was planned to enroll 180 participants, with IRB approval, I enrolled an additional ten participants to account for possible attrition over semester breaks. The final sample included 187 participants (M_{age} = 21.98, *SD* = 5.66). The sample was 56.70% female, 20.32% African American/Black, 60.4% Caucasian/White, 8.56% Hispanic or Latino, 12.30% Asian, 0.53% Pacific Islander, 1.07% Native American, and 6.42% “other” race. All data were excluded for three participants based on the determination that their data were unlikely to be valid as a result of (a) the amount of time they took to complete measures being dramatically shorter than most participants, and/or (b) failing several accuracy checks (e.g., “choose 3 for this item”) while completing questionnaires, indicating a high probability of not attending to the tasks. Additionally, data were excluded on certain measures or at certain timepoints for participants when the data were determined to be unlikely to be valid based on these criteria (< 1% of study data were excluded overall).

Measures

Beck Depression Inventory (BDI-II; Beck et al., 1996). The BDI-II assesses the severity of symptoms of depression during the previous two weeks. It is the most commonly-used self-report measure of depressive symptoms and has demonstrated excellent internal consistency and validity in undergraduate samples (Storch et al., 2004; Dozois et al., 1998). In the present study, αs = .87-.90 at Times 1-5.

Inventory to Diagnose Depression-Lifetime version (IDD-L, Zimmerman & Coryell, 1987). The IDD-L is a 45-item measure that indexes the number of DSM-IV symptoms of depression that a person has experienced for at least 2 weeks during their worst lifetime period of depression, and assesses whether or not the symptoms required for a DSM-IV diagnosis are endorsed. The scale has demonstrated excellent sensitivity and specificity for diagnoses made using structured diagnostic interviews (Zimmerman & Coryell, 1987). In the present study, α = .93.

Cognitive Style Questionnaire (CSQ; Alloy et al., 2000; Haeffel et al., 2008). The CSQ assesses cognitive styles for inferring causes, consequences, and characteristics about the self for twelve hypothetical negative life events, which are considered by hopelessness theory to be relevant to depression (Abramson, Metalsky, & Alloy, 1989; Alloy et al., 2006). In addition to providing a sum score of negative cognitive style, the CSQ also is used to compute explanatory flexibility by computing the standard deviation of the causes, consequences and self-characteristics. The CSQ also is used to compute the number of extreme pessimistic and extreme optimistic attributions with a frequency count of the number of times each participant endorses the endpoints of the Likert scale on the CSQ (extreme pessimistic responses are responses of "7" and extreme optimistic responses are responses of "1"). The CSQ has shown excellent validity and reliability (Haeffel et al., 2008). In the present study, α = .95.

Ruminative Response Scale (RRS-BR; Treynor, Gonzalez, & Nolen-Hoeksema, 2003). The RRS-BR is a 5-item measure that assesses trait ruminative brooding. It has excellent internal consistency and validity (Treynor, Gonzalez, & Nolen-Hoeksema, 2003). The RRS-BR also was administered at each time point as a measure of "state" brooding over the prior 3 weeks. In the present study, α = .74 for the Time 1 trait measure, and α = .74-.77 for the state measure at Times 1-5.

Life Events Scale (LES) and Interview (LEI). The LES (Alloy & Clements, 1992; Safford et al., 2007) includes 134 major and minor life events in a variety of domains relevant to college students (e.g., school, finances, family, social and romantic relationships). Individuals indicate which events have occurred for them over a given time period and can skip sections that are not relevant to them (e.g., if they don't have a boyfriend/girlfriend). The validity of these ratings are then evaluated objectively by an interviewer with the LEI to reduce any problems related to subjective report biases. Explicit criteria for event definition and a priori probes are provided to the interviewer to help him/her determine whether reported events on the LES meet the criteria of these provided definitions. Any events that do not meet the stringent event definition criteria are disqualified. Negative life events from the LES are a priori identified as interpersonally-related, achievement-related, or neither, and are rated a priori in terms of objective severity on a scale from 1 to 4. In addition, negative life events are a priori rated in terms of their independence/dependence with regard to how much influence the participant was likely to have had over the occurrence of the event, and then adjusted based on contextual information. The

LES and LEI have shown excellent reliability and predictive validity (Alloy & Clements, 1992; Safford et al., 2007; Stange et al., 2014b).

Coping Flexibility Questionnaire (CFQ; Cheng, 2001). The CFQ examines coping flexibility. Participants are instructed to describe all of the strategies deployed to handle each stressful event endorsed on the LES, and then to classify each strategy into one of two categories based on their goal in using the strategy: "strategy used for managing the event" (i.e., problem-focused) and "strategy used for regulating the emotion associated with the event" (i.e., emotion-focused). Participants also report the perceived controllability of each event. A strategy-situation fit index is derived to reflect the extent of situation-appropriateness of coping patterns. Problem-focused coping is considered more effective in handling controllable stressful situations, whereas emotion-focused coping is more effective in handling uncontrollable stressful situations (Cheng, 2003; Aldwin, 1994; Miller, 1992; Lazarus & Folkman, 1984). The CFQ has good reliability and criterion-related validity (Cheng, 2001, 2003). Given that computation of the strategy-situation fit index requires variability in the number of life events experienced, we only included data points in which at least two life events occurred, consistent with prior reports (e.g., Cheng, 2001). At least two life events were reported by 93.6% of participants at Time 1, and 83.6%, 69.8%, 67.2%, and 70.4% at Times 2-5, respectively. Results reported were comparable when using a more stringent criterion of only including participants who reported at least three life events.

To evaluate alternative aspects of coping, we also computed variables representing the number of emotion-focused, problem-focused, and overall coping strategies used at each time point. To prevent skew based on the number of events experienced (which would be expected to be linearly associated with the number of strategies used), these variables were divided by the number of events experienced to create variables representing the average number of strategies used per event experienced.

To reduce the likelihood that participants who endorsed more events would have to spend a longer amount of time completing surveys (due to the fact that the number of coping strategies about which participants were asked was tied to the number of events endorsed), which could lead to participants under-endorsing the true number of events that occurred on subsequent assessments, participants only completed information about coping for up to eight of the life events endorsed, which were randomly selected by the computer. This measure was administered along with the LES at all five time points.

Cognitive Responses to Life Events. Following the procedure described above for the CFQ, participants were asked questions about their perceived explanations about the causes and consequences about life events endorsed on the LES, following the format of the CSQ. Thus, this measure was administered along with the LES at all five time points. It was used to compute event-specific explanatory flexibility and extreme attributions, which were used to test Primary Aim 2.

Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001). The D-KEFS Color Word Interference task was used to measure cognitive flexibility. It assesses set-shifting abilities and cognitive inhibition, which are relevant to cognitive flexibility, as well as concept formation and problem solving. Participants complete four trials that involve a Stroop task: (1) verbally labeling patches of color (color naming), (2) reading words of colors (word reading), (3) verbally labeling the color of the ink in which color words are printed while inhibiting the dominant response to read the word (inhibition), and (4) alternating between verbally labeling the color of the ink in which color words are printed and reading the color words (set-shifting).

To improve the amount of variability in the data given that college samples perform at levels that are above average on this task, I used normalized raw reaction time scores for each trial. The primary predictor variables generated from this task were inhibition and set-shifting, controlling for Trials 1 and 2, so that inhibition and set-shifting represented costs beyond each individual's general verbal fluency. The D-KEFS has been shown to have good validity and reliability, and has been well-validated in healthy samples (Dawson et al., 2012; Delis et al., 2004; Farmer et al., 2007).

Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research (EXAMINER; Kramer et al., 2014). The EXAMINER measure is a test battery that assesses domains of executive function across an assortment of ages and disorders. The present study used the flanker task and the set-shifting task, which assess inhibition and set-shifting, respectively. These tasks have been demonstrated to have good validity and reliability (Kramer et al., 2014).

The flanker task requires individuals to view several adjacent arrows and to identify, as quickly and accurately as possible, what direction the center arrow is pointing. On "congruent" trials, arrows point in the same direction so identifying the direction of the center arrow (which is consistent with the arrows on either side of it) is relatively easy. On "incongruent" trials, the center arrow points in a different direction than the surrounding arrows, making the task more difficult. The primary measure of inhibition ability generated from the flanker task is the difference in each participant's average reaction time between incongruent and congruent trials, which represents inhibition costs (i.e., how much additional time participants take to respond to incongruent trials, which represents the extent to which the participant experienced greater difficulty inhibiting the dominant response to sort the middle arrow according to the direction that surrounding arrows are pointing).

The shifting task requires individuals to match target shapes, presented one at a time in the middle of the screen, with a shape at the lower left and lower right corners of the screen. Target shapes and shapes at the bottom of the screen are squares and triangles, and are either red or blue. Participants match the target shape with the shape at the bottom of the screen according to one of two rules, depending on the trial, either by "shape" (e.g., matching a rectangular target shape with the rectangular shape at one of the bottom corners of the screen) or by "color" (e.g., matching a blue target shape with the blue shape at one of the bottom corners of the screen). Participants typically show greater difficulty on "incongruent" trials, when the current trial requires sorting by a different rule than the previous trial (e.g., sorting by shape when the previous trial required sorting by color), than on "congruent" trials, which require sorting by the same rule as the previous trial (e.g., sorting by shape when the previous trial also required sorting by shape). The primary measure of shifting ability generated from the shifting task is the difference in each participant's average reaction time between incongruent and congruent trials, which represents shifting costs (i.e., how much additional time participants take to respond to incongruent trials, which represents the extent to which the participant experienced greater difficulty switching mental sets from the previous sorting rule to the current sorting rule).

Flexible Affective Processing Task (FAPT; Genet et al., 2013). The FAPT is an affective set-shifting paradigm that measures flexible control in processing affective stimuli (negatively- and positively-valenced images) using affective and non-affective processing rules (sorting of pictures by valence or by number of people present). On each trial, individuals are presented with a stimulus (picture) and a processing cue (rule of how to sort the picture) and must sort pictures by pressing one of two keys. On “congruent” trials, individuals sort pictures that have the same valence and the same sorting rule as the previous trial. On “incongruent” trials, individuals sort pictures that have the same valence but that have a different sorting rule as the previous trial. Given that there are two types of pictures (positive and negative) and two sorting rules (affective or non-affective), four sets of switch costs (differences in reaction times between incongruent and congruent trials) are computed: (1) switch costs away from the non-affective sorting rule to the affective sorting rule for positive images, (2) switch costs away from the non-affective sorting rule to the affective sorting rule for negative images, (3) switch costs away from the affective sorting rule to the non-affective sorting rule for positive images, and (4) switch costs away from the affective sorting rule to the non-affective sorting rule for negative images. Of these four types of switch costs, the fourth is considered to be the most maladaptive given that difficulty disengaging from focusing on affective aspects of negative information is highly relevant to perseverative negative thought processes implicated in depression (e.g., Joorman, 2010; Joormann & Siemer, 2011; Joormann & Vanderlind, 2014).

This type of switch cost on the FAPT has been associated with impaired effectiveness of reappraisal on a laboratory task (Malooly et al., 2013) and greater use of rumination in daily life (Genet et al., 2013). In contrast, greater switch costs associated with disengaging from affective components of positive stimuli were associated with less use of rumination in daily life (Genet et al., 2013), whereas greater switch costs associated with disengaging from non-affective components of positive stimuli were associated with poorer ability to effectively use reappraisal (Malooly et al., 2013). Data were inspected prior to analysis to identify and exclude participants ($n = 1$) with low accuracy rate (< 75%), which could represent lack of effort or lack of understanding the task instructions. Additionally, one participant's data failed to save upon completing the task, resulting in missing data for the task.

Respiratory Sinus Arrhythmia (RSA). RSA was assessed with a three-lead electrocardiogram and BioPac BioHarness with AcqKnowledge software, a system that monitors, analyzes and records numerous physiological parameters, including heart rate and respiration, which are necessary to calculate RSA, a proxy for cardiac vagal control and flexibility of emotion regulation. The BioHarness is a wireless device that is attached to individuals via an adjustable chest strap. Resting RSA was calculated across a single 5-minute epoch of rest while viewing an emotionally-neutral film (Salomon, 2005). Participants then watched a two-minute neutral nature film for a resting video baseline, followed by a sad film depicting a boy who is distraught at the death of his father (Rottenberg et al., 2005, 2007), which has been validated to elicit sadness (Rottenberg et al., 2007b). Participants then completed a three-minute recovery period of rest in which they were asked to sit quietly. RSA reactivity and HR reactivity were computed as the difference between RSA or HR during the neutral film and RSA or HR during the sad film. RSA recovery and HR recovery were computed as the difference between RSA or HR during the sad film and RSA or HR during the recovery period, (Rottenberg et al., 2005). Higher levels of resting RSA, and RSA and HR reactivity and recovery, were considered adaptive and evidence of flexible, contextually-sensitive autonomic responses.

Respiration data were high-pass filtered and visually inspected for artifacts and corrected when needed, followed by natural-log transformation to reduce skew by outliers, following well-established procedures outlined elsewhere (Grossman et al., 1990; Rottenberg et al., 2007). To remove potential confounds, residualized variables were computed for resting RSA, RSA reactivity, and RSA recovery after controlling for heart rate and number of breaths in the relevant periods. Due to technical errors (e.g., sensor falling off of participant without examiner's knowledge, resulting in unusable heart rate or respiration signal; computer freezing and failing to save acquired data), two participants were missing all RSA and HR variables, and seven additional participants were missing the RSA and HR reactivity and recovery variables.

Data Analysis

Hierarchical linear modeling (HLM) was used to test the primary and secondary aims for the study (Raudenbush & Bryk, 2002). This design allowed for an idiographic (person-centered) approach to the measurement of stress which provides a more accurate and powerful test of theories of depression than is possible with a nomothetic (sample mean-centered) approach (Abela & Hankin, 2008). Additionally, HLM is advantageous in terms of maximizing data usage because it can flexibly handle cases with missing data, so participants with missing data (e.g., participants who miss a follow-up visit) are not eliminated from the data analyses by listwise deletion. Analyses were conducted with the Mplus 6.12 statistical software package (Munthen & Munthen, 2011), which allowed for use of full information maximum likelihood (FIML) estimation of missing data points based on all available data for each participant (Enders & Bandalos, 2001). This technique is roughly equivalent to alternative data imputation techniques and generally is the most commonly-preferred technique for regression-based analyses such as HLM (Graham, 2009). FIML was used to estimate missing data on predictor and outcome variables to avoid losing participants for whom data were available on some measures.

Using at least three observations typically is recommended when using idiographic assessment of life events that are centered on each participant's mean (to represent the individual's average level of events; e.g., Abela & Hankin, 2008). Thus, participants were included in prospective analyses if they had completed the baseline assessment and at least two follow-up assessments (*n* = 141 participants met this criterion, which was adequate given the a priori power estimates that indicated that 139 participants were required for prospective analyses).

To test Primary Aim 1, fluctuations in person-centered life events at each wave were evaluated as the focal predictor of depressive symptoms (BDI) at each wave, with level-2 observations of the various indices of flexibility at Time 1 serving as moderators of this relationship at each wave, accounting for lagged BDI at the previous wave (e.g., controlling for Time 1 BDI when predicting Time 2 BDI). Sensitivity analyses evaluated whether findings differed when controlling for lifetime history of major depressive episodes (i.e., to determine whether effects were predictive of future depression symptoms independent of history of depression). Significant interactions between flexibilities and life events were probed by testing the simple slopes of each predictor at ± 1 standard deviation from the mean of the other predictor (Aiken & West, 1991). Interactions between each type of flexibility and life events were tested in separate models followed by a combined model containing interactions between all of the primary components of flexibility and life events. All Time 1 measures of flexibility were Z-standardized to aid in interpretation and comparability.

To test Primary Aim 2, BDI (at Times 1-4) served as the predictor variable with rumination, coping flexibility and explanatory flexibility for actual life events (at the next time point, Times 2-5) as outcome variables, accounting for respective levels of these flexibilities at Times 1-4. At the same time, models were cross-lagged so that flexibilities (at Times 1-4) served as predictors of BDI at subsequent time points (Times 2-5), accounting for respective levels of BDI at the Times 1-4. Concurrent measures of flexibilities and BDI were allowed to covary.

HLM also was used to evaluate the Secondary Aim. Levels of the various flexibilities at Time 1 served as (level 2) predictors of (level 1) BDI at Times 2-5, controlling for (level 2) BDI at Time 1. Thus, these analyses represented the extent to which flexibilities predicted prospective levels of depressive symptoms. Flexibilities were tested in separate models followed by a combined model containing all of the components of flexibility that were significant in separate models. The Exploratory Aim was evaluated with cross-sectional analyses evaluating Pearson product-moment correlations between explanatory flexibility, extreme attributions, and coping flexibility and the other primary components of flexibility.

CHAPTER 3

RESULTS

Preliminary Analyses

Examination of the distribution of study variables revealed generally normally distributed variables with little skew and few outliers (<5% of cases). Outliers existed for each of the raw D-KEFS variables, the EXAMINER shifting and inhibition tasks, and RSA reactivity and recovery. In these cases, outliers were recoded to be within +/- 3 standard deviations from the mean to improve the variable distributions, followed by re-standardization of the variables. After recoding outliers, distributions were normal. Descriptive statistics are displayed in Table 1.

Participants completed a mean of 2.84 (*SD* = 1.51) of the four possible follow-up assessments. All participants completed all measures at the Time 1 visit. Time 1 variables (demographic characteristics and study variables) were examined to determine whether they were associated with missingness on follow-up data (Times 2-5). Only one Time 1 variable, FAPT switch costs to focusing on neutral components of negative stimuli, was associated with the number of follow-up assessments completed, $r = .17$, $p = .04$. Analyses did not differ substantively when including FAPT switch costs as a covariate.

In addition, collinearity diagnostics were conducted for analyses that included multiple domains of vulnerability as predictor variables. In all cases, there were no indications of multicollinearity using a standard Variance Inflation Factor (VIF) critical value of 10 (VIFs < 2.35, tolerance coefficients > .43) (Tabachnik & Fidell, 2007).

Table 1. Descriptive statistics for study variables.

	Mean	SD
Coping Flexibility	0.54	0.19
Explanatory Flexibility	1.61	0.39
Explanatory Flexibility (controlling for Extreme Pessimistic Attributions)	0.00	0.32
Extreme Pessimistic Attributions	8.47	7.64
Extreme Pessimistic Attributions (controlling for Explanatory Flexibility)	0.00	6.35
Extreme Optimistic Attributions	10.26	8.82
Negative Cognitive Style	174.06	44.52
FAPT switch costs to affective rule, positive	121.65	110.86
FAPT switch costs to affective rule, negative	219.82	117.89
FAPT switch costs to non-affective rule, positive	105.20	118.92
FAPT switch costs to non-affective rule, negative	53.85	135.25
DKEFS Inhibition	46.46	11.06
DKEFS Set-Shifting	53.07	11.03
EXAMINER Inhibition	0.09	0.06
EXAMINER Set-Shifting	0.06	0.09
RSA (Rest)	0.00	40.78
RSA Reactivity	0.26	21.98
RSA Recovery	0.55	21.71
Heart Rate Reactivity	-1.26	2.78
Heart Rate Recovery	-3.99	3.18
Coping Flexibility (Time 1)	0.54	0.19
Coping Flexibility (Time 2)	0.54	0.26
Coping Flexibility (Time 3)	0.53	0.31
Coping Flexibility (Time 4)	0.52	0.30
Coping Flexibility (Time 5)	0.55	0.32
Explanatory Flexibility (Time 1)	1.87	0.40
Explanatory Flexibility (Time 2)	1.69	0.58
Explanatory Flexibility (Time 3)	1.74	0.55
Explanatory Flexibility (Time 4)	1.74	0.56
Explanatory Flexibility (Time 5)	1.79	0.51
Extreme Pessimistic Attributions on CRLE (Time 1)	0.33	0.38
Extreme Pessimistic Attributions on CRLE (Time 2)	0.30	0.38
Extreme Pessimistic Attributions on CRLE (Time 3)	0.87	0.51
Extreme Pessimistic Attributions on CRLE (Time 4)	0.41	0.51
Extreme Pessimistic Attributions on CRLE (Time 5)	0.49	0.63
Brooding (Time 1)	12.16	3.61
Brooding (Time 2)	9.97	3.78
Brooding (Time 3)	9.42	3.46
Brooding (Time 4)	9.44	3.71
Brooding (Time 5)	9.18	3.35
LEI (Time 1)	10.59	7.14
LEI (Time 2)	9.64	7.28
LEI (Time 3)	8.14	7.34
LEI (Time 4)	7.10	6.02
LEI (Time 5)	5.98	1.78
BDI (Time 1)	8.82	7.54
BDI (Time 2)	7.29	7.19
BDI (Time 3)	6.40	7.50
BDI (Time 4)	6.01	7.20
BDI (Time 5)	4.77	5.91

Note. SD = Standard deviation; FAPT = Flexible Affective Processing Task; D-KEFS = Delis-Kaplan Executive Functioning System; EXAMINER = Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research; RSA = Respiratory Sinus Arrhythmia; CRLE = Cognitive Responses to Life Events; LEI = Life Event Interview (number of life events from the Life Event Scale verified by interview); BDI = Beck Depression Inventory. Descriptive statistics are provided for variables prior to standardizing.

Primary Aim 1: Does Flexibility Moderate the Association between Life Events and Depression?

Results from HLM analyses evaluating Primary Aim 1 are presented in Table 2. The intra-class coefficient was .602, indicating that 60.2% of the overall variance in BDI was explained by level 2 (between-person) variability, whereas 39.8% of the overall variance in BDI was explained by level 1 (within-person) variability.

Inconsistent with hypotheses, neither coping flexibility nor explanatory flexibility interacted with life events to predict symptoms of depression. In contrast, extreme pessimistic attributions interacted significantly with life events to predict symptoms of depression (Figure 1a), such that life events predicted symptoms of depression more strongly among individuals who made more extreme pessimistic attributions, $B = 0.54$, $SE = 0.06$, $t(703) = 8.47$, $p < .001$, than among individuals who made less extreme pessimistic attributions, $B = 0.38$, $SE = 0.08$, $t(703) = 4.47$, $p < .001$. Extreme optimistic attributions did not interact with life events to predict symptoms of depression. Consistent with the hopelessness theory, general negative cognitive style also interacted significantly with life events to predict symptoms of depression (Figure 1b), such that life events predicted symptoms of depression more strongly among individuals with more negative cognitive styles, $B = 0.72$, $SE = 0.09$, $t(703) = 8.22$, $p < .001$, than among individuals with less negative cognitive styles, $B = 0.37$, $SE = 0.10$, $t(703) = 3.69$, $p < .001$. To compare the relative predictive strength of negative cognitive style and extreme pessimistic attributions (e.g., whether the effect of extreme pessimistic attributions was driven by its association with negative cognitive style or vice versa), a combined model was run containing main effects of both variables as well as interaction terms with negative life events. In this model, neither interaction effect was significant.

Consistent with hypotheses, brooding interacted significantly with life events to predict symptoms of depression (Figure 1c), such that life events predicted symptoms of depression more strongly among individuals with higher levels of brooding, $B = 0.69$, $SE = 0.10$, $t(703) = 7.01$, $p < .001$, than among individuals who had lower levels of brooding, $B = 0.31$, $SE = 0.08$, $t(703) = 3.78$, $p < .001$. Neither inhibition nor set-shifting on the EXAMINER task interacted with life events to predict symptoms of depression, nor did set-shifting costs on the D-KEFS. However, D-KEFS inhibition costs did interact significantly with life events to predict symptoms of depression (Figure 2a), such that life events predicted symptoms of depression more strongly among individuals with higher inhibition costs, $B = 0.67$, $SE = 0.10$, $t(703) = 6.98$, $p < .001$, than among individuals with lower inhibition costs, $B = 0.41$, $SE = 0.09$, $t(703) = 4.38$, $p < .001$. In contrast, none of the four types of affective set-shifting costs on the FAPT interacted with life events to predict symptoms of depression.

In terms of psychophysiological flexibility, resting RSA did not interact with life events to predict symptoms of depression. However, consistent with hypotheses, RSA reactivity did interact with life events (Figure 2b), such that life events predicted symptoms of depression more strongly among individuals who showed less RSA reactivity, $B = 0.68$, $SE = 0.07$, $t(703) = 9.39$, $p < .001$, than among individuals who showed greater (more contextually appropriate) RSA reactivity, $B = 0.42$, $SE = 0.08$, $t(703) = 5.51$, $p < .001$. In contrast, neither RSA recovery nor HR Reactivity interacted with life events to predict symptoms of depression. However, consistent with hypotheses, HR recovery did interact with life events (Figure 2c), such that life events predicted symptoms of depression among individuals who showed less appropriate HR recovery, $B = 0.89$, $SE = 0.22$, $t(703) = 4.07$, $p < .001$, but not among individuals who showed more appropriate HR recovery, $B = -0.04$, $SE = 0.21$, $t(703) = -0.17$, $p = .87$.

In a model containing each of the moderators that were significant in models run independently, only RSA reactivity and HR recovery remained significant moderators of the relationship between life events and symptoms of depression.

All results remained consistent when controlling for history of major depressive episodes.

Table 2. Flexibilities as moderators of the association between life events and depression.

Model	Moderators (Flexibility)	*t*	*p*	*ΔR²* (level 1)	*ΔR²* (level 2)
1	Coping flexibility	-0.11	.92	.002	.003
2	Explanatory Flexibility	0.11	.91	.010	.015
3	Extreme Pessimistic Attributions	3.70	**<.001**	.014	.021
4	Extreme Optimistic Attributions	-0.13	.20	.014	.064
5	Negative Cognitive Style	2.87	**<.01**	.027	.114
6	Negative Cognitive Style	0.65	.52	.019	.141
	Extreme Pessimistic Attributions	1.19	.24		
7	Brooding	2.30	**.02**	.003	.015
8	FAPT switch costs to affective rule, positive	1.03	.30	.003	.002
9	FAPT switch costs to affective rule, negative	-0.46	.66	.000	.002
10	FAPT switch costs to non-affective rule, positive	0.77	.44	.001	.002
11	FAPT switch costs to non-affective rule, negative	0.88	.38	.000	.001
12	D-KEFS inhibition	2.15	**.03**	.018	.008
13	D-KEFS set-shifting	1.04	.30	.012	.001
14	EXAMINER inhibition	0.24	.81	.000	.005
15	EXAMINER set-shifting	-0.62	.53	.002	.012
16	RSA (Rest)	-0.14	.89	.013	.028
17	RSA Reactivity	-2.21	**.03**	.009	.058
18	RSA Recovery	0.13	.90	.002	.018
19	Heart Rate Reactivity	-0.30	.76	.002	.035
20	Heart Rate Recovery	-2.39	**.02**	.021	.033
21	Extreme Pessimistic Attributions	-1.30	.19	.045	.077
	Negative Cognitive Style	1.61	.11		
	Brooding	0.19	.85		
	D-KEFS inhibition	1.02	.31		
	RSA Reactivity	-2.35	**.02**		
	Heart Rate Recovery	-2.48	**.01**		

Note. Model containing lagged Beck Depression Inventory (BDI) and life events accounted for 27.5% of level 1 variance and 41.6% of level 2 variance beyond an empty model. Lagged BDI and life events predicted significant variance in BDI in all models. Models containing interactions reported here also controlled for main effect of the relevant form of flexibility included in the interaction. ΔR^2 reported is for the interaction term. FAPT = Flexible Affective Processing Task; D-KEFS = Delis-Kaplan Executive Functioning System; EXAMINER = Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research; RSA = Respiratory Sinus Arrhythmia.

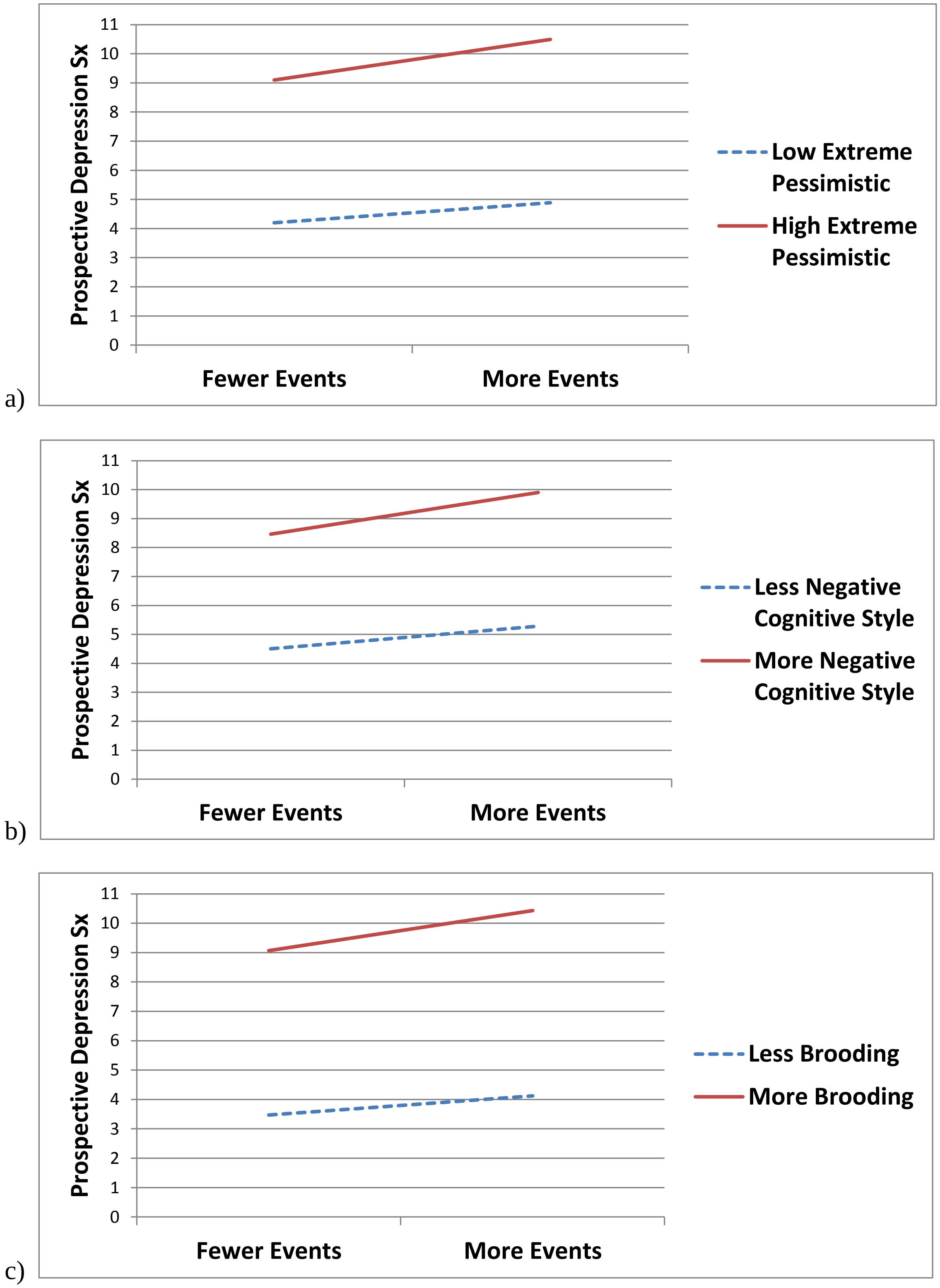

Figure 1. *Interactions between Life Events and (a) Extreme Pessimistic Attributions, (b) Negative Cognitive Style, and (c) Brooding, Predicting Symptoms of Depression.*

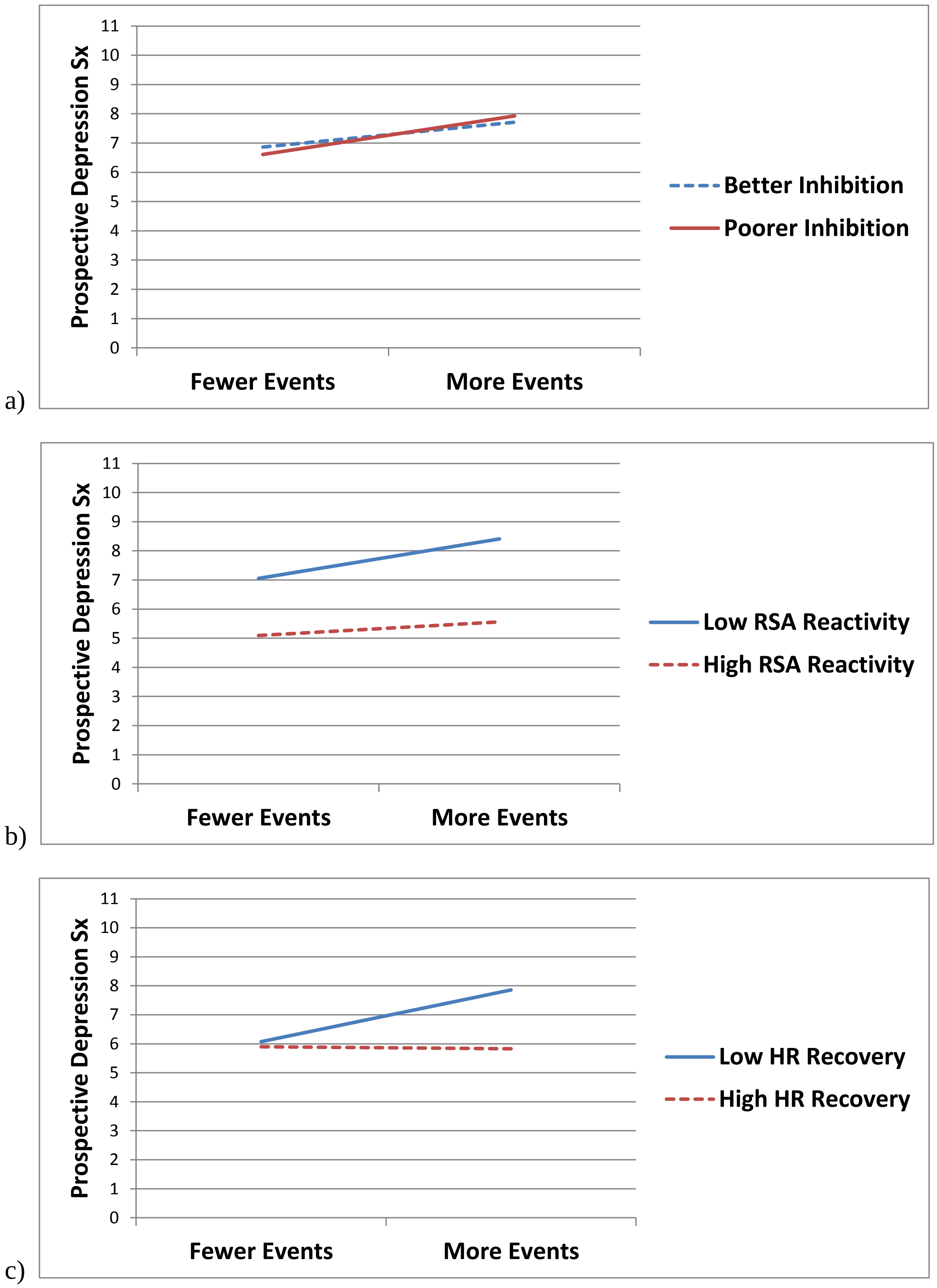

Figure 2. Interactions between Life Events and (a) Inhibition, (b) Respiratory Sinus Arrhythmia Reactivity, and (c) Heart Rate Recovery, Predicting Symptoms of Depression.

Primary Aim 2: Do Symptoms of Depression Predict Subsequent Decreases in Explanatory and Coping Flexibilities?

HLM analyses for each type of period-specific flexibility that was assessed prospectively (explanatory flexibility, extreme attributions, coping flexibility, and brooding) evaluated whether higher symptoms of depression predicted prospective decreases in each component of flexibility across the three week intervals, while simultaneously evaluating whether lower levels of each component of flexibility predicted prospective increases in symptoms of depression (Table 3).

Inconsistent with hypotheses, symptoms of depression did not predict subsequent levels of explanatory flexibility, extreme pessimistic attributions, or coping flexibility. However, symptoms of depression did predict prospective increases in brooding; in contrast, brooding did not significantly predict changes in depressive symptoms.

Table 3. Tests of transactional prospective relationships between symptoms of depression and flexibilities.

		BDI Predicting Flexibility			Flexibility Predicting BDI		
Model	**Flexibility type**	***t***	***p***	ΔR^2	***t***	***p***	ΔR^2
1	Coping Flexibility	-0.01	.99	<.001	-0.13	.90	<.001
2	Extreme Pessimistic Attributions	0.30	.76	<.001	0.02	.98	.005
3	Explanatory Flexibility	-0.25	.81	.004	0.52	.60	.014
4	Brooding	3.26	**<.001**	.022	1.54	.12	.181

Note. BDI = Beck Depression Inventory. Intraclass correlation (ICC) for BDI in all models was .602; ICC for coping flexibility was .147; ICC for extreme pessimistic attributions was .347; ICC for explanatory flexibility was .398; ICC for brooding was .641. Model containing lagged Beck Depression Inventory (BDI) and life events accounted for 27.5% of level 1 variance and 41.6% of level 2 variance beyond an empty model. Lagged BDI and lagged flexibilities significantly predicted BDI and flexibilities, respectively, in all models.

Secondary Aim: Which Components of Flexibility Predict Symptoms of Depression Most Strongly?

Results from HLM analyses evaluating the Secondary Aim are presented in Table 4. Inconsistent with hypotheses, coping flexibility did not predict prospective symptoms of depression, and explanatory flexibility predicted greater symptoms of depression. Extreme pessimistic attributions were positively but not significantly associated with greater symptoms of depression. After accounting for the influence of extreme pessimistic attributions, explanatory flexibility no longer was significantly positively associated with symptoms of depression, suggesting that this original counterintuitive relationship may be better accounted for by extremity of responses. As expected, overall negative cognitive style and brooding both were associated with greater symptoms of depression.

As hypothesized, set-shifting costs on the EXAMINER task predicted higher levels of prospective symptoms of depression. However, inhibition costs on the EXAMINER task, and D-KEFS set-shifting and inhibition, did not predict prospective symptoms of depression. On the FAPT, set-shifting costs away from non-affective components of negative and positive stimuli did not predict symptoms of depression. Inconsistent with hypotheses, set-shifting costs away from the affective components of negative stimuli did not predict symptoms of depression. In contrast, set-shifting costs away from the affective components of positive stimuli predicted greater levels of prospective symptoms of depression.

In terms of psychophysiological flexibility, neither resting RSA nor RSA recovery predicted prospective symptoms of depression. However, consistent with hypotheses, greater RSA reactivity predicted lower prospective symptoms of depression. In contrast, neither HR reactivity nor HR recovery predicted prospective symptoms of depression.

In a model containing each of the predictors that were significant in models run independently, only set-shifting costs on the EXAMINER task remained a significant predictor of higher levels of prospective symptoms of depression.

Table 4. Flexibilities as predictors of prospective symptoms of depression.

Model	Moderators (Flexibility)	*t*	*p*	ΔR^2 (level 1)	ΔR^2 (level 2)
1	Coping Flexibility	-1.17	.24	.002	.011
2	Explanatory Flexibility	2.03	**.04**	.003	.028
3	Extreme Pessimistic Attributions	1.63	.10	.003	.056
4	Extreme Optimistic Attributions	-0.25	.80	.001	.003
5	Explanatory Flexibility	0.99	.32	.000	.058
	Extreme Pessimistic Attributions	0.98	.33		
6	Negative Cognitive Style	2.32	**.02**	.008	.089
7	Brooding	3.30	**<.001**	.002	.095
8	FAPT switch costs to affective rule, positive	-1.55	.12	.000	.018
9	FAPT switch costs to affective rule, negative	-0.17	.86	.000	.000
10	FAPT switch costs to non-affective rule, positive	2.91	**<.01**	.000	.062
11	FAPT switch costs to non-affective rule, negative	0.56	.57	.001	.001
12	D-KEFS inhibition	-0.18	.86	.001	.001
13	D-KEFS set-shifting	1.11	.27	.000	.014
14	EXAMINER set-shifting	2.72	**<.01**	.003	.064
15	EXAMINER inhibition	-0.07	.95	.000	.000
16	RSA (Rest)	0.86	.39	.000	.008
17	RSA Reactivity	-2.04	**.04**	.002	.049
18	RSA Recovery	-0.34	.73	.001	.001
19	Heart Rate Reactivity	0.83	.41	.002	.003
20	Heart Rate Recovery	-0.09	.93	.000	.000
21	Explanatory Flexibility	0.76	.45	.026	.341
	Extreme Pessimistic Attributions	0.40	.69		
	Negative Cognitive Style	1.02	.31		
	Brooding	1.71	.09		
	FAPT switch costs to non-affective rule, positive	1.94	.05		
	EXAMINER set-shifting	2.75	**.01**		
	RSA Reactivity	1.48	.14		

Note. Model containing lagged Beck Depression Inventory (BDI) and life events accounted for 27.5% of level 1 variance and 41.6% of level 2 variance beyond an empty model. Lagged BDI and life events predicted significant variance in BDI in all models. FAPT = Flexible Affective Processing Task; D-KEFS = Delis-Kaplan Executive Functioning System; EXAMINER = Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research; RSA = Respiratory Sinus Arrhythmia.

Exploratory Aim: Psychophysiological and Behavioral Correlates of Explanatory and Coping Flexibilities

Pearson product-moment correlations between explanatory and coping flexibilities and the other primary components of flexibility at Time 1 are displayed in Table 5. To examine whether correlations with explanatory flexibility were driven by extreme responding on the CSQ, I also evaluated correlates of explanatory flexibility when controlling for extreme pessimistic attributions, correlates of extreme pessimistic attributions themselves, and correlates of extreme pessimistic attributions controlling for explanatory flexibility.

Neither explanatory flexibility nor extreme pessimistic attributions were correlated with coping flexibility. Consistent with hypotheses, explanatory flexibility was associated with greater resting RSA, even after controlling for extreme pessimistic attributions. In contrast, extreme pessimistic attributions also were associated with greater resting RSA, but not after controlling for explanatory flexibility. Unexpectedly, explanatory flexibility was associated with less RSA reactivity and recovery, although these associations were no longer significant when controlling for extreme pessimistic attributions. Consistent with hypotheses, extreme pessimistic attributions were associated with less RSA reactivity; however, this associations was no longer significant when controlling for explanatory flexibility.

Unexpectedly, explanatory flexibility also was associated with higher levels of brooding; however, this relationship was reduced to nonsignificance when controlling for extreme pessimistic attributions. Relatedly, extreme pessimistic attributions also were associated with higher levels of brooding, and this relationship was maintained even when controlling for explanatory flexibility. Explanatory flexibility was not associated with any aspects of cognitive flexibility on the behavioral tasks. However, consistent with hypotheses, extreme pessimistic attributions were associated with greater set-shifting costs on the D-KEFS, although this association was attenuated to marginal significance when accounting for explanatory flexibility.

Consistent with hypotheses, coping flexibility was associated with greater RSA reactivity and greater RSA recovery. Coping flexibility was not significantly associated with any of the other hypothesized components of flexibility.

Table 5. Psychophysiological and behavioral correlates of explanatory and coping flexibilities.

		1	2	3	4	5
1	Explanatory Flexibility	---	**.83****	**.56****	---	-.10
2	Explanatory Flexibility (controlling for Extreme Pessimistic Attributions)	**.83****	---	---	**-.56****	-.04
3	Extreme Pessimistic Attributions	**.56****	---	---	**.83****	-.11
4	Extreme Pessimistic Attributions (controlling for Explanatory Flexibility)	---	**-.56****	**.83****	---	-.07
5	Coping Flexibility	-.10	-.04	-.11	-.07	---
6	Brooding	**.31****	.08	**.43****	**.32****	-.11
7	DKEFS Inhibition	.09	.00	.12	.14	-.09
8	DKEFS Set-Shifting	.00	-.08	**.16***	.14	-.03
9	EXAMINER Inhibition	.00	.02	-.02	-.03	-.04
10	EXAMINER Set-Shifting	.02	.03	-.02	-.04	.02
11	FAPT switch costs to non-affective rule, negative	-.08	-.07	-.04	.00	-.03
12	RSA (Rest)	**.23****	**.18***	**.15***	.02	-.05
13	RSA Reactivity	**-.19***	-.12	**-.16***	-.07	**.16***
14	RSA Recovery	**-.20***	-.14	-.14	-.04	**.19***

Note. * $p < .05$; ** $p < .01$. FAPT = Flexible Affective Processing Task; D-KEFS = Delis-Kaplan Executive Functioning System; EXAMINER = Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research; RSA = Respiratory Sinus Arrhythmia.

CHAPTER 4

DISCUSSION

This study represented the first longitudinal multi-wave test of multiple components of flexibility in relation to symptoms of depression. The results of this study provided partial support for inflexibility as a vulnerability to depression. Several components of cognitive and autonomic inflexibilities appeared to confer vulnerability to depression, particularly when individuals encountered high levels of negative life events. There was also some evidence that explanatory and coping flexibilities were associated with greater levels of cognitive and autonomic flexibility. Several other hypotheses, however, were not supported. There also was little evidence that explanatory and coping flexibilities fluctuated with symptoms of depression over time. More specific results for each type of flexibility, as well as implications for future research and clinical work, are discussed below.

Explanatory Flexibility

The prospective results with explanatory flexibility from this study contrast with findings reported previously. Whereas Fresco et al. (2007) found that explanatory flexibility interacted with life events to predict prospective symptoms of depression, no such association was found in the multi-wave design in the present study, a result consistent with Haeffel (2010), who also found no such interaction. Unexpectedly, in the present study, explanatory flexibility actually predicted greater prospective symptoms of depression. However, this association no longer was significant when accounting for extreme pessimistic attributions, which may have been driving this effect. Indeed, extreme pessimistic (but not extreme optimistic) attributions interacted with life events in the expected direction to predict symptoms of depression. In relation to other measures, explanatory flexibility was correlated with resting RSA, and extreme pessimistic attributions were associated with less contextually-appropriate RSA reactivity and greater set-shifting costs. These correlations provide some support for the idea that explanatory flexibility and more moderate attributions may facilitate emotional or regulatory flexibility, as being able to generate a variety of balanced explanations about the causes of life events may allow individuals to successfully adapt to changes in environmental circumstances. In contrast, event-specific explanatory flexibility and extreme attributions (that were made based on life events that participants experienced over the course of the study) did not appear to fluctuate along with symptoms of depression.

Overall, these results seem to suggest that extreme pessimistic attributions may be a stronger vulnerability factor for depression than is explanatory inflexibility. Previous studies typically have not evaluated explanatory flexibility and extreme attributions simultaneously, a notable limitation given the conceptual questions about how to interpret explanatory flexibility, which is computed as a measure of variability in responses (Stange et al., under review). Although admittedly speculative, it is possible that Fresco et al.'s (2007) finding that explanatory flexibility protected against the effects of life events on depression was driven by the (college sample's) endorsement of many extreme optimistic responses, which could have resulted in elevated explanatory flexibility scores; if students in the present study endorsed more extreme pessimistic responses, this could have similarly resulted in elevated explanatory flexibility scores that were driven by responses of the opposite pole. Alternatively, the present study's use of idiographic (person-centered) assessment of life events contrasted with the approach used in previous studies with two time points (e.g., Fresco et al., 2007; Haeffel, 2010), perhaps contributing to this discrepancy in findings. It is important to note, however, that in the present study, extreme pessimistic attributions were not associated with depression more strongly than the negative cognitive style proposed by hopelessness theory, either as a main effect or in interaction with life events. Thus, in contrast with results among individuals with bipolar spectrum disorders (Stange et al., 2013a, 2015), the present results do not suggest that extreme attributions have incremental validity beyond negative cognitive style in predicting symptoms of depression, consistent with Haeffel's (2010) results with a college sample. Additionally, whereas in bipolar disorder, extreme optimistic (and extreme pessimistic) attributions were associated with maladaptive characteristics and outcomes such as personality disorder characteristics, depression, mania, and suicide (Stange et al., 2013a,b, 2014, 2015), in the present study, extreme pessimistic (rather than optimistic) attributions appeared more strongly linked to symptoms of depression. It is possible that extreme optimistic attributions confer risk for poor outcomes in bipolar spectrum disorders, but that in non-clinical samples they are indicative of more adaptive optimistic inferential styles.

Coping Flexibility

Contrary to hypotheses, coping flexibility did not predict prospective symptoms of depression either as a main effect or in interaction with negative life events. However, it did correlate positively with contextually-appropriate reactivity and recovery of RSA in response to the sad film, associations that have not been reported in the literature previously. These associations are consistent with the idea that RSA is a physiological indicator of regulatory flexibility (Bonanno & Burton, 2013; Kashdan & Rottenberg, 2010) that may indicate the mobilization of autonomic resources to facilitate the ability to cope appropriately with difficult events. In contrast, individuals who do not experience contextually-appropriate vagal withdrawal and recovery may be less physically or emotionally prepared to take the necessary action to adapt to changes in situational demands. Previous studies also have not reported whether coping flexibility fluctuates along with symptoms of depression. The results of the present study do not provide support for this hypothesis.

The fact that coping flexibility did not appear to confer vulnerability to depression was surprising, as the ability to fit one's coping responses with the demands of given situations is thought to be a highly adaptive trait (Cheng, 2001; Bonanno & Burton, 2013). It is possible that issues with the measurement of coping flexibility (using the strategy-situation fit index based on perceived controllability of actual life events; Cheng, 2001) interfered with the ability to detect effects that do exist in reality. This measurement technique has several strengths, including that it asks about coping strategies recently used when participants faced actual (rather than hypothetical or distant) life events, and that it does not require participants to directly report on their perception of the "flexibility" of their own strategies, instead indirectly computing a measure of fit. However, because the measure is based on actual life events over the prior three weeks (a number that varies between individuals), coping flexibility is not computed based on the same number of events for each participant. It is possible that expanding the time period within which life events were evaluated, or having all participants respond to the same set of hypothetical events (e.g., Cheng, 2003) would ensure that trait coping flexibility was measured more consistently for all participants, which potentially could change the results reported here. Notably, these results did not change (coping still did not predict symptoms of depression) when controlling for the total number of life events participants experienced, but the potential measurement limitations noted above remain.

Rumination

Results for rumination were consistent with hypotheses across the board. Rumination predicted prospectively greater symptoms of depression over time, and conferred particular vulnerability to depression when individuals experienced high levels of negative life events. These findings are consistent with the literature on the response styles theory of depression (Nolen-Hoeksema, 1991) that has found that rumination (particularly brooding) is a strong risk factor for the onset and recurrence of symptoms and episodes of depression, particularly in the context of high levels of negative events (e.g., Abela & Hankin, 2011; Nolen-Hoeksema, 2000; Stange et al., 2014b). Negative events often precipitate negative affect, and when individuals respond to this affect by brooding rather than by engaging in more adaptive strategies for affect regulation, the negative affect is likely to continue and may lead to more persistent symptoms of depression (Nolen-Hoeksema et al., 2008). Partially consistent with hypotheses, the main effect of brooding accounted for more between-subject (level 2) variance in prospective symptoms of depression than any of the other flexibilities. However, the interaction term between brooding and life events did not have the strongest effect size, and brooding did not remain a significant predictor of symptoms of depression in either of the combined models containing the significant flexibilities (or flexibility x life event interactions).

Tests of Primary Aim 2 indicated that, consistent with hypotheses, higher levels of depressive symptoms at a given time point predicted increases in state rumination at the following point. This suggests that individuals were more likely to engage in rumination following periods of time when symptoms were elevated. It is possible that individuals chose to ruminate more during these periods of time because the presence of depressive symptoms motivated them to attempt to regulate their affect. Alternatively, rumination could have occurred more implicitly (i.e., unintentionally) as symptoms of depression exhausted cognitive resources necessary to engage in more adaptive forms of affect regulation (e.g., Joormann, 2010; Koole, Webb, & Sheeran, 2015; Phillips, Ladouceur, & Drevets, 2008). Broadly, this result provides some evidence that in addition to brooding (and other forms of inflexibility) leading to depression, depression may in turn contribute to decreases in this component of regulatory flexibility, potentially leading to a vicious cycle that maintains depression and leads to futile attempts to escape from depression by ruminating (e.g., Mennin & Fresco, 2013).

Cognitive Flexibility

Results with cognitive flexibility (inhibition and set-shifting on the D-KEFS and EXAMINER tasks) provided partial support for the hypothesis that cognitive flexibility would confer vulnerability to depression. Relative to individuals with stronger inhibition ability on the D-KEFS, individuals with poorer inhibition were more likely to experience symptoms of depression following life events. Additionally, although set-shifting costs did not interact with life events, individuals with poorer shifting ability (on the EXAMINER task) experienced more prospective symptoms of depression. These results are consistent with theoretical perspectives on depression that suggest that inhibition impairments allow irrelevant negative emotional material to intrude into consciousness following stressful events (e.g., Joormann, 2010). Similarly, having difficulty shifting between different ways of thinking may lead to difficulty with using cognitive reappraisal or problems with viewing situations from alternative perspectives, processes that could maintain or exacerbate dysphoric mood (Joormann & Siemer, 2011). Set-shifting costs on the D-KEFS also were associated with the tendency to make extreme pessimistic attributions about the causes of life events, suggesting that extreme attributions potentially could result in part from difficulty with switching between mental sets.

It is possible that stronger support for cognitive inflexibility as a vulnerability to depression would have been found in samples with a greater range in functioning, as students in the present sample scored approximately one standard deviation above the mean on the D-KEFS.

Thus, samples that include more individuals with lower executive functioning abilities might be able to detect whether more severe impairments in set-shifting confer vulnerability to depression in the context of negative life events.

Affective Set-Shifting

Although set-shifting impairments appear common in depression (Lee et al., 2012; Wagner et al., 2012), in the present study, it was hypothesized that set-shifting costs in the context of affective stimuli in particular, or the inability to disengage from focusing on affective components of negative information, is theoretically relevant to the phenomenon of depression, and therefore, would be particularly likely to confer vulnerability to future depression. Although findings with overall cognitive flexibility were broadly consistent with hypotheses, affective set-shifting results from the FAPT were not consistent with hypotheses. Set-shifting costs when disengaging from focusing on affective components of *negative* stimuli were not associated with depression either as a main effect or in interaction with life events. In contrast, contrary to hypotheses, greater costs shifting away from focusing on affective components of *positive* stimuli, which appears less theoretically consistent with the phenomenon of depression, in fact was associated with greater prospective levels of depressive symptoms. It is not clear why this was the case. Although it was expected that general shifting costs would confer risk for depression, it was surprising that the association between depression and affective set-shifting costs would be specific to positive stimuli. For example, the empirical literature on attention bias suggests that depressed individuals tend to focus attention more on negative stimuli and less on positive stimuli (Peckham, McHugh, & Otto, 2010), which should lead to greater shifting costs for negative stimuli (because of difficulty disengaging from focusing on affective components of these stimuli) than for positive stimuli (from which disengagement should be relatively easier because it is less consistent with the attention bias). Although the task used in the present study evaluated set-shifting ability rather than attention per se, the findings are inconsistent with this literature on attention bias. Notably, costs shifting away from focusing on affective components of positive stimuli still predicted depression when controlling for other study measures of general set-shifting, so this result did not appear to be simply due to this measure's association with general shifting ability.

This result also was surprising given that a previous study using this task found that switch costs associated with disengaging from affective components of positive stimuli were associated with less use of rumination in daily life (Genet et al., 2013). Switch costs associated with disengaging from affective components of negative stimuli also predicted greater use of rumination in daily life (Genet et al., 2013) and impaired reappraisal effectiveness (Malooly et al., 2013), whereas in the present study this variable was not associated with depression. Although speculative, one possibility is that although the stimuli used in this task were designed to be emotionally-evocative (e.g., a picture of a starving child; a picture of a man holding a knife to a person's neck), it is possible that measuring stimuli that were simply generally negative was not specific enough to the core features of depression. Instead, perhaps using stimuli designed to evoke sadness, rather than general negative affect, might evaluate set-shifting under conditions more likely to resemble the precursors of depression, which potentially could lead to a pattern of findings more consistent with the study hypotheses.

Autonomic Inflexibility

Individuals who showed inflexible, contextually-inappropriate autonomic responses, characterized by hypo-reactivity of RSA in response to a sad film, or delayed heart rate recovery following the film, appeared to be vulnerable to experiencing symptoms of depression, particularly under conditions of life stress. These findings extend the literature on emotion context sensitivity in depression (Rottenberg et al., 2005) by suggesting that autonomic inflexibility may not only characterize MDD (Rottenberg, 2007) and predict a longer time to recovery of MDD (Rottenberg et al., 2005), but also may confer vulnerability to the onset of symptoms of depression. Lacking appropriate vagal withdrawal to emotional challenges, such as periods of sadness, may result in difficulty mobilizing resources to adequately regulate sadness. Relatedly, prolonged arousal following emotional challenges could reflect difficulty with modulating emotions appropriately across situations. Individuals who lack the ability to effectively regulate sadness may be more prone to experiencing prolonged periods of distress such as depression, particularly following difficult experiences (e.g., negative events) that may elicit sadness. Recent research also has indicated that individuals with greater autonomic flexibility may perceive social-emotional information more accurately and show greater sensitivity to social context (Muhtadie, Koslov, Akinola, & Mendes, in press), perhaps allowing these individuals to adapt to effectively meet contextual demands.

Notably, the interactive effects of RSA reactivity and heart rate recovery with the occurrence of negative life events remained significant predictors of symptoms of depression when including the other significant interactions in a model simultaneously, suggesting the importance of these physiological indicators relative to the other forms of flexibility examined. There also was a significant main effect of RSA reactivity on prospective symptoms of depression, although this effect was reduced to nonsignificance when accounting for the other significant main effects of flexibilities. Additionally, as noted above, RSA reactivity and RSA recovery both were correlated in the expected directions with extreme attributions and coping flexibility. This suggests that these physiological indicators of regulatory capacity may be relevant to flexibility in both thinking and coping.

In contrast, findings with resting RSA were less consistent with hypotheses. Given that meta-analyses have demonstrated that resting RSA is associated with lower levels of depression (Rottenberg, 2007; Kemp et al., 2010), it was surprising that in the present study, higher levels of resting RSA were associated with less explanatory flexibility and more extreme attributions. Many existing studies of resting RSA, however, have had methodological limitations such as not controlling for potential confounds (such as heart rate and respiration) and sampling biases (e.g., selecting participants within a restricted range of values) (Rottenberg, 2007), which could account in part for the discrepancy with the current study's findings. Alternatively, recent studies have proposed that there may be a curvilinear (inverted U-shape) relationship between resting RSA and well-being, finding evidence that individuals with moderate resting RSA had lower levels of depression and superior life satisfaction, relative to individuals with either low or high resting RSA (Kogan, Gruber, Shallcross, Ford, & Mauss, 2013). This would suggest that there may be diminishing returns for higher resting RSA levels; future work could examine non-linearity of relationships between resting RSA and well-being in more detail as this was outside of the proposed aims and scope of the present study. Overall, the results of the present study converge with recent research that suggests that evaluating reactivity of RSA in contexts that are theoretically relevant to the phenomenon of interest (e.g., during sadness inductions when investigating depressive disorders) may be more informative than only evaluating resting RSA (e.g., Bylsma et al., 2014; Rottenberg, 2007; Rottenberg et al., 2007a; Yaroslavsky et al., 2013a,b) and potentially could serve as an endophenotype for depression (Yaroslavsky, Rottenberg, & Kovacs, 2014).

Strengths and Limitations

The present study had several notable strengths. It was the first study to compare and evaluate multiple inflexibilities as vulnerabilities to depression using a large sample with a multi-wave design with idiographic assessment of life events, which is superior to two-timepoint designs that often have been used when evaluating vulnerability-stress relationships (e.g., Fresco et al., 2007; Busso, McLaughlin, & Sheridan, 2014). The study assessed flexibility using multiple methodologies, reducing the likelihood that associations between measures exist due to shared method variance (e.g., Campbell & Fiske, 1959). It was also the first study to evaluate the temporal sequencing (and potentially-transactional relationships) between inflexibility and depression, finding evidence that components of inflexibility may precede symptoms of depression, and that depression may precede use of rumination, providing evidence that inflexibility could be both a cause and a consequence of depression. The use of behavioral and physiological indices of flexibility in the present study was important in avoiding some of the limitations of self-report measures, which may require participants to be willing and able to accurately report on their own tendencies. Even some of the measures that are self-reported (e.g., explanatory and coping flexibilities) are indirectly behavioral measures, since participants do not directly report on their own flexibility; rather, these measures are computed after the fact by the researcher, helping to avert the possibility of demand characteristics or lack of insight into one's cognition or behavior (Stange et al., under review).

Nevertheless, several limitations of the present study also should be noted. Several measures in the present study, including symptoms of depression and rumination, were based on self-report measures. Although self-reports are valid methods of assessing constructs about which participants are likely to be self-aware (Haeffel & Howard, 2010), it is possible that behavioral or interview-based measures of flexibility and depression would be more accurate. Effect sizes in the present study (see Tables) generally were small. This was expected a priori given that interaction effects often predict little additional variance after accounting for main effects, and is consistent with the literature on other vulnerabilities to depression, but renders the practical clinical significance of the findings unclear. Still, the fact that such effects were measureable and detectable suggests that the phenomena could have real-world applicability. Additionally, most participants in the study exhibited symptoms of depression that were in the subclinical range. Thus, although some relationships were detected among continuous measures of inflexibility and symptoms of depression, whether these results would generalize to individuals with more clinically-significant symptoms of depression is not clear. Next, the retest reliability of several components of flexibility over longer periods of time has not been well-established. Although it was assumed in the present study that measures of flexibility are trait-like and are relatively stable, it remains possible that flexibilities would fluctuate more significantly over periods of time that are longer than the twelve-week interval in the present study; for example, one correlational study suggested that RSA may fluctuate along with current mood state (Bylsma et al., 2014). Thus, the extent to which inflexibilities appear to confer vulnerability to depression may depend on what point in time they are assessed.

Although the technique used for assessing autonomic inflexibility across different emotional contexts has been recommended for inducing sadness and measuring physiological reactivity (Rottenberg et al., 2007b), it is possible that different effects would be detectable if the epochs of time analyzed were grouped differently. For example, rather than averaging RSA values across the entire sad film or the entire recovery period, more detailed information could be available by assessing physiology across smaller epochs of time (e.g., in the second half of the film when the content becomes more sad; or toward the end of a recovery period when the flexible individual's physiology would be expected to return to normal). Such a more detailed approach could yield different results, such as that lack of RSA recovery, or lack of heart rate reactivity, could confer vulnerability to depression (cf. Rottenberg et al., 2007a). Additionally, although the present study evaluated symptoms of depression, inflexibility appears to characterize many psychological disorders (Aldao et al., in press; Kashdan & Rottenberg, 2010). Thus, components of inflexibility could serve as non-specific vulnerabilities to other types of psychopathology (e.g., anxiety disorders, eating disorders, personality disorders), a possibility that should be evaluated in the future. The present study used a convenience sample of college students. Although college is a useful time to assess these constructs given that students experience considerable variability in stressors over time and often are at risk for the first onset of depression, the extent to which the present results can be generalized to people of different ages and in different contexts (e.g., younger adolescents, older individuals in the workforce or with families) is not clear.

Directions for Future Research

A number of important questions remain regarding inflexibility and depression that are ripe for programmatic research. First, what are the building blocks of flexibility – are there more basic component processes (e.g., executive functions, neurobiological substrates) that underlie the capacity for flexibility? Flexibility may require a complex coordination of components and may draw upon multiple more basic systems. As one example, perseverative thinking processes that contribute to inflexibility in depression are associated with hyperactivity in the default mode network (Langenecker et al., 2014; Whitfield-Gabrieli & Ford, 2012). Second, under what conditions do these building blocks of flexibility actually lead to behavioral flexibility, and what characteristics facilitate (vs. detract from) the capacity for flexibility? For example, the impact of explanatory inflexibility on depression may be strengthened by poor cognitive control, which could further prevent individuals from considering multiple explanations because of difficulty switching attention away from salient negative material (e.g., Pe et al., 2013a,b). Although negative emotional reactivity may narrow attentional scope and lead to difficulty thinking and behaving flexibly (Langenecker et al., 2014), there is evidence that cognitive control (and corresponding activity in the ventrolateral prefrontal cortex) may help to regulate strong emotions (and amygdala activity) (Langenecker et al., 2014; Phillips et al., 2008), perhaps protecting against depression via improved capacity for thinking and behaving in ways that are contextually-appropriate and effective despite the presence of strong emotions.

Additional theoretical work on "fit" indices such as Cheng's (2001) measure of coping situation-strategy fit also might be useful for advancing the field of flexibility. For example, in addition to variability in perception of the causes of events, do certain classes of situations have corresponding types of attributions or emotion-regulation strategies that would be most adaptive (cf. Aldao et al., in press; Troy et al., 2013)? Preliminary work has indicated the adaptiveness of the ability to flexibly engage in different coping and emotion-regulation strategies depending on the demands of the situation (Aldao, 2013; Bonanno et al., 2004; Bonanno & Burton, 2013; Kato, 2012), a possibility that should be extended further to evaluating vulnerability to (and resilience against) depression. Future work also could evaluate whether it is the effectiveness of strategies in meeting the goal at hand, rather than the flexibility of the strategies per se (which may facilitate the effectiveness of strategies), that confers vulnerability to depression (e.g., Aldao et al., in press; Cheng, 2001). Additionally, the extent to which components of flexibility are stable traits versus representing transient states is not well-established. Future research could evaluate flexibilities over time using trait-state-occasion models (Cole, Martin, & Steiger, 2005) to further elucidate these characteristics, as this question was outside of the primary aims and scope of the present study.

Stressful life events represent one type of context that requires individuals to evaluate situational demands and choose strategies for self-regulation, which may explain the substantial variability in the extent to which life events precipitate depression (e.g., Monroe et al., 2009). To the extent that encountering context changes throughout life is typical, flexibility will be adaptive in facilitating the ability to meet one's goals and desires. If inflexibilities only confer vulnerability to depression in contexts that require flexible shifting, however, main effects of inflexibility on depression might not be apparent unless contextual factors, which include but are not limited to life events, are assessed (e.g., Aldao, 2013). The current study was one of the first to evaluate flexibilities in the context of variability in exposure to negative life events. Future research should also consider whether inflexibility could confer vulnerability to depression in other contexts that require successful self-adjustment, even if not considered "life events" per se. For example, inflexible individuals might not experience depression if they are only operating within one context (or one type of context) in which the current style of thinking or behavior is useful. However, upon changing contexts, the same strategies might be less useful, which could result in failure to attain goals, leading to problems such as frustration and sadness. Thus, whether inflexibility precipitates depression might depend on how many types of contexts (that require different strategies for effective adaptation) individuals encounter.

Additionally, by what mechanisms does inflexibility lead to depression? The domains and constructs proposed by the Research Domain Criteria (Sanislow et al., 2010) provide a promising framework for understanding causes and mechanisms of disorders; preliminary evidence in non-selected samples suggests that flexibility may be applicable to negative and positive valence systems involved in depression such as loss, frustrative nonreward, and low approach motivation, each of which may occur when inflexibility leads to failure to meet goals (Johnson et al., 2010). Additionally, aspects of flexibility are relevant to cognitive systems such as attention and cognitive control (e.g., shifting), systems for social processes including perception and understanding of the self and others (e.g., explanatory flexibility), and arousal and modulatory systems (e.g., RSA and heart rate). Given the overarching conceptual similarities between aspects of flexibility, it is possible that some types of flexibility facilitate other aspects of flexibility, which serve to protect against depression (e.g., Fresco et al., 2006a). Alternatively, future work also could evaluate whether multiple components of flexibility load onto a common latent factor(s) of flexibility which may be a stronger predictor of vulnerability (Stange et al., under review). Given the presence of some evidence that components of flexibility are impaired in individuals with current or remitted depression (Stange et al., under review), individuals at risk for depression, and family members of individuals with mood disorders (e.g., Doyle et al., 2009; Kim et al., 2012; Yaroslavsky et al., 2014), future work should consider the possibility that inflexibility is an endophenotype of depression (Hasler et al., 2004; Mennin & Fresco, 2013; Yaroslavsky et al., 2014).

Additional work investigating how flexibility fits with other theories of depression also is warranted. For example, it is possible that other vulnerabilities proposed by other theories of depression such as rumination, cognitive reactivity, or blunted cortisol responses could to some extent be manifestations of inflexibility, representing difficulty in successfully modulating cognition and affective responses to meet situational demands. Alternatively, perhaps putative cognitive and behavioral vulnerabilities to depression such as rumination actually may be adaptive or helpful when able to be successfully matched to contextual needs (and hence relevant to flexibility), instead of being universally maladaptive (e.g., Aldao, 2013; Bonanno et al., 2004). Additionally, whether flexibility can predict additional variance beyond that predicted by other established vulnerabilities to depression is an important empirical question to be answered. At least with respect to explanatory flexibility and extreme attributions when compared to general negative cognitive style, the present results do not support this hypothesis. Future work should evaluate these questions with other components of vulnerability, such as whether coping flexibility can predict additional variance beyond general types of coping strategies.

Clinical Implications and Conclusions

The present study represents an early step in the process of evaluating inflexibility through the lens of vulnerability to depression. Broadly, the results suggest that flexibility may facilitate adaptation to stressful events. Lack of flexibility in some contexts may lead to thwarted goal attainment (e.g., failing to improve the situation or one's emotions) and subsequent depression (Bonanno & Burton, 2013). Thus, inflexibility may be an important target for the prevention and treatment of emotional disorders.

Several clinical interventions exist that target or have the potential to influence flexibility, thereby possibly reducing vulnerability to depression. One of the most promising avenues for improving flexibility is mindfulness training, which facilitates interoceptive awareness and connection to the present moment while reducing deautomization of cognition and behavior, allowing for more deliberate control of self-regulation (Kang, Gruber, & Gray, 2013). Numerous studies have demonstrated that mindfulness training improves emotion regulation, cognitive flexibility and other executive resources while reducing symptoms of depression and risk for depressive relapse (e.g., Chiesa, Calati, & Serretti, 2011; Holzel et al., 2011; Stange et al., 2011; Teasdale et al., 2000; Teper, Segal, & Inzlicht, 2013). Treatments that involve mindfulness training (and that either implicitly or explicitly target flexibility) include mindfulness-based cognitive therapy (Segal, Williams, & Teasdale, 2012), emotion regulation therapy (Mennin & Fresco, 2015), acceptance and commitment therapy (Hayes et al., 2006), and dialectical behavior therapy (Linehan, 2014), each of which has been shown to improve components of flexibility and reduce symptoms of depression.

Coping flexibility training also has been developed to help teach people the skills necessary to appropriately match coping strategies to situational demands, thereby reducing symptoms of depression (Cheng et al., 2012). Several new treatments also involve cognitive control training, which may improve flexibility of self-regulation and reduce inflexible response styles to sad mood such as rumination (e.g., Siegle et al., 2014; Wells, 2011). Additionally, it is possible that improvements in flexibility actually mediate the effects of other interventions for depression that were not specifically designed to enhance flexibility. For example, by helping individuals to consider multiple possibilities rather than assuming that the initial emotionally-driven thought is the most accurate one, cognitive therapy (Beck & Rush, 1987) might increase explanatory flexibility. One of the reasons that behavioral activation treatments for depression (Jacobson, Martell, & Dimidjian, 2001) could be effective is that they may enhance behavioral flexibility by expanding the variety of activities in which individuals participate. Future research could investigate these possibilities by including theoretically-relevant measures of flexibility within treatment outcome studies.

In sum, the present study provided partial and initial support for the hypothesis that inflexibility may confer vulnerability to depression. In clarifying which are the key components of inflexibility, we may discover which features are the most suitable targets for prevention and treatment, which may help to reduce the substantial burden of depression.

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