2018

Adolescent Emotion Expression, Emotion Regulation, and Decision-Making in Social Context

Tennisha N. Riley
Virginia Commonwealth University

ADOLESCENT EMOTION EXPRESSION, EMOTION REGULATION, AND DECISION-MAKING IN SOCIAL CONTEXT

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

By: TENNISHA N. RILEY

B.S., Florida State University, December 2006

M.A., LaSalle University, September 2009

M.S., Virginia Commonwealth University, December 2015

Director: Zewelanji N. Serpell, Ph.D.

Associate Professor Department of Psychology

Developmental Psychology

Virginia Commonwealth University

Richmond, Virginia

May 2018

Acknowledgements

I would like to thank and acknowledge the members of my dissertation committee. Thank you, Dr. Zewelanji Serpell for your kindness, patience, and motivation throughout my graduate training. You have set the best example as a mentor and academic advisor. Thank you, Dr. Scott Vrana, for igniting my passion for this dissertation and the many grant applications I submitted. Your work in the field is truly inspiring and I look forward to having many more discussions. Thank you, Dr. Vivian Dzokoto, for your involvement and inspiration on the pilot project for this dissertation study. Thank you, Dr. Fantasy Lozada, for aiding in the extension of my work around African American adolescents and for donning me with Kente. And thank you, Dr. Thomas Farmer, for being a part of my academic growth from thesis to dissertation. I have thoroughly enjoyed your perspective and value you input.

I would also like to formally thank my funding sources: Society for Research in Child Development, American Psychological Association, and the National Science Foundation (small grant through the Temporal Dynamics of Learning Center awarded to PI: Zewelanji Serpell, grant # SMA-1041755).

Personal Acknowledgments

The completion of this dissertation was supported by so many family, friends, colleagues, and community friendships. I would like to thank the CIRCLES lab; the undergraduate research assistants who helped organize and manage this dissertation study, and my lab family members (Dr. Aysha Foster, Krystal Thomas, and Melissa Washington-Nortey) who were always willing to help, and most importantly, willing to listen during all the stages of this dissertation project. BGM, thank you for your support. The cheering and the GIFs were instrumental in keeping my head in the game.

Thank you to my family. My parents, Marilyn and Ralph, and my sister Shannett for all of the encouragement and support during my long career as a student. Thank you to my cousins, aunts, and uncles who showered me with praise even when I wasn't so sure of myself. Thank you to my sidekick for life, Casey for pushing me to be the best me. I dedicate this dissertation to my uncle Junior, my grandmother Henry-Mae, and my granddaddy Jessie. I hope I've made you proud.

Thank you to my colleagues and the students of B.L.A.C.K (Building Legacies Around Cultural Knowledge) for aiding in the recruitment of this project. Thank you to the community leaders and program staff that also aided in recruitment of this project. Most importantly, I want to acknowledge and thank the Black/African American adolescents and their families who saw value in my research, who participated in the study, and who encouraged me to finish. Their participation aided in the completion of this project and inspired me to think about the implications of my work. I am so grateful to have worked with an extraordinary group of adolescents and families. And yes, I'm also a hugger.

Table of Contents

Adolescent Emotion Expression, Emotion Regulation, and Decision-Making in Social Context

List of Tables

List of Figures

Abstract

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Adolescents engage in risk behaviors at an alarming rate, and particularly when they are with peers. Despite efforts to develop prevention and intervention programs, rates of risk-taking among adolescents is still relatively high. Adolescents continue to engage in physical fights and aggressive behavior, use substances such as alcohol and illicit drugs, and make decisions that impact driving and motor vehicle incidents. The regulation of emotions plays a significant role in adolescents' decisions to engage in such risk behaviors. Examining adolescents' emotion expression and regulation is therefore critical to identifying ways to support positive development.

This dissertation project explored important regulatory mechanisms that underlie adolescents' behavior in 108 adolescents, by examining synchrony between emotion expression and physiological arousal (change from baseline heart rate to tasking heart rate) during a risk-taking task. The study also assessed the extent to which the social context of peers shifts emotion

expression and physiological arousal, and whether this is associated with adolescents' behavioral and social outcomes, and if these associations vary by gender.

Study results suggest that the presence of a peer influences adolescents' emotion expression. Specifically, adolescents showed greater expression of emotion when completing a risk-taking task in the presence of a peer, than when they completed the task alone. Additionally, adolescent girls are generally more expressive than their male counterparts and equally expressive alone and with a peer, but adolescent boys express more when they are with a peer than when they are alone. Synchrony between emotion expression and physiological arousal was not evident, however results of supplemental analyses suggest that physiological arousal (change from baseline heart rate to heart rate during the task) plays a moderating role in the association between emotion expression and social competence.

Findings from the proposed study may inform intervention and policy efforts to understand and promote positive development among adolescents. In particular, results may shift how adults understand and respond to adolescent behavior in social contexts such as classrooms.

Adolescent Emotion Expression, Emotion Regulation, and Risk-Taking in Social Context

Chapter I: Introduction

Adolescents' engagement in risky behavior remains a major societal concern in the United States, because it often leads to unintentional injury—the leading cause of death among adolescents (Heron, 2013; Murphy, Xu, & Kochanek, 2013). Further, risky behavior in adolescence often begins a trajectory of problem behavior into adulthood; including conduct problems, substance use, and criminality (O'Donnell et al., 2006; Raine et al., 2006). Given the potential for such adverse outcomes, understanding the developmental processes that undergird adolescents' decisions to engage in risk behaviors is critically important.

There are substantial cognitive gains associated with the stage of adolescence, yet adolescents engage in risk behaviors at alarming rates compared to any other age group (Cauffman et al., 2010; Silva, Chein, & Steinberg, 2016). As a developmental period, adolescence confers vulnerabilities for risk-taking as a result of gaps in maturation (Steinberg, 2007; Willoughby, Good, Adachi, Hamza, & Tavernier, 2014), higher levels of emotional reactivity (Silvers et al., 2012), and most importantly, heightened peer influence (Steinberg, 2005; Yurgelun-Todd, 2007). There is a vast amount of research on adolescents' risky behavior and associated outcomes, yet we know little about the underlying processes that help shape such behavior.

One important underlying process that is associated with adolescent risk and behavioral outcomes is emotion and its regulation (Hare et al., 2008; Hessler & Katz, 2010; Vorbach & Foster, 2003). Adolescents' social contexts elicit a range of expressed emotions (Kaiser & Wehrle, 2001) and their ability to regulate these emotions has important implications for how

they adapt to and behave in these social contexts (Thompson, 1994). Existing research suggests that emotion and reward processing are largely responsible for noted discrepancies between knowledge of the consequences of risk and engaging in risk behavior (Steinberg, 2008). Moreover, studies in developmental neuroscience show an increase in risk-taking in the presence of peers—including same-age peers that are unknown to the adolescent and within false-peer presence paradigms (Albert, Chein, & Steinberg, 2013; Steinberg, 2008; Weigard, Chein, Albert, Smith, & Steinberg, 2014). Effective regulation of emotion in social contexts is further complicated by the fact that social goals may shift depending on who and what is present, and so what is adaptive may change rapidly in a dynamic social context. The regulation of emotion can also be a challenge as adolescents are increasingly aware of their peers and are attempting to balance intrapersonal (i.e., self-identity) and interpersonal tasks (i.e., relationship with others) (Smetana, Campione-Barr, & Metzger, 2006).

This dissertation study explores important regulatory mechanisms that underlie adolescents' behavior in social contexts using the polyvagal theory of regulation as a framework. The polyvagal theory suggests that involuntary emotion processes (i.e., emotion expression and autonomic response) are interdependent in their role of regulating emotions in social context (Porges, 2003). This dissertation study specifically examines whether emotion expression aids in the internal physiological regulation of emotion. In addition, the study assesses the extent to which levels of synchrony between emotion expression and physiological arousal (change from baseline heart rate to heart rate during the task) influence adolescents' engagement in risk behaviors in the presence of a peer.

The above questions are explored in a sample of African American adolescents—a group often understudied in the affective science literature, and with arguably unique experiences

related to processes of emotion as well as risk-taking (Gardner & Steinberg, 2005). Emotion regulation—as an attempt to up-regulate or down-regulate the intensity, duration, and/or quality of emotions experienced in social context (Diaz & Eisenberg, 2015)—may be more complex for African American adolescents. African American youth not only manage interpersonal and intrapersonal regulation, but they do so across in-group and out-group social contexts. Because emotion regulation strategies are adaptive to context and situation, for African American adolescents the 'what' and 'who' of the social context may shift whether, and which, emotions are appropriate for up- or down-regulation. Additionally, African American youth face more punitive consequences in the community and in school settings for engaging in risky behavior. In particular, African American adolescents are also more likely to be suspended and expelled from school than their White counterparts (Fenning & Rose, 2007), and for minor infractions based on subjective evaluations of emotion-laden behaviors; such as loud verbal play, laughing, rough play, insults, and threatening behavior (Riley, Foster, & Serpell, 2015). Further, African American adolescents who engage in risk behaviors are more likely to receive harsh discipline from the justice system ("Statistical Briefing Book: Law Enforcement & Juvenile Crime Juvenile Arrest Rate Trends," 2015).

Understanding African American adolescents' emotion expression and emotion regulation is critical to identifying ways to support the development of their positive psychosocial, mental health, and behavioral outcomes (Heller & Casey, 2016; Zeman, Cassano, Perry-Parrish, & Stegall, 2006). Results of this dissertation study will advance theory on the regulatory processes that underlie adolescents' risk behavior but may also shift interventions toward a more ecological perspective that focuses on understanding adolescents' decision-making in social contexts. Such insights can inform the development of interventions and help

shape policies for promoting positive socio-emotional development for African American adolescents.

Chapter II: Review of the Literature

This review of the literature examines adolescence as a unique developmental period strongly influenced by social context. It specifically addresses the underlying emotion processes involved in adolescents' decisions to engage in risk behaviors when they are in the presence of peers. The review is framed by two emotion regulation theories: the polyvagal theory of emotion regulation and the extended process model of regulation. First, background information on adolescents' engagement in risk behavior is situated in a developmental understanding of the uniqueness of this stage of development, including the importance of the social context of peers. This is followed by literature that illustrates that emotion regulation is key to how adolescents operate in social contexts, and the implications of emotion regulation for decision-making. The polyvagal theory of emotion regulation and extended process model of regulation are reviewed to illustrate the interconnections among the physiological, cognitive, and behavioral aspects of functioning in social contexts that link emotion processing and adolescent decision-making. This dissertation rests on a key premise of the polyvagal theory: that, "*emotions defined by shifts in the regulation of facial expression and vocalizations, will produce changes in RSA (Respiratory Sinus Arrhythmia or the variability of heart rate) …mediated by the vagus nerve."* Research that suggests that emotion expression and emotion regulation both play an important role in adolescents' decision-making is therefore reviewed. Lastly, based on this review of the literature, a case is made for exploring the dynamic interface between adolescents' facial affect, physiological regulation and decision-making—specifically risk-taking—in social contexts.

Adolescents' Engagement in Risk Behaviors

Adolescents engage in risk behaviors at an alarming rate, and particularly when they are with peers. Despite efforts to develop prevention and intervention programs, rates of risk-taking among adolescents is still relatively high. Adolescents continue to engage in physical fights and aggressive behavior, use substances such as alcohol and illicit drugs, and make decisions that impact driving and motor vehicle incidents (Allen & Brown, 2008; Kann et al., 2014). These risk behaviors are preventable, yet when they are not prevented can often lead to adolescent injury or death.

Adolescents take risks despite having the necessary knowledge/cognitive skill not to. In fact, research in developmental science suggests that adolescents and adults do not differ much in their ability to accurately evaluate risk, rewards, and subsequent consequences of their behaviors (Blakemore & Choudhury, 2006; Steinberg, 2008). In addition, adolescents perform equally well as adults on cognitive ability tasks that measure executive functioning, such as those assessing working memory (Steinberg, 2007, 2008). The discrepancy between cognitive ability and knowledge, and engagement in risk behavior is driven in part by the role that emotions play in adolescent social contexts (Steinberg, 2005). The developmental stage of adolescence is unique: along with a steady and substantial improvement in cognitive processes, emotional reactivity to social stimuli shows a dramatic spike (Hare et al., 2008; Steinberg, 2008; Willoughby et al., 2014). This "maturation gap" leaves adolescents vulnerable to poor decision-making (Steinberg, 2007; Willoughby et al., 2014).

The Social Context as a Powerful Influence on Risk-Taking in Adolescence

Prior research demonstrates that the presence of peers has a significant influence on the decisions adolescents make and may lead to undesirable behaviors (Blakemore & Choudhury,

2006; Silva et al., 2016; Steinberg, 2007). Even in the false presence of peers (i.e., anonymous and not physically present), adolescents are more likely to make decisions based on immediate reward and gratification than when alone (Albert et al., 2013; Silva et al., 2016; Weigard et al., 2014).

Across several studies of adolescent risk behaviors Albert et al. (2013); Silva et al. (2016); Steinberg (2008) examine the processes that underlie peer influence on reward processing and risk decisions. In a simulated driving task (Steinberg, 2008) conducted a cross-sectional research study to assess whether adolescents and adults differed on risk decisions. Peers were present during the study protocol to examine effects of social context. Study results indicate that when adolescents were not in the presence of peers they made less risky driving decisions; in fact, their decision-making was similar to that of adults in the study. However, when adolescents were told that a peer was watching in the next room as they completed the driving simulation task, adolescents engaged in more risk behaviors than adults who also performed the simulation task in the presence of a peer. Researchers identified that the presence of a peer during the study protocol increased activation in the reward processing regions of the brain for adolescents. The study highlights that peers do serve as a reward for adolescents and increase the likelihood of poor decision-making and in particular risk-taking.

In addition, Silva et al. (2016) examined whether age of peer groups made a difference in heightened activity of the reward processing region. A similar cross-sectional design was conducted in which a risk-taking simulated task was completed. Participants were part of four possible contexts; alone, group of same-age adolescent peers, group of same-age adults, or group of adolescents with one slightly older peer. Results indicate that adolescents make fewer risk decisions alone, but when same-age peers were present they made more risk decisions than the

adult same-age peer group. These findings support the aforementioned Steinberg (2008) study. Additionally, when a slightly older peer was placed in a group of adolescents the number of risk decisions decreased, and in fact mimicked the number of risk decisions adolescents took when in the alone context. The mere presence of an adult (absent of advice or discouragement) shifted adolescents' decisions to engage in less risk behaviors. The cross-sectional design highlights the uniqueness of adolescent social context that includes peers and the influence of peers on emotion regulatory processes that may contribute to engagement in risk behavior.

As previously noted, while adolescents are well aware of the risk behaviors in which they engage, the limbic system will override cognitive control systems in particular context of emotions and rewards (Ahmed, Bittencourt-Hewitt, & Sebastian, 2015). There are notable differences in how adolescents express and regulate their emotions in the context of receiving a reward (Bjork et al., 2004; Casey et al., 2008; Steinberg, 2008), and for adolescents this context of reward includes peer evaluation. Due to cognitive developmental changes (e.g., improvement in perspective taking, abstract thought, relativism) adolescents care more about what others think of them—particularly how they are viewed by their peers (Steinberg, 2016). As such, social appraisal guides emotion regulation and expression, and it is informed by the social norms of adolescent peer groups (Parkinson & Manstead, 2015; Steinberg, 2008). In social contexts, adolescents' adaptation entails appraisals of their own emotions, along with the appraisal of others' emotions and likely guide how they regulate themselves and behave in decision-making contexts.

In sum, high levels of risk behavior in adolescence persist, and there is a dearth of information about the underlying emotion regulation processes involved in adolescents' decisions to engage in risk. Understanding adolescents' emotion processing (i.e., emotion

expression and emotion regulation) is therefore critical to identifying ways to support better decision-making in adolescence.

Emotion Regulation and Risk Behavior in Adolescence

The regulation of emotions plays a significant role in adolescents' decisions to engage in risk behaviors, and the literature confirming a relationship between emotion processing and adolescent risk is extensive (Hessler & Katz, 2010; Zeman et al., 2006; Zimmermann & Iwanski, 2014). Adolescents with particular emotion regulation profiles show an increase in risk-taking and problem behaviors, as well as deficits in social functioning (Zeman et al., 2006) . More recently, the use of psychophysiological measures of emotion regulation has improved what we know about adolescent risk behaviors. In particular, measures of heart rate response, respiratory sinus arrhythmia (RSA), and heart rate variability (HRV) as indices of an individual's ability to regulate emotions (Appelhans & Luecken, 2006) are linked to engagement in risk. For example, emotion regulation measured using heart rate change and vagal control, have been linked to adolescent substance use (Wills, Pokhrel, Morehous, & Fenster, 2011), aggression (Beauchaine, Gatzke-kopp, & Mead, 2007) and other antisocial behaviors, including callous-unemotional trait (Frick & Viding, 2009; Loney, Frick, Clements, Ellis, & Kerlin, 2003). Further, studies that examine neurobiological processing during cognitive tasks that involve emotionally relevant rewards (i.e., the Iowa Gambling Task and incentivized go-no-no measures) indicate that adolescents show increased activation in regions of the brain associated with the regulation of reward and motivation compared to adults (Bjork et al., 2004; Hare et al., 2008).

Defined as one's ability to monitor, evaluate, and modify emotional reactions (both positive and negative) to accomplish a desired goal, emotion regulation is key to understanding behavior in social contexts (Thompson, 1994). The role of emotion regulation is to support the

adaptation and organization of behavior, particularly in challenging settings and social context where decisions about one's behavior relies on interpretation of others responses to that behavior (Aldao, 2013; Halberstadt, Denham, & Dunsmore, 2001). Two theories in the emotion regulation literature help explain emotion expression in social context and its relation to emotion regulation that may influence adolescent decision-making: the extended process model of regulation (Gross, 1998b), and the polyvagal theory of regulation (Porges, 2003). The extended process model of regulation relies on cognitive regulation of emotions in social context, while the polyvagal theory explains emotion processing in social context and the underlying autonomic response—the latter is the primary theoretical framework for the dissertation current study.

Extended Process Model of Regulation

In early research on emotion regulation, (Gross, 1998b) proposes a model of affective systems interdependent on one another—noted as the extended process model of regulation. The extended process model of regulation (EPM) defines emotion regulation as the activation of the goal to modify one's emotional responses to social stimuli and involves stages of identification, selection, and implementation (Gross, 2015a, 2015b). Specifically, emotion regulation behaviors proceed in this order: (a) selecting situations in which one will be exposed to, (b) modifying the current situation, (c) attending to particular parts of the situation, (d) altering one's cognitive representation of the situation, (e) modifying one's emotional response (Gross, 1998b, 2015b).

Gross (1999) outlines two basic types of emotion regulation strategies: (1) antecedent emotion regulation strategies; which are utilized before the activation of emotion response, and (2) response-focused strategies that come after an emotion response is elicited. Antecedent emotion regulation strategies are commonly known in the literature as *reappraisal* and include strategies such as thinking about something positive, or thinking about the positive outcomes of a

potential negative event (Gross & John, 2003). The latter strategy is a response focused or *suppression* strategy, which includes the active suppression of emotional expression after exposure to negative emotional stimuli (Gross, 1998a). Previous research indicates that self-report of reappraisal and suppression strategies are associated with adolescents' behavioral outcomes (Gullone, Hughes, King, & Tonge, 2010).

Both suppression and reappraisal strategies for regulating emotion are associated with emotion expression. Greater use of suppression as an emotion regulation strategy is associated with lower positive valence of coded emotion, while greater use of reappraisal strategies is associated with lower intensity of emotion to both negative and positive stimuli (Gross, 1998a). Moreover, the strategies used to regulate emotions may change over time. For example, adolescents may continue to use regulation strategies that are successful, or shift to another strategy/stop use of a strategy if unsuccessful—all within the same context (Aldao & Christensen, 2015). The social context is therefore critical to identifying and appraising emotion stimuli, and individuals must adapt when selecting responses, as particular emotion regulation strategies that are helpful in one context may not be in another (Gross, 1998b, 2015b).

The Polyvagal Theory of Regulation

The polyvagal theory of regulation (1995) specifies the underlying autonomic and neurobiological processing of emotion and emotion regulation in social contexts. Specifically, it models how processes involved in our autonomic nervous system (ANS) operate within the social context via emotional experience, emotion expression, and emotion regulation (Porges, 2003). The ANS contains two operating branches: the sympathetic nervous system (i.e., arousal and excitatory) and the parasympathetic sympathetic nervous system (i.e., inhibitory). Porges' theory highlights the function of the parasympathetic nervous system (PNS) and the role of the

vagus nerve—a process Porges calls vagal control. The vagus nerve (the 10th cranial nerve) works to maintain homeostasis of the autonomic nervous system in social environments by being somewhat of a heart "pacemaker" (Quintana, Guastella, Outhred, Hickie, & Kemp, 2012)—maintaining control in emotionally-arousing environments. Thus as part of the parasympathetic system, the vagus nerve is responsible for the managing the behavioral, psychological, and physiological processes that underlie functioning in social contexts (Porges, 2003).

Maturation of the PNS contributes to enhanced regulation of emotion and behavior over time as individuals age (Porges, 2007). Further, the changes that occur in the prefrontal cortex across the developmental lifespan allow for more planned regulation of emotions and behavior—a function of both retrieval from previous experiences and greater inhibitory control (Fox, 1994). The function of the PNS and vagus nerve are important in determining adolescent behavior in social context. For example, assessment of the PNS via heart rate variability (HRV) is often associated with decisions to engage in aggression and problem behaviors in adolescence (Allen, Matthews, & Kenyon, 2000; Beauchaine et al., 2007; Beauchaine, Katkin, Strassberg, & Snarr, 2001). Research specifically examining psychophysiological response and adolescent decision-making provides evidence of heart rate slowing (i.e., adaptive vagal control) prior to disadvantageous decisions and after reward loss during risk-taking tasks (Crone & Van Der Molen, 2007). In addition, measures of respiratory sinus arrhythmia (RSA) are associated with disruptive behavior disorders that are co-morbid with callous-unemotional trait, as well as co-morbid Attention Deficit-Hyperactivity Disorder and Conduct Disorder ADHD/CD among adolescent boys (Diamond & Cribbet, 2013). For example, in a study sample of adolescents aged 10-18 years old Cui et al., (2015) found associations between higher resting RSA and prosocial behaviors.

RSA is part of the parasympathetic nervous system (PNS) that works to provide inhibitory control of cardiac function, specifically the vagus nerve—capturing the variation in one's heart rate as a function of inhalation and exhalation during breathing (Pu, Schmeichel, & Demaree, 2009). Further RSA is often associated with cognitive processes that are involved in goal-directed behavior, such as inhibition (Venables & Fairclough, 2009)—an important contribution to adolescent regulatory processing in social context.

The consensus in the literature is that higher levels of resting autonomic function measured by RSA suggest more healthy and adaptive responses to challenging social and emotional stimuli, as well as greater ability in allocating and maintaining attention to appropriate stimuli (Venables & Fairclough, 2009). Further, as discussed in the section following, there is some evidence that resting RSA is also associated with expression of emotion (Demaree, Robinson, Everhart, & Schmeichel, 2004; Marsh, Beauchaine, & Williams, 2008).

Polyvagal Theory and the Role of Emotion Expression in Emotion Regulation

A premise of the polyvagal theory that is less often investigated posits that both autonomic physiological response and facial affect are a means of regulation, as neurobiological systems responsible for the regulation of physiological response and affective facial expression are anatomically adjacent (Porges, 2003). Porges explains that the brainstem structures involved in the expression and regulation of facial muscles are also involved in the regulation of internal autonomic states (Porges, 2003, 2007). This tenant of the polyvagal theory of regulation is different from the facial feedback hypothesis. Often conflated with the polyvagal theory, the facial feedback hypothesis (FFH) suggest that voluntary control of emotion expression via facial affect influences both subjective and internal states (Buck, 1980). The differences in theory lie in voluntary learned emotion expression (FFH) versus involuntary innate emotion expression

(polyvagal theory). The polyvagal theory explains natural processes of emotion that occur in dynamic social context. An additional distinction is that brain and neural processes responsible for voluntary expression are different from those that are responsible for involuntary expression (Izard, 1990), and so processes involved in the relationship between involuntary facial expression and autonomic response may influence emotion regulation processes by different means.

Examining correspondence between emotion expression and autonomic response is infrequent in the literature, particularly with respect to the developmental stage of adolescence. In one of the few studies to examine this relationship as an indication of emotion regulation Demaree, Pu, Robinson, Schmeichel, & Everhart, (2006a) sought to understand why higher levels of vagal control (measured by resting levels of RSA) are associated with less negative expression of emotions in a sample of young adults. The study examined if the relation between autonomic response and emotion expression is due to an individual's effortful attempt to regulate (i.e., whether emotion expression is a function of emotion regulation). Study participants were asked to watch either a positive or negative film for the duration of two minutes. Researchers assessed RSA, as well as electrodermal response (EDR)—a measure of skin conductance and sympathetic nervous system response—two minutes prior to the participant viewing the film and the during the film. In addition, participants' facial expressions were recorded during the film and subsequently coded. Participants self-reported on the types of emotion regulation strategies used during the viewing of the film. Using regression analysis, the researchers found no associations between autonomic activity (RSA and EDR) and emotion regulation or emotion expression. Their results suggest that the relation between affective valence and autonomic activity is not a function of emotion regulation.

However, there are a few methodological limitations to the study conducted by Demaree et al. (2006b) that may explain their null findings. First, similar to previous studies examining emotion expression and emotion regulation Demaree et al. (2006b) utilize stimuli that are not particularly representative of the social context in which individuals interact with regularly. Specifically, for adolescents, context that do not include daily stressors and interactions with true social context may yield different results. Second the aforementioned study coded for participant emotion expression in a non-systematic manner. Emotional valence (positive/negative) and intensity of emotional arousal (low/high) were coded by research assistants in what the researchers describe as, a "natural ecological" manner. No validated coding measure such as the Facial Action Coding System (FACS; Ekman & Friesen, 1977) was used to assess study participant emotion expression.

Emotions serve an important functional role in social context, and understanding the coordination between emotion expression, appraisal, and physiological responses are critical for advancing theory on adolescents' regulatory processes and behavior in social contexts (Marsh et al., 2008).

Emotion Expression and Regulation in Social Contexts

Emotions expressed via facial affect are typically viewed as a means of social communication; in that they convey social understanding, empathy, joy, or distress (Kaiser & Wehrle, 2001). In addition, the perception that others have of one's emotions provides information that may influence social decisions and subsequent behaviors (Van Kleef, De Dreu, & Manstead, 2010). The expression of emotions via facial expression is also reflexive, as viewing negative stimuli (e.g. pictures of individuals frowning) elicits a response of similar emotion (Vrana & Rollock, 1998; Wu, Winkler, Andreatta, Hajcak, & Pauli, 2012).

Emotion expression cannot be separated from emotion regulation, as experiences of emotion shift attention toward relevant information needed to assess social goals and adjust accordingly (Davis & Levine, 2013). Within social contexts, emotion expression through facial affect is defined as observable reflections of internal emotional states and regulation of social interactions (Kaiser & Wehrle, 2001). As such, emotion expression and emotion regulation can be regarded as inter-reliant processes (Porges, 2003, 2007; Porges, Doussard-Roosevelt, & Maiti, 1994). Empirical research indicates that the internal physiological experience of emotion such as heart-rate increases during moments of expressed joy or anger via facial affect in children (Hubbard et al., 2002), and similar findings of heart-rate acceleration during expression of disgust, joy, and anger, have been found among adults (Vrana, 1993). Less understood, is whether these associations are a part of the emotion experience or the regulation of emotion.

Research examining emotion experience and emotion expression suggests that congruence between the two indicates greater emotional control and management based on display rules (Kaiser & Wehrle, 2001). For example, Marsh et al., (2008) examined the congruence between emotion expression and physiological arousal in adolescents. Using a time-linked methodology they examined the correspondence between facial expressions of sadness and autonomic responding (RSA) during a sad emotion induction in a sample of boys with disruptive behavior disorder, and in typically-developing controls. Results of their study indicate that low congruence between emotion expression and adaptive RSA is associated with externalizing symptomatology.

Examining emotion expression and autonomic response in authentic social interactions among adolescents is difficult—the social context includes layers of complexity in movement and interaction with others (Kaiser & Wehrle, 2001). Researchers often rely on measuring

associations between emotion expression and autonomic response within simulated social "settings" (i.e., images and videos that depict social context). For example, in one of the first studies to examine physiological response and emotion expression in social context (Vrana & Rollock, 1998) use a simple social task to examine the autonomic response of heart rate and skin conductance, and emotion expression in a sample of young adults. In fact, Vrana & Rollock (1998) appear to be the first to specifically examine emotion expression via measurement of facial affect in a social context by assessing changes in the zygomaticus and corrugator muscles through facial electromyography (EMG). The social context in this study included an initial greeting of 30 seconds paired with a 30 second basic touch on the participants' wrist by the experimenter. Results of the study indicate the importance of physiological measurement on social context, such that mere presence of others can and will impact emotion regulation processes. This is important to understanding the mere presence of peers in adolescent social contexts, and the influence that peers may have on regulatory processes and decision-making.

The Impact of Social Context on Adolescents' Regulatory Processes

Emotions are defined as complex configurations of social-affective-cognitive-behavioral-physiological states that dynamically unfold over time in complex and context-specific ways (Kaiser & Wehrle, 2001). Further, the regulation of emotion is identified, learned, and adjusted within social context (Shuman, 2013)—including the context of family, culture, and peers. It is difficult to view emotion regulation outside of social context because emotion regulation by definition is a social phenomenon. Shuman (2013) makes this important contribution by proposing that; (1) social contexts stir and steer emotions, (2) a common objective of emotion regulation is to change social situations, (3) the communication of emotions is a means of regulating emotions, and (4) emotion regulation and social cognition are linked. The social

context directly arouses emotions, as the expression of emotions is more likely to occur in social context (Hare et al., 2008). Social interactions elicit a range of emotions, (Kaiser & Wehrle, 2001) and the regulation of these emotions is essential to maintaining social relationships and influences subsequent decision-making (Silva et al., 2016). Social context also aids in the development of goals for emotion regulation—which is most evident when assessing how strategies for emotion regulation vary across context and culture (Diaz & Eisenberg, 2015; Gross, 2015b). As a means of engaging in social context, emotion expression serves to convey particular information to individuals in specific context through emotion regulation "flexibility" (Aldao, Sheppes, & Gross, 2015; Bonanno & Burton, 2013). Flexibility of emotion regulation refers to the matching of emotion regulation strategy to a given context or circumstance (Aldao et al., 2015; Diaz & Eisenberg, 2015; Gross, 2015a).

Context-dependent shifts in emotion expression and regulation are most evident in the research that examines gender differences. Models of emotional development acknowledge that social norms and expectations around gender may impact emotion expression and regulation (Ostrov & Godleski, 2010)—such as gender schema models of peer relationships. Specifically, these models suggest that social contexts are typically constructed in ways that impact emotion expression and regulation. For example, boys tend to form peer groups that are large in size and characterized by a system of hierarchy, while girls tend to engage in long-term dyadic relationships (Rose & Rudolph, 2006). These structures have implications for emotion expression, one study shows that adolescent girls are less likely to suppress their emotions than are adolescent boys (Gullone et al., 2010).

Despite our understanding of the dynamic role that emotion plays in social contexts, research often examines emotion and emotion regulation as an individual trait (e.g.,

temperament, personality, psychopathology) that may shift or be impacted by environment due to vulnerabilities (Diamond, Fagundes, & Cribbet, 2012). For adolescents, the regulation of emotion—both social regulation and emotion regulation relative to the self—is essential to guiding behavior in challenging contexts (Collins & Steinberg, 2006). In particular, intra-individual emotion regulation (i.e., an individual's appraisal of the emotions and behavior of others) (Kaiser & Wehrle, 2001) is important in an adolescent context in which the importance of peers' perceptions are highlighted (Albert et al., 2013). Moreover, as emotion regulation develops across the lifespan, it is further influenced by "cognitive affective" schemas that link specific emotions with previous situations, goals, actions, and regulation processes (Camras & Shuster, 2013).

Current Study

Because the developmental stage of adolescence is so uniquely complex, examining cognition, affect, behavior, and underlying physiology separately does not adequately represent what typically occurs in adolescents' social contexts—as such, the current study adopts an integrative approach. Specifically, the current study examines emotion and emotion regulation in social context and the influence of performance on a risk-taking task, and adolescents' self-reported social-behavioral outcomes.

Pilot Studies for the Study Proposed

Two pilot studies conducted in our research lab on emotion expression and autonomic arousal support the basic assumptions of this dissertation study. The first study examined emotion regulation and affective facial expression of researcher-coded engagement during a cognitive learning task among African American adolescents and emerging adults. Results

suggest that students high in trait emotion regulation (i.e., higher HRV) tend to display facial expressions that are perceived as being more engaged in a learning task than students low in trait emotion regulation. This supports the notion that emotion regulation works to shift attentional efforts toward intended environmental stimuli via vagal control (Porges, 2007). The second study examined autonomic arousal and facial affect (coded with automated software) within in a learning context. Multivariate analyses indicate that high physiological arousal was associated with lack of emotion expression (i.e., neutral or no emotion detected). Results suggest that context is important to strategies for regulating emotion (Gross, 2015b), and that emotion suppression of facial affect may occur in African American adolescents when they are experiencing high levels of autonomic arousal during complex problem solving. Recent research has found that suppression is a form of emotion regulation more related to engagement, and that in times of high intensity of emotional arousal, distraction may be a more adaptive regulation strategy than suppression. Based on these pilot studies, it is anticipated that emotion expression assessed via facial affect will be associated with autonomic arousal, and that social context (peer presence) will shift whether emotion expression is more adaptive and facilitates better behavioral outcomes.

Statement of the Problem

Emotions expressed and experienced in social context are complex and multifaceted (Kaiser & Wehrle, 2001). Our current understanding of the regulation of emotions in social context has yet to fully explore the role of emotion expression in emotion regulation. A greater understanding of the relationship between emotion expression and emotion regulation may uncover what contributes to adolescents' risk-taking. This is particularly important because

emotions are tied to social contexts (Kaiser & Wehrle, 2001), and for adolescents peers serve as a guide for processing emotion and strongly influence risk-taking (Albert et al., 2013).

Research Questions and Hypotheses

Grounded in the polyvagal theory and process model theories of regulation, the proposed dissertation seeks to answer the following research questions regarding adolescents' emotion expression, regulation and risk-taking:

RQ1: Can synchrony between emotion expression and physiological arousal define a new metric of emotion regulation in a sample of African American adolescents?

Hypothesis 1: It is hypothesized that a new measure of emotion regulation will be defined by the synchrony between emotion expression (via facial affect) and physiological response (heart rate) over time. In addition, it is hypothesized that the new index of synchrony for emotion regulation will be associated with a more traditional, trait measure of emotion regulation (resting HR).

RQ2: Is the new metric of emotion regulation, that considers emotion expression and physiological arousal in synchrony, associated with adolescent risk-taking and is this association present when controlling for trait autonomic functioning?

Hypothesis 2: It is hypothesized that at higher levels of risk-taking (both assessed by performance on the IGT and self-reported risk behaviors), there will be lower levels of synchrony between emotion expression and physiological arousal.

Hypothesis 3: Compared to a traditional trait-like measure of emotion regulation (resting HR), the new congruence metric of emotion regulation will be a better predictor of risk-

taking on the Iowa gambling task, and of adolescents' self-report of risk-taking behaviors.

RQ3: Does the social context of peers influence the relationship between the new metric emotion regulation and adolescent risk-taking?

Hypothesis 4: It is hypothesized that within a peer context, adolescents will exhibit less ability to regulate emotions (measured by lower levels of synchrony between facial affect and HR), and that less synchrony will be associated with greater levels of risk as measured by scores on the IGT and self-reported risk-behaviors.

Chapter III: Methodology

Overall Research Approach

The proposed work employs an experimental design in which photoplethysmography (PPG; heart rate measure) is used to assess autonomic response at resting and during a risk-taking task completed on a computer. Adolescents completed the risk-taking task (1) alone, and (2) under a social context with a same-age, same-gender peer watching their performance. The total experimental session took the adolescent pair approximately 60 minutes to complete. Emotion expression or facial affect were recorded via video camera during the completion of the risk-taking task and was later coded using software that automatically detects and codes for emotion states. Adolescents' also completed a battery of self-report measures that included demographic information, emotion expression, emotion regulation, and engagement in risk behaviors and social competence.

Sample Population

An a priori power analysis using Optimal Design Plus Empirical Evidence Software version 3.01 (OD) was conducted in order to determine estimated sample size for data analysis. OD is a statistical tool used to compute estimated sample size for hierarchical data structures (Spybrook et al., 2011). Previous studies examining emotional reactivity and emotion regulation in adolescents report medium effect sizes of .22 (Hare et al., 2008; Silvers et al., 2012). Power analysis was based on the estimated moderate effect size of previous studies with power at .80 (i.e., 1-β)(Cohen, 2004). A minimum of 103 participants is needed to conduct the multilevel model analyses conducted in the current study. In order to address the possibility of recruitment no-shows, efforts were made to recruit an additional 10% of the minimum participants needed with the aim to enroll a total participant sample consisting of 114 adolescents aged 12-17 years.

The final sample included 108 adolescents between the ages of 12-17 years old (M = 14.34, SD = 1.70). There was an equal distribution of gender (n=54 for boys and n=54 for girls). Students reported being in the 5th (n =1), 6th (n =14), 7th (n =21), 8th (n =19), 9th (n =13, 10th (n =17), 11th (n =10), and 12th (n =3) grade, with middle school students making up a majority of the students in the sample. Ninety-one percent of the sample population identified as Black/African American. Other students in the sample self-identified as Black but from other ethnic backgrounds including: Arabic (n =1), Hispanic/Latino (n =2), or multi-racial (n =3). All adolescents in the sample lived and attended school in a Southeastern urban city and its surrounding metro areas.

Participants were recruited from a community sample of adolescents through parent information letters sent to youth at local community after-school programs, and community service providers. Through a pre-enrollment screening, potential participants were identified as

meeting the study's inclusion criteria before being enrolled. Participants were included in the study if they self-identified as: Black/African American, between that ages of 12-17 years old, and were able to read and speak English at a 5th grade level. In addition, adolescents were required to bring a peer of the same gender that was also about the same age. Excluded from the study were those that had any known cardiovascular conditions, cognitive deficits, or muscular facial conditions that would have confounded data processing of facial affect.

Measures

Autonomic Response. In order to assess autonomic response at resting and during task engagement adolescents were asked to wear a wireless heart rate monitoring device on their wrist. The hardware device measures continuous heart rate through pulsewaveforms (i.e., photoplethysmography, PPG) and supports the collection of heart rate via beats-per-minute (BPM) for analysis. Data transmitted from the device detects pulsewaveforms that allow for the determination of moment-to-moment heart rate reactivity (HR) as well as changes in heart rate overtime, as indices of emotion regulation. Each adolescent's heart rate was measured for an initial 5 minutes to obtain a resting heart rate reading. During this assessment of heart rate, the adolescent remained in the testing setting alone. Data was synchronized using iMotions© software and later exported to calculate metrics of heart rate during the risk-taking task.

Emotion Expression via Facial Affect. During the risk-taking task, adolescents' expression of facial affect was recorded using a video camera embedded in the computer screen on which they completed the risk-taking task. The study utilized iMotions© software, which allows for real time recording and analyzing of participant facial affect. iMotions© uses a platform, Facet 4.1—an emotion and sentiment detection software—which provides analysis of core affective expressions (i.e. anger, frustration, joy, surprise, confusion, fear, sadness,

contempt, and disgust), sentiments (i.e. positive, negative, or neutral expression of emotion), as well as indications of particular facial muscle movements or action units (AUs) based on Ekman's Facial Action Coding System (FACS; Ekman, 1992). In social context, the expression of emotion occurs at a rapid pace. The ability to use the software in the current study allows for the capture of fine grain moment-to-moment expression of emotion (*see appendix A for example of data extracted from facial affect detection software)*. Each participant's face was recorded, synchronized with data from the heart rate device, and later extracted to assess emotion expression via facial affect during tasking. For clarity, in the current study emotions were assessed at levels of positive, negative, and neutral affect. Positive emotions included those of joy and surprise, while negative emotions included those of anger, sadness, fear, and disgust. Neutral affect is defined as maintaining the baseline neutral face position (i.e., less expression of positive or negative affect). Other emotions examined in this study included: contempt, confusion, and frustration.

Adolescent Risk-Taking. A well-known task: the Iowa Gambling task (IGT; Anderson, Bechara, Damasio, Tranel, & Damasio,1999) was used to assess adolescent risk-taking. The IGT is a commonly used assessment of cognitive-affective decision-making, which is sensitive to manipulations to the social and emotional context of performance (Cauffman et al., 2010). The task consists of four facedown decks of cards, and for each trial participants are instructed to pick a card from any deck to gain as much money as possible. Two of the decks of cards are disadvantageous—yielding high rewards on some trials, yet large costs on others. The other two decks of cards yield the most gains/ the most reward. These two decks yield smaller rewards on some trials, but also smaller punishments (Anderson et al., 1999). The continued drawing from

the disadvantageous deck suggest a "myopia for the future" (Crone & Van Der Molen, 2007) or lack of consideration for future negative outcomes.

Cross sectional research examining the IGT across development reveals that the typical patterns of adaptive decision-making among adolescents show participants begin by drawing cards from all decks, with a gradual improvement over the course of the task ultimately drawing from the more advantageous decks 55-60% of the trials (Hooper, Luciana, Conklin, & Yarger, 2004; Steinberg, 2005). Low or no improvement in strategy and consistent drawing from disadvantageous decks are observed in young participants, participants with significant cognitive impairment due to lesions of the prefrontal cortex, or those who tend to engage in risk behaviors (Anderson et al., 1999; Cauffman et al., 2010; Hooper et al., 2004).

In the current study, a version of the Iowa Gambling Task is used from the online experimental site, psytoolkit (Stoet, 2010, 2017) (*see appendix B, figure 2 for an example of the Iowa Gambling Task followed by participant instructions)*. In the version used for the current study, adolescents were asked to choose from four buttons (A, B, C, D) instead of a deck of cards. All other rules for the game were the same, with two buttons being more advantageous (i.e., smaller rewards, but also smaller punishment) than the other two buttons. Every time a button is chosen, the participant wins an amount of money, however there are some trial in which the participant has to pay a fee which is the "punishment". Consistent with typical measures of the IGT and research examining adolescent decision-making (Hooper et al., 2004) the current study presented each participant with 100 trials. Buttons A and B yielded high rewards of $100, with a 50% change of higher punishment ($250), while buttons C and D yield smaller rewards of $50, but also smaller punishment ($50). Participants began with a bank "loan" of $2000, and after each trial information was provided to the participant indicating how much money

remained in the bank. Choosing from button(s) labeled with the letter "A or B" resulted in an overall net loss. These trials were noted as disadvantageous. However, choosing button(s) labeled with the letter "C or D" resulted in an overall net gain and were therefore coded as advantageous trials. Accuracy for each trial is calculated by assessing the net gain (dollar amount) won for that trial, while reaction time is calculated by time (milliseconds) for each trial such that greater values is indicative of slower reaction time. ln order to calculate an overall efficiency score on the IGT, the accuracy on trials (amount of dollars gained in the trial) was divided by the reaction time for the trial, with higher values representing greater efficiency.

Self-Report Measures of Behavioral Outcomes

Adolescent Risk-Taking Questionnaire (ARQ). Processes of emotion as measured by autonomic response are associated with adolescent risk behaviors including; aggression and substance use (Beauchaine et al., 2007; Cui et al., 2015; Wills et al., 2011), and disruptive behaviors (Marsh et al., 2008). To add to this body of literature and examine the relationship between regulatory processes and problem behavior, adolescents completed an adapted version of the adolescent-risk taking questionnaire (ARQ; Gullone, Moore, Moss, & Boyd, 2000). The ARQ is a 22-item self-report measure that assesses adolescent thrill seeking, rebellious behaviors, reckless behaviors, and antisocial behaviors. In this study, only the latter three subscales were used to assess adolescent risk behaviors (i.e., rebellious behaviors, reckless behaviors, and antisocial behaviors). Adolescents self-reported on the frequency of their engagement in risk behaviors using a 5-point Likert scale, rated from 1 = never done to 7 = done very often. Adolescents were prompted with the question stem, "Circle the response that best describes your behavior about each item below". Example items include, "smoking, getting drunk, staying out late, having unprotected sex, etc.). The ARQ demonstrates good internal

consistency with a Cronbach's alpha of .97, and good test-retest reliability with an alpha of .99. Additionally, previous research supports the validity of the ARQ across developmental age and gender such that older adolescents and boys engage in more risk behaviors than younger adolescents and girls (Gullone, Moore, Moss, & Boyd, 2000). In the current study, Cronbach's alpha was .82.

Adolescent Social Competence. Understanding the underlying regulatory processes that underlie adolescent decision-making and risk behaviors is essential to preventing detrimental outcomes such as of injury and potential death. However, it is also important to examine how regulatory processes contribute to more adaptive social behaviors. Research within adolescent samples typically focuses on negative outcomes, which promotes the myth that the developmental stage of adolescence is filled with turmoil (storm and stress) instead of normative developmental behavior and opportunity for growth (Arnett, 1999).

In the current study, adolescent positive behavior was measured using the social competence scale for teenagers developed by Child Trends for the Flourishing Children Project, funded by the Templeton Foundation (http://www.performwell.org). The measure includes nine items that assess general social competence, defined as a set of positive social skills necessary to get along well with others and function constructively in groups. Skills assessed in the measure include: self-reported respect and expression of appreciation for others, social communication and ability to work well with others, behavior that is consistent with social norms, and ability to resolve conflict. Response items are on a 5-point Likert scale rated from 1 = *not at all like me* or *none of the time* to 5 = *exactly like me* or *all of the time*. An example item is," *If two of my friends are fighting, I find a way to work things out*". The social competence scale for teenagers was tested with a nationally representative sample of teenagers aged 12-17 years old. The

measure has excellent reliability (α =.79) and concurrent validity. Specifically, the measure is associated with better academic outcomes and lower depression symptoms, as well as lower likelihood of engagement in risk behaviors such as smoking and fighting. Reliability for the current study was .69.

Additional Measures and Covariates

The Pubertal Development Scale (PDS). During the developmental stage of adolescence biological changes (i.e., puberty) impact levels of emotionality and therefore the ability to regulate and process emotions. Specifically the research notes that the processes of the adolescent brain that are most susceptible to social-emotional stimuli are interrupted by the process of puberty (Steinberg, 2007). To account for possible differences attributable to pubertal timing a measure of pubertal development was included as a covariate measure. The PDS measure (Petersen, Crockett, Richards, & Boxer, 1988) is a self-reported assessment of pubertal status in which adolescents answer questions related to their own pubertal status (e.g., growth spurt, pubic hair, and skin change). The measure for boys has additional questions about the growth and development of facial hair, while the questions for girls inquire about start of menarche. The measure has a four-item response scale that allows the adolescent to report on where they are in pubertal development (i.e., has not yet begun, has barely started, is definitely underway, and growth or development is complete). The PDS has good reliability ranging from .68 to .83, and provides a valid means of measuring puberty outside of hospital settings that can be used in the school or home (Petersen et al., 1988). In the current study, reliability was .70 for boys and .66 for girls.

Emotion Expression. A measure of general expression of emotion was used to assess adolescent emotion expression—both positive and negative. While the automated coding

software allows for assessment of specific emotions—this measure is a participant's self-report of their emotional expressivity used to validate the automated assessment. Adolescents completed the Berkeley Expressivity Questionnaire (BEQ; Gross & John, 1995). The BEQ is a 16-item measure that assesses individual differences in willingness to openly express emotional experiences. Three subscales compose the measure—expression of positive emotions (e.g., "Whenever I feel positive emotions, people can easily see exactly what I am feeling" or "I laugh out loud when someone tells me a joke that I think is funny."), expression of negative emotions (e.g., "No matter how nervous or upset I am, I tend to keep a calm exterior" or "Whenever I feel negative emotions, people can easily see exactly what I am feeling"), and strength of impulse to express emotions or intensity of emotion experience (e.g., "I am sometimes unable to hide my feelings, even though I would like to."). The item responses for the BEQ use a 7-point Likert scale, rated from 1 (strongly agree) to 7 (strongly disagree). The BEQ subscales demonstrate adequate internal consistency with alpha coefficients of .71 and .72, for the positive and negative scales respectively. Cronbach's alpha for the current study was .78.

The BEQ is frequently used with older adolescents and young adult samples, but less so with younger adolescent samples. Items on the BEQ were therefore adjusted to fit the younger sample population in this study. For example, the question item, "*No matter how nervous or upset I am, I tend to keep a calm exterior*" was adjusted to "*No matter how nervous or upset I am, I tend to keep calm on the outside*." In addition, similar to other studies that have adjusted emotion and emotion regulation scales, the 7-point Likert response scale was adjusted to an item response scale with 5 points (1 = strongly disagree, 2 = disagree, 3 = half and half, 4 = agree, 5 = strongly agree).

Emotion Regulation. Adolescents also completed the Emotion Regulation Questionnaire for Children and Adolescents (ERQ-CA) as validation for the assessment of physiological response. The ERQ-CA assesses cognitive strategies for emotion regulation (Gross & John, 2003; Gullone et al., 2010; Gullone & Taffe, 2011). The ERQ-CA is an adapted version of the original Emotion Regulation Questionnaire (ERQ; Gross & John, 2003) and is comprised of 10 items assessing cognitive reappraisal (6 items) and expressive suppression (4 items). The child and adolescent version is revised by simplification of item wording (e.g., "*I control my emotions by not expressing them*" was reworded to "*I control my feelings by not showing them*"), as well as a reduction of the item response scale to 5 points (1 = strongly disagree, 2 = disagree, 3 = half and half, 4 = agree, 5 = strongly agree). Higher scores on each scale indicate greater use of that particular emotion regulation strategy. Confirmatory factor analyses indicate the same two-factor model proposed in the original ERQ by Gross & John (2003). In addition, the ERQ-CA shows good internal consistency across scales with alpha coefficients of .81 and .69 for reappraisal and suppression respectively (Gullone & Taffe, 2011). Cronbach's alpha for the current study was .78 and .64 for the reappraisal and suppression subscales respectively.

Procedures

The researcher presented the opportunity to participate in the research study during after-school and community programming. Caregivers of adolescents interested in participating contacted the researcher via phone or email. A short screening took place to ensure student eligibility based on the aforementioned inclusion criteria. Potential participants and their parents then scheduled a time to come to the study location—a research lab on a university campus. In addition, if participants were not able to come to the study location, the researcher met with participants and/or their families at local libraries and within community centers.

The study was designed to assess adolescent regulatory processing of emotion and risk-taking, with the additional goal of examining these processes in social contexts. Research indicates that adolescents make significantly more risk decisions when in the presence of a peer (Albert et al., 2013; Steinberg, 2008). A repeated measures design was employed to assess two social contexts for each participant (*see appendix A*); one in which each adolescent participant completed a risk-taking task alone and in the presence of a peer. Which context came first was counter balanced, and randomly assigned prior to the adolescent completing the study to account for carryover effects. Prior to adolescent participants completing the social context condition they were asked to rate their familiarity to the person in the peer context on a scale of 1-100 (1 being not very familiar with the peer to 100 extremely familiar). The peer that participated with the adolescent in the study was either a friend identified and brought in by the adolescent participant or an adolescent in the participant's after-school program that the adolescent identified as a friend. The peer familiarity rating scale was a manipulation check to ensure that familiarity with the peer did not influence the experience in peer context for participants that completed the task with a peer who attended the same after-school program. Research indicates that even in presence of an unknown peer, adolescents still make significantly more risky decisions than they would alone (Weigard et al., 2014)—suggesting that adolescent engagement in risk is less about social relationships and more about emotional processing of peer presence. However, in order to control for possible friendship bonds, adolescents reported on their familiarity with the peer.

A brief description of the study objectives and procedures, as well as informed consent and assent were reviewed prior to the start of the study. Adolescents and their caregiver were required to sign informed consent and/or assent, with a witness present. After the consent

process, the researcher placed the heart rate device on the adolescent's wrist. In the alone context, once the device was placed, the adolescent was asked to remain still for a resting period of 5 minutes during which the adolescent's resting heart rate was measured as an indication of trait autonomic functioning in the absence of cognitive processing or provocation. The adolescent completed the resting period alone to reduce interference of others' presence, as the mere presence of individuals influences physiological arousal (Zajonc, 2001). The adolescent participant then completed the second trial of the risk-taking task, with instructions for the peer context preceding. The time between the alone and peer condition was dependent on the random assignment. For adolescents in group 'A' the peer context was first, and there was an approximately 5-minute transition to switch the adolescent from being the participant completing the task to be the peer observer. For adolescents assigned to group 'B', the alone context was first and, the time between it and the peer context was approximately 7 minutes. The gap was longer for "B" because each adolescent completed the task separately and alone, and then they transitioned to the peer context. In the peer context, the adolescent that was the observing peer was asked to remain seated next to the adolescent completing the task and instructed not to speak or interfere.

Participants were placed in front of a laptop with an attached camera, and the device measuring heart rate was placed on their left hand, and its electrodes were placed on the two forefingers. Participants were asked to place their hand to the left of the laptop on the desk, and not to make any large movements or obstruct their face. All data recorded in the experimental portion of the study was synchronized using iMotions© software (iMotions, 2016). The study protocol allowed for the assessment of resting autonomic function of adolescents at baseline, as

well as efforts to maintain adaptive regulation during task—so that the association between emotion processes and adolescent risk-taking and social outcomes could be assessed.

During each component of the task the heart rate monitor continuously recorded the participants' heart rate and provided inter-beat-intervals (IBI) from which task-related HR (change from baseline heart rate to heart rate during the task) was derived. In addition, a video camera recorded movement of facial muscles, which were later coded using automated coding to assess for the presence of particular muscle movements and associated emotions. These data were collected continuously throughout the risk-taking task and the software generated a frequency count of coded facial affect, and IBI (inter-beat-intervals) of heart rate per millisecond. In order to reduce the data and assess synchrony between facial affect and heart rate, each participants' data during the task (both alone and in the peer context) was segmented into 10 timepoints and the average frequency of facial affect and heart rate were calculated. While some participants completed the task in the expected time frame of 5 minutes, other participants took longer to complete the task. Segmenting the data did not affect the data analyses, as analysis methods for the current study accommodate varying task lengths across participants.

Data Analysis

First, data were checked for missing data, outliers and normality. These analyses revealed that all emotions were positively skewed. In addition, self-report of risk behaviors was also positively skewed. Variables that were skewed were transformed using guidelines from Tabachnick & Fidell (2001). Specifically, substantially skewed variables (i.e., variables skewed $> \pm 2$) were log-transformed and moderately skewed variables were square root-transformed. Second, descriptive statistics examining emotion expression and emotion regulation in the alone

and peer context were conducted. Multilevel regression analyses were used to address the key study hypotheses using STATA 15 (StataCorp, 2017). A multilevel model approach allows for the assessment of nested structures in which level-1 units of analysis within an individual adolescent (i.e., momentary responses of affect and heart rate) are nested within level-2 units of analysis at the person level (i.e., individual differences in resting HR and self-reports of risk behaviors and social competence). In the current study emotion expression and heart rate during the task served as the level-1 variables and were examined at 10 segmented timepoints during the risk-taking task. This allowed for the amount of time each adolescent took to complete the task to be different, while facilitating an examination of synchrony between emotion expression and physiological arousal at level-1 over time.

Chapter IV: Results

Descriptive Statistics

In order to examine emotion processes within social context, descriptive analyses were conducted in SPSS 24 (IBM, 2016). Comparison analyses were conducted to assess whether emotion processes and risk-taking outcomes were different across context (alone versus with a peer—social), and gender (adolescent girls and boys). In addition, bivariate correlations were conducted for the variables included in the descriptive analyses mentioned above. Correlation coefficients were examined for the study

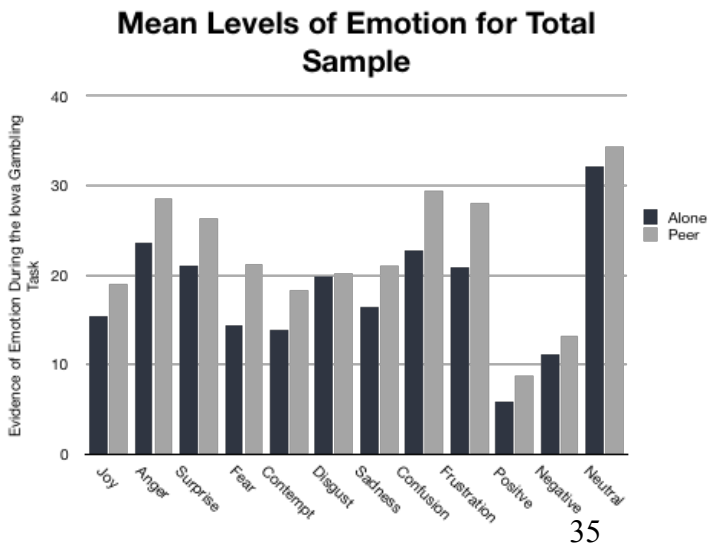

Figure 1. Expression of emotion assessed via facial affect by alone and peer context

population as a whole, as well as separately for boys and girls.

Mean comparisons: examining adolescent social context and gender differences. A series of paired t-test comparisons were conducted to assess mean differences in emotion expression between the alone and peer context as prior work suggests emotion processes are likely impacted by the presence of an adolescent peer. Specific emotions (joy, anger, frustration, disgust, fear, sadness, contempt, confusion, and surprise) as well as sentiments of positive, negative, and neutral emotion, physiological arousal during the task and IGT scores were entered into comparison analyses. Given the use of multiple t-tests, Bonferroni corrections were made in which the hypothesized alpha (.05) was divided by the total number of tests (Shaffer, 1995), setting a new alpha to .00. For the sample as a whole, there was a significant difference in the expression of fear, confusion, and frustration (see Table 1 for t statistics), with higher frequency of expression in the peer context than in the alone context. A descriptive depiction of the comparisons is presented in figure 1.

Analyses comparing the two contexts were also conducted separately for boys and girls again using Bonferroni test correction. For boys, there was a significant difference in the expression of anger, fear, frustration, and confusion in the two contexts, with more frequent expression in the peer context (see Table 1 for t statistic). Although not statistically significant, surprise and joy approached trend levels for boys also similarly indicated more frequent expression in the peer context. No significant context differences emerged for girls (Figure 3 depicts estimated mean comparisons for boys and girls separately). Moreover, no significant context differences were found for boys or girls in either physiological arousal during the task nor IGT scores.

Table 1. Paired Samples t-test Comparing Alone and Peer Contexts

	Total Sample			Boys			Girls		
	Alone Mean (SD)	Peer Mean (SD)	*t*	Alone Mean (SD)	Peer Mean (SD)	*t*	Alone Mean (SD)	Peer Mean (SD)	*t*
Emotions									
Joy	15.31 (13.15)	19.00 (14.48)	-1.99	13.72 (12.93)	20.65 (16.08)	-2.75	17.18 (13.31)	17.07 (12.25)	.04
Anger	23.67 (16.54)	28.46 (16.91)	-2.25	21.25 (15.65)	30.81 (18.43)	-3.28*	26.50 (17.29)	25.72 (14.69)	.27
Surprise	21.04 (15.64)	26.35 (16.37)	-2.47	17.32 (15.08)	24.84 (16.85)	-2.82	25.38 (15.32)	28.12 (15.81)	-.79
Fear	14.34 (11.61)	21.25 (14.87)	-3.72*	12.26 (11.28)	21.32 (15.52)	-3.84*	16.78 (11.65)	21.16 (14.26)	-1.51
Contempt	13.82 (13.71)	18.35 (15.77)	-2.42	13.24 (14.18)	18.98 (17.49)	-2.27*	14.50 (13.27)	17.60 (13.66)	-1.11
Disgust	19.80 (15.36)	20.15 (14.58)	-.16	16.91 (13.51)	20.26 (15.95)	-1.20	23.18 (16.81)	20.00 (12.98)	.96
Sadness	13.36 (15.55)	21.11 (17.20)	-1.98	12.22 (13.38)	17.92 (17.36)	-1.84	21.21 (16.63)	24.85 (16.43)	-.97
Frustration	20.82 (16.55)	27.95 (17.11)	-3.33*	18.07 (15.15)	28.69 (19.27)	-3.53*	24.03 (17.70)	27.10 (14.36)	-1.04
Confusion	22.68 (16.58)	29.47 (17.83)	-2.88*	18.93 (16.23)	29.75 (19.63)	-3.32*	27.08 (16.08)	29.14 (15.69)	-.63
Positive	5.83 (8.57)	8.82 (9.72)	-2.28	4.99 (8.30)	8.37 (10.02)	-1.89	6.82 (8.87)	9.33 (9.47)	-1.33
Negative	11.10 (12.62)	13.10 (14.55)	-1.19	9.68 (13.47)	12.77 (16.07)	-1.34	12.76 (11.49)	13.48 (12.73)	-.29
Neutral	32.13 (16.15)	34.32 (14.91)	-1.17	27.73 (16.33)	32.72 (16.78)	-1.20	37.28 (14.48)	36.19 (12.32)	.39
Heart Rate	2.21 (.10)	2.22 (.11)	-.78	2.21 (.01)	2.22 (.12)	-.36			-.83
IGT Performance									
Reaction Time	1023.23 (621.08)	1212.14 (635.81)	-2.22	932.62 (522.02)	1135.95 (594.59)	-1.76	1140.27 (709.36)	1301.66 (677.67)	-1.35
Accuracy	110.59 (1149.85)	67.65 (975.31)	.32	148.89 (1256.46)	-10.00 (1005.53)	.74	67.50 (1031.03)	155.00 (945.15)	-.56
Efficiency	393.8 (3152.71)	214.30 (1204.15)	.53	532.98 (3424.57)	89.57 (1273.57)	.84	237.39 (2851.25)	354.63 (1120.25)	-.28
Advantageous Trials	50.09 (22.99)	47.91 (18.28)	.83	50.55 (26.04)	46.13 (19.52)	1.04	49.55 (19.12)	50.00 (16.69	-.17

Note: * $p < .00$

In order to examine whether adolescent boys and girls differed on the study variables, a series of multivariate analysis of variance (MANOVA) were conducted to examine potential group differences in overall emotion expression and regulation. The first analysis examined emotion expression measured during the IGT task for the alone context. Disgust, as well as general negative emotion was not included in the models due to non-significance in the previous comparison models. Results of the first MANOVA indicated significant differences in emotion expression during the alone context between adolescent boys and girls F (10,83) = 2.07, p = .04; Wilk's λ = 8.01, partial η^2 = .20. Specifically, examination of univariate tests indicates that in the alone context, girls expressed more joy (M = 19.56), surprise (M = 25.16), fear (M = 17.14), sadness (M = 19.35), and more neutral emotion (M = 36.48) than boys. Secondly, emotion expression measured during the peer context was examined controlling for ratings of peer familiarity. The overall model examining differences in emotion expression

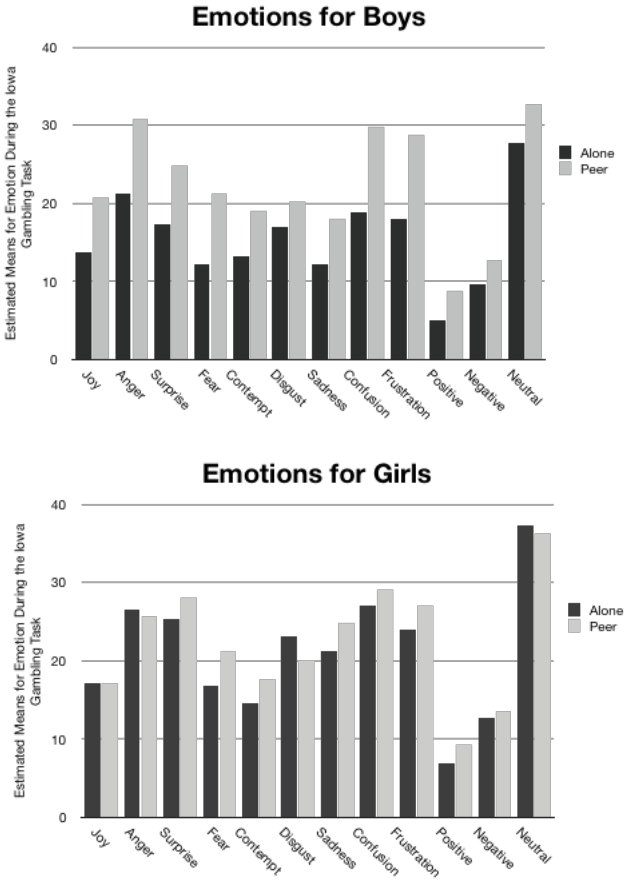

Figure 2. Expression of emotion via facial affect by context and gender.

during the peer context between adolescent boys and girls was significant F (10,79) = 2.53, p = .01; Wilk's λ = .76, partial η^2 = .24 (see figure 5 for a descriptive depiction of mean comparisons). However, when the univariate tests were examined, only the expression of sadness approached significance with girls expressing more sadness than boys in the peer context (M = 25.62, p = .06).

The second set of MANOVAs examined performance on the IGT (efficiency) and heart rate measures (resting heart rate and physiological arousal or change in heart rate during task) as the dependent variables. Both models (alone and peer context) examining differences between boys and girls on IGT performance and physiological arousal during the task indicated no

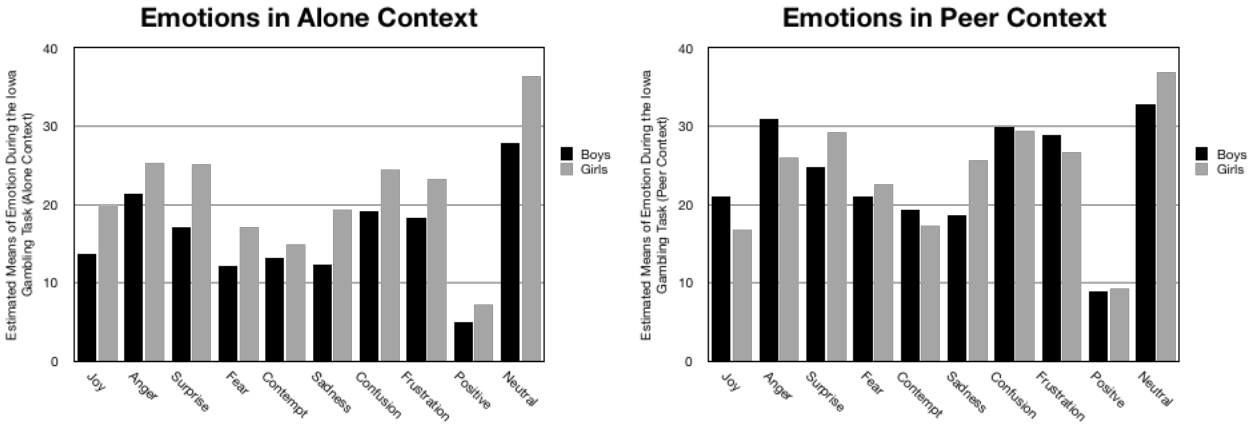

Figure 3. Estimated means of emotion during the Iowa Gambling Task by context and gender

significant gender differences. Lastly, a MANOVA was conducted to assess gender differences in self-reports of risk behaviors (i.e., scores on the adolescent risk-taking questionnaire) and social competence (i.e., scores on the social competence teen survey) as well as measures of emotion expression (BEQ) and emotion regulation (ERQ-CA). The overall model was significant F (6,99) = 3.44, p < .01; Wilk's λ = .83, partial η^2 = .17. Univariate tests indicate that adolescent girls self-reported more positive expression of emotion (M = 15.60) and greater intensity in their experience of emotion than boys (M = 21.85).

Bivariate correlations. Correlation analyses were conducted to examine associations between study variables. Tables 2 and 3 display correlations between grouped emotions (positive, negative and neutral) and study variables. For a comprehensive correlation table that includes all study variables for the total sample see Appendix C. For the total sample, an increase in physiological arousal (HR) during the alone context was associated with greater self-report of social competence (r = .22). While an increase in physiological arousal (HR) in the peer context was associated with less frequent negative emotion expression, as well as less frequent expressions of surprise and anger. In the peer context, slower reaction time was associated with less accuracy (r = -.29) and therefore more risky decision-making, and also with less efficiency (r = -.35). Associations between reaction time and emotion were also present. Specifically, slower reaction time on the IGT in the peer context was associated with more frequent expression of joy. In contrast, slower reaction time during the alone context was associated positively with all the negative emotions including anger, contempt, disgust, sadness, frustration, and confusion. Significant correlations also emerged in the peer context between efficiency and the expression of joy (r = -.28) such that greater expression of joy was associated with less efficiency on the IGT during the peer context. Finally, neutral emotion expression was positively correlated with slower reaction time within both the alone and the peer contexts and was negatively associated with accuracy and efficiency but only during the peer context. Peer familiarity was not associated with any of the dependent variables observed in the peer condition.

Bivariate correlations were also examined among the study variables separately by gender. For boys, slower reaction time during the alone context was positively associated with frustration (r = .31), as well as with sadness (r = .33), and contempt (r = .40). In the alone

context, reaction time was also associated with neutral emotion expression (r =.50 and .48) for both boys and girls such that a slower reaction time was associated with greater neutral expression. For girls, an increase physiological arousal (HR) in the alone context was associated with greater efficiency on the IGT (r = .36).

Additionally, reaction time during the peer context was associated with emotion expression for boys and girls. Specially, for boys a slower reaction time was associated with more frequent expression of anger (r = .35) and frustration (r = .33) during the peer context. For girls, slower reaction time during the peer context correlated positively with expression of joy (r = .50), positive expression (r = .42), as well as neutral expression (r = .41). In addition, expression of negative emotions such as anger (r = -.33) and negative expression (r = -.46) correlated negatively with increased physiological arousal during the peer context for girls. Lastly, during the peer context, for girls more frequent neutral expression was negatively correlated with IGT accuracy (r = -.35), and efficiency (r = -.38).

Table 2. Bivariate Correlations for study variables in the total sample

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Age	_														
2	Peer Familiarity	-.19	_													
3	Risk Behaviors	**.22***	.00	_												
4	Social Competence	**.21***	.09	**-.23***	_											
5	Resting Heart Rate	**-.28****	.03	-.12	-.15	_										
6	Heart Rate (*alone*)	.05	.03	-.05	**.22***	**-.24***	_									
7	Heart Rate (*peer*)	**.26***	.05	.06	.18	**-.58****	**.24***	_								
8	Positive Affect (*alone*)	-.12	**-.22***	-.12	.09	.06	.18	.09	_							
9	Positive Affect (*peer*)	.01	.15	.02	.06	-.04	.15	.07	.09	_						
10	Negative Affect (*alone*)	.00	-.00	-.03	.06	.04	.01	-.00	**.26***	.13	_					
11	Negative Affect (*peer*)	-.18	-.01	.06	**-.25***	.04	-.04	**-.35****	.06	-.03	**.32****	_				
12	Neutral Affect(*alone*)	.01	.13	-.06	.19	-.02	-.03	.07	.14	.16	.12	.04	_			
13	Neutral Affect (*peer*)	-.02	.00	-.10	-.06	-.02	-.02	-.17	.05	**.26***	-.01	**.23***	**.35****	_		
14	IGT Efficiency (*alone*)	-.02	.12	.08	.09	-.05	.09	.08	.08	.16	.01	-.06	.07	.07	_	
15	IGT Efficiency (*peer*)	-.05	.08	-.11	.17	.16	-.14	.00	.13	-.17	.01	-.07	.17	**-.30****	.20	_
	Mean	14.34	69.25	1.66	24.86	157.26	.26	3.58	6.08	9.05	10.61	13.46	32.22	34.69	358.60	184.11
	SD	1.70	34.95	1.24	5.06	34.37	22.21	26.79	8.46	9.88	12.29	14.61	16.27	14.76	3034.97	1204.64

Note:
*$p < .05$
**$p < .01$

Table 3. Bivariate Correlations for study variables by gender

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Age	_	-.20	.21	**.30***	**-.32***	.12	**.38***	-.05	-.17	-.09	-.27	-.03	-.02	.01	-.03
2	Peer Familiarity	-.16	_	-.09	.17	.05	.19	.05	-.28	.19	.03	.01	-.07	.07	.08	.14
3	Risk Behaviors	.26	.07	_	-.18	-.03	-.04	.15	-.10	-.16	-.10	-.14	.14	-.22	**.32**	-.11
4	Social Competence	.10	-.24	-.24	_	**-.30***	.21	.26	.01	-.06	.02	-.21	.01	-.04	.10	.13
5	Resting Heart Rate	-.26	-.17	-.17	-.08	_	**-.50****	**-.57****	-.04	.02	.18	-.08	-.07	-.07	-.11	.08
6	Heart Rate (*alone*)	-.03	-.03	-.03	.19	-.12	_	**.45****	.02	.15	-.04	-.29	-.03	.08	**.36**	-.11
7	Heart Rate (*peer*)	.14	-.01	-.01	.12	**-.61****	.11	_	-.00	-.07	-.20	**-.46****	.11	-.23	.13	-.09
8	Positive Affect (*alone*)	-.21	-.11	-.11	.11	.11	.28	.18	_	.12	.21	-.10	.16	.28	.05	-.11
9	Positive Affect (*peer*)	.17	.18	.18	.15	-.08	.15	.18	.06	_	.16	-.03	.13	.29	.07	-.20
10	Negative Affect (*alone*)	.08	-.05	.05	.06	-.07	.02	.13	.28	.10	__	.14	.07	.08	-.17	-.08
11	Negative Affect (*peer*)	-.13	.22	.22	**-.31***	.08	.07	-.25	.17	-.04	**.43****	_	-.02	**.32***	-.15	-.02
12	Neutral Affect(*alone*)	.03	-.16	-.16	.25	-.04	-.11	.02	.06	.16	.13	-.08	_	.13	.06	.11
13	Neutral Affect (*peer*)	-.03	.02	.02	-.10	.03	-.09	-.15	-.12	.24	-.08	.17	**.45****	_	-.16	**-.38***
14	IGT Efficiency (*alone*)	-.04	-.09	-.09	.10	-.01	-.05	.05	.11	.22	.15	-.00	.10	.19	_	**.39***
15	IGT Efficiency (*peer*)	-.06	-.08	-.08	.18	.13	-.16	.08	**.33***	-.15	.05	-.12	.18	-.28	.08	_
Boys	Mean	14.20	71.09	1.83	24.06	153.21	-2.69	3.55	4.99	9.06	9.67	12.61	27.73	33.23	524.41	93.11
	SD	1.60	34.20	1.25	5.22	37.87	23.44	27.25	8.30	10.39	13.47	15.76	16.33	16.63	3386.31	1259.57
Girls		14.47	67.41	1.49	25.67	161.24	3.41	3.61	7.18	9.04	11.55	14.46	36.70	36.39	192.80	281.47
		1.80	35.90	1.22	4.81	30.40	20.61	26.60	8.57	9.35	11.05	13.27	15.07	15.06	2664.61	1149.74

Note: Correlations for adolescent girls are represented in the upper diagonal and correlations for adolescent boys are represented in the lower diagonal. Significant correlation coefficients are presented in bold text.

*$p < .05$

**$p < .01$

Model Testing of Key Hypotheses Regarding Emotion Processes in Social Context

The descriptive analyses focused on how emotion expression and physiological arousal operate in the alone and peer contexts. Further, gender differences were explored. The following analyses shift to examining the underlying psychophysiological emotion processes that may drive these differences. To address the study hypotheses a series of multilevel models were conducted in four steps, and to simplify the models emotions were collapsed into broader categories reflecting specific emotion sentiments: positive, negative, or neutral.

As is the case with most multilevel modeling, the first step in the series of multilevel regressions was to conduct an unconditional model to assess whether there was variation in the specified dependent variable—emotion expression [positive affect (PA), negative affect (NA), and neutral affect (NU)]—among adolescents in the sample, and whether the data was a good fit for using multilevel modeling data analyses to address the study hypotheses. Three separate unconditional models were conducted for each dependent variable of emotion expression, and the likelihood ratio test and interclass correlation or ICC were examined to assess how much of the variation in emotion expression can be attributed to individual differences (i.e., differences in emotion expression for each adolescent participant). Unconditional models were conducted for emotion expression as the dependent variable in both the alone context and the peer context.

Regarding emotion expression during the alone context, all models of emotion expression indicated evidence of person-level effects (i.e., variance at level-2) with differences in adolescent emotion expression accounting for 61% of the variance in positive expression (χ^2-bar = 639.52, p <.000), 73% of the variance in negative expression (χ^2-bar = 923.65, p <.000), and 73% of the variance in neutral expression (χ^2-bar = 950.88, p <.000). For emotion expression during the peer context, again all models of emotion expression indicated variance at the person level.

Specifically, differences in individual adolescents' emotion expression accounted for 46% of the variance in positive expression (χ^2-bar = 357.08, p <.000), 68% of the variance in negative expression (χ^2-bar = 763.70, p <.000), and 76% of the variance in neutral expression (χ^2-bar = 979.91, p <.000). Model estimates are presented in Table 4. These initial models presented evidence of variance in emotion expression both between- and within- study participants suggesting multilevel model analyses would be appropriate.

Hypothesis 1: Emotion Regulation as the Synchrony Between Facial Affect and Physiological Arousal

The second step included entering physiological arousal or the change from baseline heart rate to heart rate during the IGT task (HR) in a random coefficient model to specify whether there is synchrony between emotion expression and heart rate during tasking. In addition, the covariate variables were entered into the model including: age, gender, pubertal development, and for the models testing the peer context peer familiarity was also entered as a covariate. It was hypothesized that a new measure of emotion regulation would be defined by the synchrony between emotion expression (via facial affect) and physiological arousal (heart rate) over time. In addition, it was hypothesized that this new synchrony-based index of emotion regulation would remain even when accounting for between individual differences in trait autonomic function (resting HR). Overall model fit was assessed by examining the coefficient estimates and conducting a comparison likelihood-ratio test(s) to assess significant improvement in model fit from the previously fitted unconditional model.

At the second step of the model, physiological arousal during the IGT task as a predictor of emotion expression yielded a trend level improvement in the model fit from the unconditional model, likelihood-ratio test (χ^2-bar = 16.26, p < .01), suggesting an increase in heart rate

(*coefficient* = -.01, p = .055) for each decrease in positive affect during the alone context. Table 3 displays these findings for this step. The model examining synchrony between negative affect and physiological arousal was not significant, while the model examining synchrony of neutral affect was significant (likelihood-ratio test = 7.27, p = .03). However, the model for neutral expression was carried by the control variable gender.

Table 4. Model Coefficients for Multilevel Models

Dependent Variable			β	SE	z	Variance Explained
Models predicting emotion expression during the ALONE context						
PA						
	Unconditional Model		1.44	.24	5.93	.61
	Step 2	HR	-.01†	.00	-1.92	.01
NA						
	Unconditional Model		2.80	.38	7.36	.73
	Step 2	HR	.01	.01	1.01	.01
NU						
	Unconditional Model		9.59	.55	17.43	.73
	Step 2	HR	-.01	.01	-1.35	.04
Models predicting emotion expression during the PEER context						
PA						
	Unconditional Model		2.62	.22	11.86	.46
	Step 2	HR	.00	.00	.49	.00
NA						
	Unconditional Model		2.17	.31	7.06	.68
	Step 2	HR	-.00	.03	-.43	.02
NU						
	Unconditional Model		7.73	.53	14.51	.75
	Step 2	HR	-.00	.06	-.18	.01

Note: For the unconditional model, coefficients are representative of the intercept. Covariates for step 2 of the models included, age, gender, and pubertal development. For the models examining peer context, peer familiarity was also entered as a covariate.
† = approached trend significance.

The same models were conducted to assess synchrony between affect and physiological arousal in the peer context. These models yielded no significant improvement in model fit. In sum, non-significant improvement in model fit was the result for all models examining neutral,

positive, and negative affect in the peer context, and for the alone context with the exception of the model predicting positive affect, which approached significance. Thus, hypothesis one was rejected with results indicating that for adolescents in the current study, synchrony between emotion expression and physiological arousal was not present.

The remaining hypotheses were contingent on the level of synchrony between emotion expression and physiological arousal as follows:

Hypothesis 2: At higher levels of risk-taking (assessed by both performance on the IGT and self-reported risk behaviors), there would be lower levels of synchrony between emotion expression and physiological arousal. In the multilevel regression analysis for hypothesis 2, HR (level-1) was entered as predictor of facial affect (i.e., positive, negative and neutral expression). Scores on the Iowa Gambling Task and self-reported risk behaviors outcomes—grand-mean centered— were entered as predictors as well, along with cross-level interaction terms with HR in order to examine at which levels of risk is there less or more synchrony between emotion expression and physiological arousal. Co-variates for the model included; gender, pubertal status, and age.

Hypothesis 3: When a traditional trait-like measure of emotion regulation is controlled for in the model testing synchrony across levels of risk-taking, that lower levels of synchrony would still predict greater levels of risk-taking both on the IGT and as self-reported by adolescents. The multilevel regression analysis for hypothesis 3, included the same steps from the previous model. In addition, trait autonomic functioning (resting heart rate)—grand-mean centered—was entered as a level-2 predictor to account for variance possibly explained by the trait measure. Gender, pubertal status, and age were entered as co-variates of the model.

Hypothesis 4: Within a peer context, adolescents would exhibit less ability to regulate emotions (measured by lower levels of synchrony between facial affect and physiological arousal), and that less synchrony would be associated with greater levels of risk as measured by scores on the IGT and self-reported risk-behaviors. Similar to the model conducted to assess hypothesis 2, HR (level 1 predictor) was entered as predictor of emotion expression/facial affect. Scores on the Iowa Gambling Task and self-reported risk behaviors outcomes—grand-mean centered—were entered as level-2 predictors, along with cross-level interaction terms that include scores on the risk-taking measures and physiological arousal. The final model using measures from the peer context was compared to the same model tested in hypothesis 2 which used measures when the adolescent was alone. Comparison of the model was evaluated using a likelihood ratio difference test, while the statistical significance of each predictor was evaluated using a *t* statistic.

Given the null findings in the synchrony models, hypotheses 2-4 were not examined and instead, exploratory analyses were conducted to further examine the relationship between facial affect and physiological arousal. First, an analysis of concordance was conducted. *Concordance* between heart and emotion expression is different from the previously proposed and examined *synchrony* between heart rate and emotion expression because concordance examines the association between two variables at one particular point while synchrony examines concurrent changes over time. The Lin (1989) concordance correlation coefficient method (i.e., agreement on a continuous measure obtained from two methods) was utilized using STATA 15 concordance coefficient add-on (Steichen & Cox, 2010). The presence of concordance between emotion expression and heart rate was assessed by examining the concordance correlation coefficient (rho_c), the Pearson correlation coefficient (r), and the Bias correction factor (C_B), a measure of how far the line of perfect concordance is from a 45-degree angle through the origin.

Concordance correlation coefficients close to 1 represent greater concordance between the two variables.

Six concordance models were conducted to assess neutral, positive, and negative affect for both the alone and peer context. These data included facial affect and heart rate during the task—not accounting for the changes over time. Results indicate non-concordance between emotion expression and heart rate across adolescents in the sample (see Table 5). However, the concordance analysis for positive affect and heart rate in the alone context indicated a greater chance that concordance is not equal to zero. This may explain the trend level of association found in the aforementioned random coefficient model.

Table 5. Concordance coefficients for models testing affect and heart rate during the Iowa Gambling Task (IGT)

Model		Rho_c	Bias correction factor (C_B)	Pearson *r*	*p*-value
Positive Affect and Heart Rate	Alone	-.015	.338	-.046	.183
	Peer	.006	.324	.017	.630
Negative Affect and Heart Rate	Alone	.011	.461	.025	.473
	Peer	.000	.318	.001	.981
Neutral Affect and Heart Rate	Alone	-.011	.493	-.023	.504
	Peer	.000	.513	.001	.985

Note: p-value is associated with the null hypothesis that concordance is equal to zero.

Social-Emotional Processes in Developmental Context

The second set of exploratory analyses, using simpler non-nested approaches, were conducted to assess associations between emotion expression (i.e., facial affect) and self-reports of social competence and risk behavior, as well as risk-taking measured by the IGT. Heart rate during the IGT task (physiological arousal) was assessed as a potential moderator. Moderation models were conducted in SPSS using a regression method. Predictor variables and moderating variables were standardized or centered, and interaction terms were created between the predictors and moderating variables. Step one of the model included covariates of age, gender,

and pubertal development. For the peer context models, ratings of peer familiarity were also included as a covariate. Models were conducted for the three outcomes of interest: risk-taking assessed via IGT, self-reported risk behaviors, and social competence.

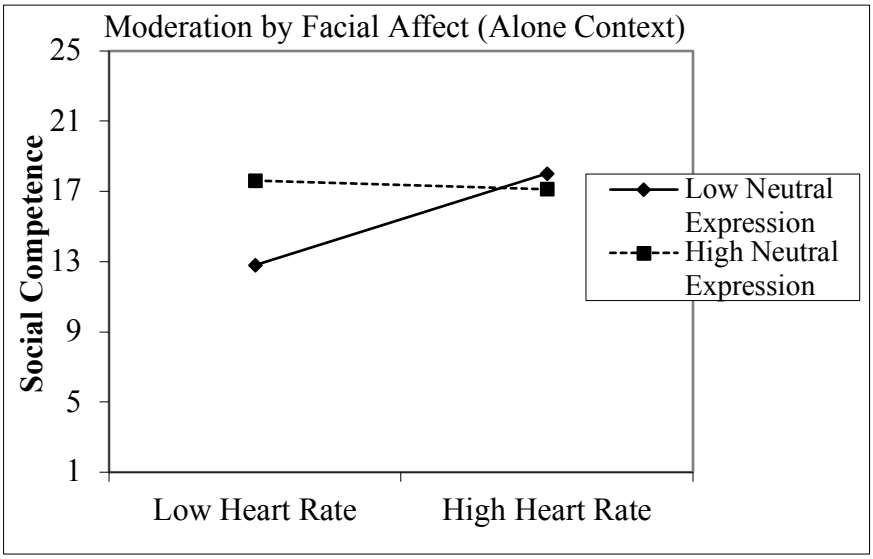

Figure 4. Moderating effect of heart rate on the relationship between neutral affect and social competence

Facial affect, physiological arousal and outcomes on risks and social competence. The first set of models examined facial affect (positive, negative, and neutral) as predictors of outcomes related to risk and social *competence, with physiological* arousal as a moderator. Four models were examined for each dependent variable (IGT efficiency in the alone, IGT efficiency in the peer context, self-reported risk behaviors, and self-reported social competence). For the alone context, the models examining efficiency scores on the Iowa Gambling Task (IGT) were not significant, as was the model examining self-report of risk behaviors. However, for the model examining social competence there was a moderated effect of physiological arousal (HR) for the alone context $\Delta R^2 = .06$, $F (5, 88) = 4.20$, $p < .01$, albeit a small effect. Specifically, greater neutral affect in the alone context was associated with greater social competence at lower levels of heart rate, and positive affect in the alone context was associated with greater social competence at higher levels of heart rate,

(see Figures 5 and 6). The models examining IGT efficiency, and self-reports of risk behaviors and social competence for the peer context were not significant.

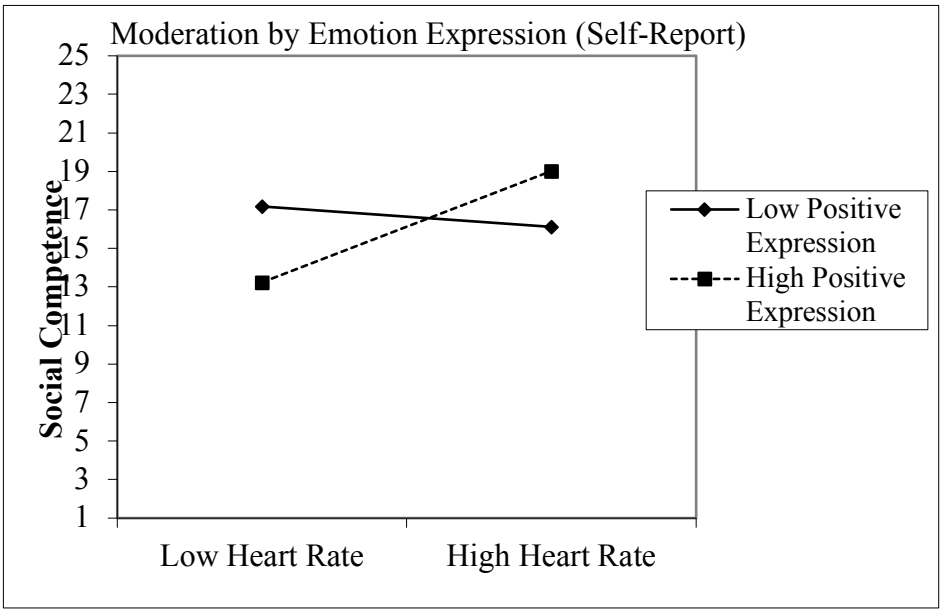

Figure 5. Moderating effect of heart rate on the relationship between positive affect and social competence

Self-Report of Emotion Expression, Emotion Regulation, and Behavioral Outcomes. The second set of exploratory models examined self-report of emotion expression (positive, negative, and intensity of emotion experience) as predictors of risk behaviors and social competence. Self-report of emotion regulation was entered as a

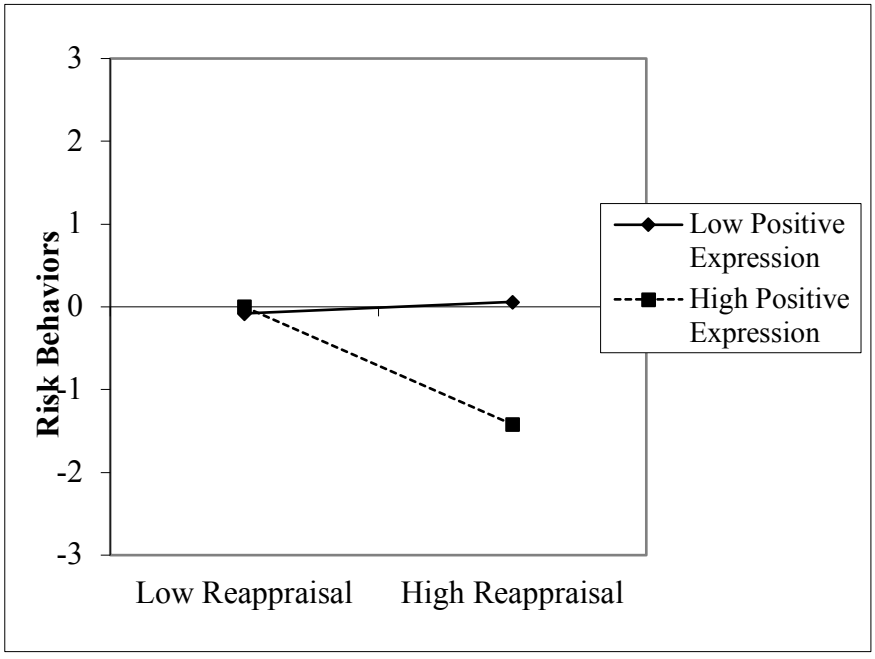

Figure 6. Moderating effect of reappraisal on positive affect and risk behaviors

moderator in these models (i.e., suppression and reappraisal). For the alone context, models examining the three outcomes of interest: IGT efficiency, risk behaviors, and social competence were not significant. However, a significant moderated effect of self-report of emotion regulation emerged for the association between positive emotion expression and self- report of risk behaviors in the peer context ($\Delta R^2 = .03$, $F (5, 101) = 4.18$, $p < .01$, albeit a small effect. Specifically, there was a main effect for reappraisal on risk behaviors ($B = -.32$, $p = .01$), and a significant interaction such that self-report of positive expression and greater reappraisal of emotion was associated with less risk behaviors (see Figure 7). The models examining IGT efficiency and social competence were not significant. In addition, the same models were conducted with suppression of emotion as the moderator but yielded non-significant findings for moderation.

Discussion

The current dissertation study sought to examine emotion processes in adolescent social contexts. Primary hypotheses focused on examining emotion-related processes or what "lies beneath" risk-taking by adolescent boys and girls in social contexts. More specifically, the study examined associations between emotion expression (measured via facial affect) and physiological arousal and whether their synchrony during a risk-taking task functioned as an index of emotion regulation. Models tested whether this relation between emotion expression and physiological arousal remained after controlling for individual differences (risk and social competence) and the degree to which context and gender mattered. Further, the study sought to assess whether the inter-reliance (i.e., synchrony) between emotion expression and physiological response would be associated with risk-taking, engagement in risk behaviors, and social competence.

Adolescence is a unique developmental stage in which previous development of emotional competence and cognitive ability, shift from an acquisition process to an adaptation process contingent on the context. As such, the first set of data analyses examined emotion processes in adolescent social context, with a focus on peer influences and gender differences. Results indicate that girls express more emotion in the alone context than their male counterparts. This suggests that girls are generally more expressive than boys regardless of the context. It is possible that (1) peers do not explicitly influence female adolescents' expression of emotion or (2) because female adolescents construct more intimate friendships (Rose & Rudolph, 2006), they feel more open to express their emotions generally. Comparison tests additionally suggest that girls report themselves as having more social competence than boys. This result is not surprising given the relationship between emotion expression and social competence. In fact, youth that have greater emotional competence (i.e., emotion awareness and emotion expression, in support of emotion regulation) are better able to build lasting peer relationships (Booker & Dunsmore, 2017).

In contrast to girls, adolescent boys are far more expressive in the context of their peers, than when they are alone. Research notes that adolescent boys desire intimate relationships and closeness with friends but have concerns about expressing their emotions only with trusted friends (Way et al., 2014; Way, Gingold, Rotenberg, & Kuriakose, 2005). The early childhood development literature also suggests boys are less likely to be socialized to regulate emotion—negative emotions in particular (Nelson, Leerkes, O'Brien, Calkins, & Marcovitch, 2012) —and this impacts ideas about masculinity and emotion expression and regulation, especially for African American boys (Belgrave & Brevard, 2015). Specifically, boys are socialized by gender standards—both in the family and other social contexts—that the expression of negative

emotions, such sadness, is less masculine than negative emotions such as anger (Root & Denham, 2010). In Way et al.'s (2014) *"It might be nice to be a girl... Then you wouldn't have to be emotionless": Boys' resistance to norms of masculinity during adolescence,* the researchers examine the impact of masculinity on male adolescents' emotion expression with implications for effects on psychosocial adjustment. Results in the current study suggest that the presence of peers influences the expression of both negative and positive emotions for African American adolescent boys, including an increase in expression of fear and sadness. This is inconsistent with the aforementioned research and has implications for how we understand boys' social relationships and in what context emotion expression occurs freely (decision-making) versus those in which emotion expression is suppressed. Further investigation of adolescent male relationships during this heightened period of peer status and perspective is fundamental.

In addition to shaping emotion expression, correlation analyses suggest context also plays a role in emotion regulation, and risk taking on the IGT. More specifically, greater expression of joy in the peer context was associated with quicker responses to trials on the risk-taking task. This association highlights the previous literature on adolescent development—implicating that peers influence reward systems for adolescents. Given these are correlations, these findings should be interpreted with caution as they do not suggest causation, and the associations are not very strong. Nevertheless, these results resonate with the previous research that suggests the presence of peers affects adolescents processing of emotion and reward stimuli (Bjork et al., 2004; Steinberg, 2010).

The primary research question in this study was based on polyvagal theory—which suggests that emotion expression and physiological response and regulation are interrelated in social contexts. The current study tested the possibility that synchrony between emotion

expression and physiological arousal could serve as a new metric for emotion regulation. Results of the current study indicate emotion expression and physiological response of heart rate were neither concordant during the IGT tasks nor synchronized across time. There was no evidence for synchrony between emotion expression and heart rate in this sample of adolescents. which runs counter to recent studies that demonstrate synchrony between emotion expression and physiological response (i.e., heart rate and skin conductance) in adult samples. Concordance of emotion expression and physiological response was also examined to further explore inter-reliance across participants in the study. The analysis for examining concordance also yielded non-significant results. Similar studies also demonstrate inconsistent findings; with earlier studies reporting that emotion expression does not function as a form of emotion regulation (Demaree et al., 2006) and more recent studies indicating that emotion expression and heart rate response are in fact synchronized over time (Moscovitch, Suvak, & Hofmann, 2010).

There are notable differences between the current study and previous studies that examined the synchrony between emotion expression and physiological response. The first is that the aforementioned studies examined emotion expression through self-report measures over time. For example, in both the Demaree et al (2006) and Moscovitch et al. (2010) participants provided responses on self-report measures such as the Positive and Negative Affect Scales (Watson, Clark, & Tellegen, 1988) and the Self-Assessment Manikin (Bradley & Lang, 1994) at particular time points (e.g., before, during, and after an emotion eliciting task). While the use of objective measures of automated emotion expression (facial affect) would appear to be a better measurement of emotion expression, it may be that participants are more accurate in describing their "felt" emotions and self-reports therefore function as a more valid measure than measuring facial affect which could largely be involuntary, and unobserved by the participant. In one of the

few studies to examine synchrony in youth aged 9-13 years old, Marsh et al. (2008) found differences in synchrony between physiological arousal and rater-coded emotion expression among youth with disruptive behavior disorder (DBD) but not their control counterparts. The lack of synchrony in the current study could be explained by a more normative adolescent sample. Future work could also test the possibility that seeing one's own face and having to label observed emotion might be a better index of experienced emotion than emotions labelled by external raters or through automated coding.

In addition, the aforementioned studies included adults in a community sample of outpatient clients or young adults in a university psychology department. In fact, most studies of emotion regulation have adult samples that are admittedly "WEIRD" (Henrich, Heine, & Norenzayan, 2010) and likely unrepresentative of the broader human populations, including African American adolescents. Furthermore, adolescence is a unique period of development in which emotion processes become more complex. Adults are more advanced in how they engage emotion processes in social context, and adolescents appear to be far more inclined to make more risky decisions when with peers. In general, the relation between emotion expression and physiological response may be more complex than previously understood. Emotion researchers have developed several hypotheses for explaining the conflicting findings between emotion expression and autonomic emotion processes. Firstly, some researchers argue that examining synchrony or concordance between the difference emotion processes reinforces the false notion that these processes operate within separate systems (Rachman & Hodgson, 1974). This separation of processes goes against the polyvagal theory; which purports co-existence of structural and functional processes of expression and regulation/response as well as complete inter-reliance.

Additionally, some researchers have suggested that processes of emotion are hierarchical in how they function and operate in context (Gross, 2015a). Similar to cognitive processes such as executive functioning, it is possible that there exist higher order processes of emotion that are responsible for coordination of lower level processes of emotion—therefore impacting emotion behaviors that were not examined in the current study. Either way, instead of thinking about emotion and its arousal/regulation as a causality dilemma (i.e., which comes first) emotion researchers have recently leaned toward trying to understand the complex structure and functionality of processes of emotion. This dissertation study aids in this quest.

In addition to establishing whether synchrony existed, the study also sought to investigate whether synchrony between emotion expression and physiological response was associated with differential patterns of resting heart rate as a proxy for the likelihood of engaging in risk behaviors as a result of poor regulation, as well as self-reported risk and social competence.

Because the synchrony and concordance analyses did not yield the expected results, analyses were focused instead on examining moderated effects of physiological arousal on the relation between emotion expression (both automated and self-reported), and risk and social competence as a means of exploring how emotion processes operate in social context.

First, models were constructed to examine the primary variables of interest; automated coding of emotion expression and physiological response of heart rate. Results indicate that social competence is associated with greater expression of emotion at higher increases in heart rate from resting when adolescents are alone. A decrease in heart rate from resting during tasking is associated with concentrated effort and greater evaluation of error feedback (Crone & Van Der Molen, 2007). However, adolescents may use the context in which they are by themselves to practice emotion expression and regulation—in preparation for engaging in social context.

During the developmental stage of adolescence, the heightened importance of peers aids in the development of a keen awareness of the importance of emotions in social context, and which emotions are appropriate to express when. Open expression of emotion in privacy likely provides a means of coping and selective disclosure. The alone context may provide youth with the opportunity to openly engage in expression of emotion, without the need to reign in physiological arousal in response to concerns about peer perceptions. Open expression in privacy may therefore impact the fine-tuning of processes of emotion that theoretically should lead to greater social competence.

The second set of moderated models included self-reports of emotion expression and emotion regulation. As expected, lower engagement in risk behaviors was associated with greater expression of positive emotion at higher levels of emotion regulation reappraisal. Recent research on regulatory flexibility suggests that use emotion regulation strategies (i.e., reappraisal and suppression) is based on whether the strategy is appropriate for a given context. In particular, reappraisal of emotion is not particularly useful when the emotion or event is of high intensity. The current study leads to further questions of "in which context is use of reappraisal useful?"

Strengths of the Study

There are some notable strengths of the current study. First is the use of automated processing of emotion expression. While the primary study hypotheses did not yield significant findings, the use of more advanced technology to assess emotion expression moves the field forward in assessing processes of emotion that are objective. Previous studies examining similar associations between emotion expression and autonomic processes of emotion and emotion regulation, have done so through a mix of self-report or observer-report of emotion expression. The current study extends this work and adds to our theoretical understanding of emotions as

complex functions. The use of automated coding of emotion revealed some significant associations that acknowledge the role of peers in adolescent decision-making and processing of emotion.

Additionally, the study attempted to understand the association between emotion expression and physiological arousal through advanced multilevel modeling techniques. Multilevel modeling is a great method for examining synchrony in that it allows for the estimation of non-linear relationships across time of nested data (i.e., observations within individuals). Kristjansson, Kircher, & Webb (2007), suggest multilevel modeling to be particularly useful in examining physiological data. Further, the current study also included a peer context to answer questions about the real life social relationships between adolescents. Inclusion of peer context is an attempt to answer questions about the real-time context of friends within an adolescent sample, instead of video or still images which are typically used as social stimuli in the emotion literature.

Lastly, but of great importance, the current study examined the inter-reliance of emotion expression and physiological arousal in a sample of Black/African American adolescents. Most of what we know about emotion and emotion processing comes from research that involves predominately white college samples. Black adolescents are understudied in the affective science literature, and particularly when outcomes are related to positive and prosocial behaviors. The current study expands the field of emotion research to consider how African American adolescents process emotion in their peer context, with an additional focus on examining process of emotion as they relate to social competence and positive development.

Noted Limitations

The current study is not without limitations. While the use of an experimental design and automated coding of emotion expression adds to our ability to examine processes of emotion through an objective lens, data collection and accuracy can be quite messy. In the current study, the experimenter met with adolescents in community centers and local libraries if the adolescent did not have transportation to the lab setting. This may have impacted our ability to control for noise and movement artifacts. The study attempted to address this issue by using a physiological device that is more mobile than the typical use of ECG electrodes. More recent research with adolescents has considered the convenience of mobile data collection through such means, as well as through momentary assessment (watches, diary, cell phone). In addition, some of the technical issues with data collection resulted in not all participants having complete data and a lower *N* than the total sample of adolescent participants enrolled in the study. However, after careful review of the power analysis the portion of the sample with complete facial affect and physiological data was large enough to detect a small effect size. In addition, similar studies among adolescents and adults used a sample of 53 and 78 participants respectively, found small effects in the relationship between facial affect and heart rate.

Similar challenges emerged in reference to of the use of photoplethysmography or PPG in this study to examine baseline trait emotion processing and heart rate during tasking. PPG measures pulsewaveforms through blood pulse detection via LED light, with the electrode being placed on the finger or ear instead of the chest area. While more convenient and less intrusive, PPG is often less able to capture accuracy in heart rate because of the sensitivity to movement. Use of ECG in the current study would have been too invasive of a procedure for the sample of adolescents and in particular those who participated in the study in community settings. In the

current study, the use of PPG may have influenced the findings due to measurement invariance and contextual influences (e.g., noise, movement, and technical issues).

Another measurement-related issue, was the use of a widely known measure of risk-taking: the Iowa Gambling Task. While the IGT is known to elicit physiological arousal, it is not known whether the task elicits arousal of emotion expression evident as facial affect. The current study is one of the first to examine emotion expression related to the IGT in this fashion and so it is not clear if the IGT was able to elicit the level of emotions that arise from exposure to distressing videos or images. Further, in order to understand the implications for risk-taking and the underlying processes of emotion it may be beneficial to examine real life circumstances related to adolescents' decisions to engage in risk (e.g., deciding whether or not to skip school with a peer). It is unclear in the current study if adolescents understood the task and developed a level of performance that accurately assesses risk-taking.

Lastly, in the current study the self-report of engagement in risk behaviors was slightly positively skewed, with adolescents in the sample reporting less engagement in risk (e.g., smoking, alcohol use, school behavior problems). This may be because the current study sample was primarily made up of young adolescents (M_{age} = 14.37). Pubertal development was controlled for in the data analysis models. However, younger adolescents are less likely to report engagement in risk behaviors assessed in the current study (e.g., smoking, drug use, risky gender). Additionally, Crone & Van Der Molen (2007) found age-related differences in a version of the Iowa Gambling Task and heart rate—with older adolescents (age 16-18) making more advantageous trials over time and implicating greater ability in future orientation. The younger sample in the current study may have impacted level of reactivity, and in particular in the peer context.

A final point, is that generalizability to populations outside of Black/African American adolescents is an important caveat although a positive in terms of expanding the emotion literature to non-WEIRD populations. There may be differences in how African American youth express and regulate their emotions based on their racial-ethnic identity, socialization, and friendships with same-race peers (Dunbar, Leerkes, Coard, Supple, & Calkins, 2016; Way et al., 2005). Future research should examine possible cultural influences that may impact emotion expression and arousal for African American youth.

Study Implications and Future Directions

The proposed study sought to understand how emotion expression, measured using facial affect, relates to psychophysiological arousal measured as heart rate over time. The intention of the study was to identify the role of facial affect beyond social communication and reflex. In addition, the study aimed to clarify whether emotion expression and physiological arousal are adaptive—having varied associations with adolescents' level of engagement in risk-taking and risk behaviors, or whether continuing to define emotion and its regulation as trait characteristics is better suited for understanding adolescent outcomes. Findings from the study did not directly address the intended aims but still suggest that processes of emotion are complex and adaptive. Specifically, the results indicate that context impacts how adolescents process both positive and negative emotions in support of the development of positive behaviors (i.e., social competence). Continuing to assess emotion and related processes as trait-like may be problematic because it characterizes adolescents as having a deficit in ability and shifts away from a perspective that affective (emotion) and cognitive skills are present, but can may be influenced by characteristics of the context as well as developmental changes. The notion that emotion really functions as an adaptation to context has important implications for our understanding of adolescents'

relationships and the kinds of interventions that can support positive development and social skill acquisition.

Relationships with Teachers and Other Adults. The study results have implications for adolescents' relationships with adults—including their teachers. In particular, results may shift how adults understand and respond to adolescent behavior in context such as the educational setting. For example, at the core of school suspensions and expulsions is the dynamic social relationship between the student, their teacher, and the perspective of their peers. Thus, a greater understanding of adolescent regulatory processing of behavior may lead to less use of exclusionary discipline practices. This work is particularly important to efforts to understand and promote positive development for African American adolescents. African Adolescents are disproportionality excluded from the school context due to suspensions and expulsions—primarily the result of teachers' and administrators' perceptions of subjective and emotion-laden behavior, such as 'attitude' (Fenning & Rose, 2007; Skiba et al., 2011). Punitive disciplinary actions create a toxic environment characterized by lack of understanding and mistrust between students and teachers. However, intervention development that places value on empathy and understanding of adolescent emotions in context can be beneficial. For example, in a recent study examining the effects of discipline on students' academic success, researchers found that when teachers had greater empathetic understanding of adolescent behavior, they used fewer punitive disciplinary actions (Okonofua, Paunesku, & Walton, 2016). Using skills such as empathy that are inherent in social relationships, provides teachers with an opportunity to value and understand students' experiences as well as their expression of emotions that influence their behavior (Okonofua et al., 2016). Interventions that aim to increase empathetic understanding

help build positive relationships between adolescents and adults—improving behavior in the long-term.

African American Adolescent Peer Relationships. The study results also have implications for examining peer relationships between African American adolescents. Social relationships during adolescence are typically built on the development of identity (Belgrave, 2002; Williams, Tolan, Durkee, Francois, & Anderson, 2012). For African American adolescents, identity development includes their own racial-ethnic identity and understanding of their racial-ethnic identity in context. In addition, African American adolescents deal with racialized context that evoke intense emotions and includes; experiences from multiple perpetrators in their proximal environment (e.g., peers, teachers and administrators in school, adults in the community). Thus, the study results have implications for how African American adolescents navigate these emotion arousing contexts with their same-race peers, and how this may inform decision making. In the current study, adolescent pairs were instructed not to talk during the risk-taking tasks. However, review of the qualitative video data highlight that some adolescents supported each other by providing strategy and feedback during the Iowa Gambling Task. While the extant literature on peers tends to focus on risk and poor outcomes, it may be useful to also examine peer support and positive developmental outcomes, like social competence.

Considering intervention development and applicability. Given the aforementioned implications for relationships between adults and peers, there are additional implications for intervention development and applicability to adolescents 'real-world' problems. Specifically, adolescents' ability to be expressive (both positive and negative) with support of adults and peers in their context may aid in the development of social competence and positive development.

One such way to improve on social competence via emotion processing is through intervention that is focused on peer support. Previous research indicates that collective efficacy among youth in after-school programming (assessed as connectedness and willingness to intervene) is associated with better emotional adjustment outcomes concurrently (Smith, Osgood, Caldwell, Hynes, & Perkins, 2013). Further, co-regulation within group settings is associated with an increase in youth individual self-regulation (DiDonato, 2013). These types of programs have largely focused on middle childhood samples in after-school and academic settings. The extension of such intervention into adolescence has yet to be examined. Moreover, Since the development of racial-ethnic identity becomes more salient during adolescence, interventions grounded in cultural framework may be particularly useful in promoting positive development. We know specifically that the context of youth-serving programming can influence the positive development of adolescent racial-ethnic identity (Brittian Loyd & Williams, 2017). In addition, contexts that are culture-specific promote better adolescent adjustment (Belgrave et al., 2004; Brittian Loyd & Williams, 2017). It is important to consider how Afrocentric influences such as communalism may impact intervention effectiveness for African American youth.

Lastly, we should think about systems of interventions that aim to equip adults with tools to help youth create a positive peer culture. Current intervention development relies heavily on adolescents to change their behaviors—placing the onerous on them to improve behaviors that are developmentally appropriate. The current study has implications for how youth leverage their context of peers to address their social competence goals, and so addressing promotion of social behaviors at a system level is necessary. Specifically, a tripartite model of intervention development that includes adolescents, their peer relationships, and large systems (i.e., schooling) may improve on adolescent outcomes of risk and social competence. As mentioned

previously, training teachers to use empathy related to adolescent behaviors has shown significant influences on teacher-adolescent relationships and discipline outcomes (Okonofua et al., 2016). However, this intervention focuses on the teachers' perspective. It may be of value to assess adolescents' perspective of systemic influence on their behaviors.

Additionally, co-regulation of emotion between peers may promote positive development and social competence as well. Co-regulation is the process that occurs between two or more peers that supports or scaffolds individual participation toward common goals (DiDonato, 2013). Co-regulation is often examined in collaborative learning settings, and supports not only individual regulation during task, but also supports changes in developmental outcomes of regulation over time (DiDonato, 2013; Volet, Summers, & Thurman, 2009). When co-regulation occurs in supportive and collaborative environments, the processes involved help maintain group goals through other (i.e., interpersonal) and shared regulation (DiDonato, 2013)—that is, how do adolescents support the regulation of their peers and is there shared interested in regulation. While co-regulation has shown to be effective within academic settings, we know less about co-regulation processes that occur within peer relationships in behavioral and social settings.

In conclusion, this dissertation study expands the emotion literature by examining processes of emotion expression and emotion arousal in social context. The study highlights the need to encourage a supportive environment, in which we acknowledge the importance of emotion expression—both positive and negative in social and academic outcomes. Our understanding of how adolescents process information and regulate emotions can help guide intervention and policy practices that support developmental growth for African American adolescents.

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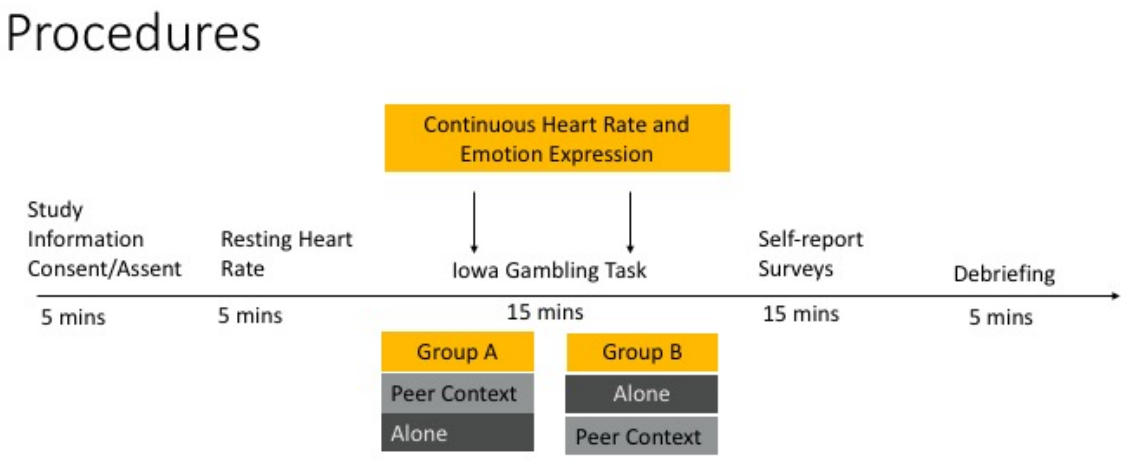
Appendix A: Research Design



Appendix B: Research Measures

Figure 1. Software Analysis of Affective Facial Expression

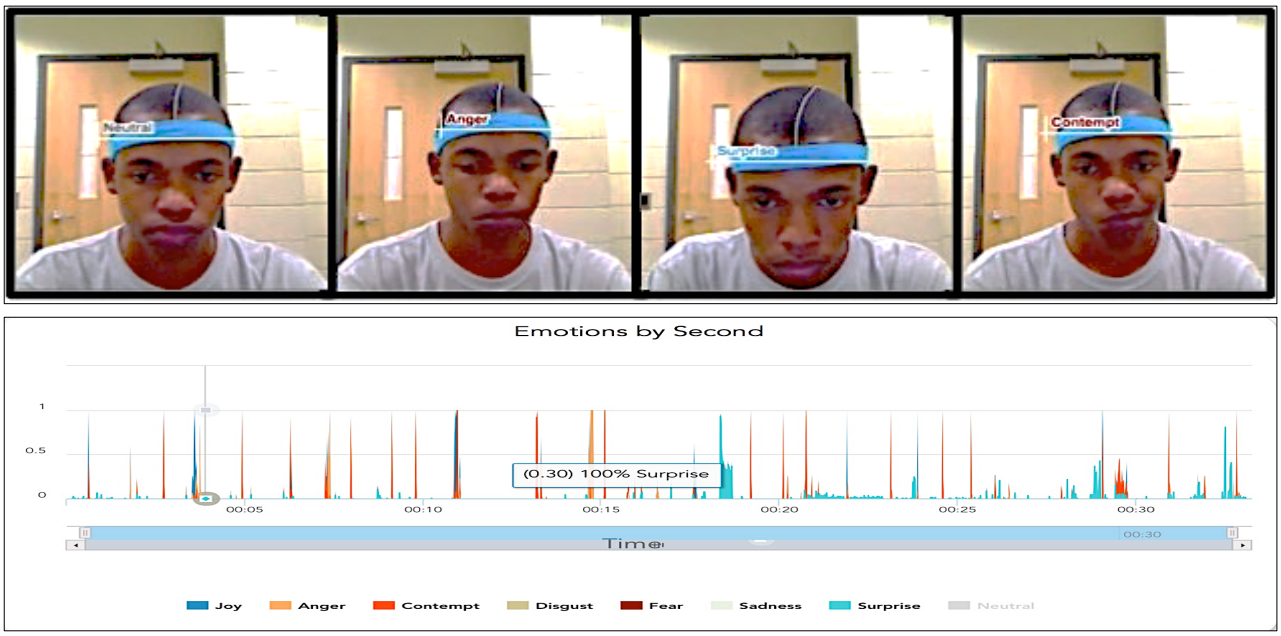
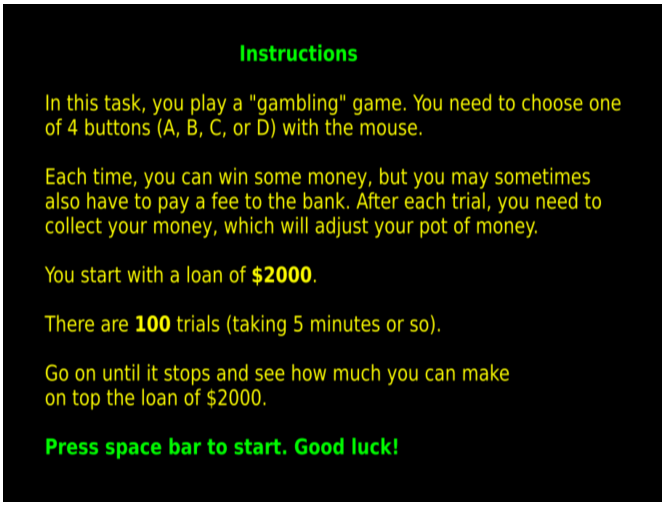
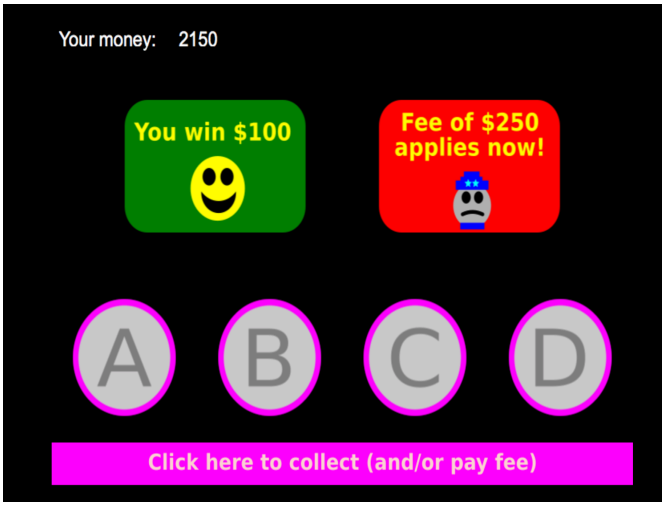


Figure 2. Example of Iowa Gambling Task Presentation





Instructions for the IOWA Gambling Task

Procedure instructions

"You're going to play a game with money. The money is not real, but we want to see how much money you can gather for your bank. You will start will a loan of $2000. The way to gather more money is to choose one of the buttons you will see on the screen. There are four of them; labeled with the letter A, B, C, D. Each time you select a button you will receive some money, but there may be a chance that you will also have to pay a fee. You can choose any button you would like, however there is a strategy to getting as much money in your bank as possible. You will get 100 times to try and it should take about 5 mins."

Adolescent Risk-Taking Questionnaire

Below is written a list of behaviors, which some people engage in. Read each one carefully and circle the answer that best describes your behavior.

There are no right or wrong answers.

Remember to circle the response that best describes your behavior about each question in the list.

Response Items:
Never Done Hardly Ever Done Done Sometimes Done Often Done Very Often

1. Smoking
2. Drinking and Driving
3. Speeding
4. Stealing cars and going to joy rides
5. Underage drinking
6. Staying out late
7. Driving without a license
8. Talking to strangers
9. Cheating
10. Getting drunk
11. Sniffing gas or glue
12. Having unprotected gender
13. Leaving school
14. Teasing and picking on people
15. Taking drugs
16. Overeating
17. Entering a competition

Social Competence – Teen Survey

Please indicate how much these statements describe you.

1. I avoid making other kids look bad.
    - Not at all like me
    - A little like me
    - Somewhat like me
    - A lot like me
    - Exactly like me
2. If two of my friends are fighting, I find a way to work things out.
    - Not at all like me
    - A little like me
    - Somewhat like me
    - A lot like me
    - Exactly like me
3. When I work in school groups, I do my fair share.
    - Not at all like me
    - A little like me
    - Somewhat like me
    - A lot like me
    - Exactly like me

Please indicate how often this happens. How often...

4. Do you get along well with people of different races, cultures, and religions?
    - None of the time
    - A little of the time
    - Some of the time
    - Most of the time
    - All of the time
5. Do you listen to other students' ideas?
    - None of the time
    - A little of the time
    - Some of the time
    - Most of the time
    - All of the time
6. Do you control your anger when you have a disagreement with a friend?
    - None of the time
    - A little of the time

- Some of the time
- Most of the time
- All of the time

7. Can you discuss a problem with a friend without making things worse?
   - None of the time
   - A little of the time
   - Some of the time
   - Most of the time
   - All of the time
8. Do you follow the rules at a park, theater, or sports event?
   - None of the time
   - A little of the time
   - Some of the time
   - Most of the time
   - All of the time
9. Do you respect other points of view, even if you disagree?
   - None of the time
   - A little of the time
   - Some of the time
   - Most of the time
   - All of the time

http://www.performwell.org/index.php/find-surveyassessments/outcomes/social-development/social-competencesocial-skills/social-competence-scale-for-teenagers

Pubertal Development Scale

Boys:

1. Have you developed body hair under your arms or down below?

2. Has your voice started to deepen?

3. Has your skin become oily, greasy, pimply, etc.?

4. Have you grown much taller very fast?

5. Have you started to grow hair on your face?

Girls:

6. Have you developed body hair under your arms or down below?

7. Have your breasts started to develop?

8. Has your skin become oily, greasy, pimply, etc.?

9. Have you grown much taller very fast?

10. Have you started to menstruate (started your period)? Yes / No [circle one]

10a. IF YES, have you had at least 3 periods in a row? Yes / No [circle one]

10b. IF you have regular monthly cycles, where are you currently on your monthly cycle?

1. I'm on my period now
2. I'm in the week after my period
3. I am mid-way through my cycle
4. I am in the week before my period

Petersen, A.C., Crockett, L., Richards, M., & Boxer, A. (1988). A self-report measure of pubertal status: Reliability, validity, and initial norms. *Journal of Youth and Adolescence, 17,* 117-133.

Berkeley Expressivity Questionnaire
(Adjusted for Adolescent Sample)

For each statement below, please indicate your agreement or disagreement.

Response Items: **strongly disagree disagree half and half agree strongly agree**

1. Whenever I feel positive emotions, people can easily see exactly what I am feeling.
2. I sometimes cry during sad movies.
3. People often do not know what I am feeling.
4. I laugh out loud when someone tells me a joke that I think is funny.
5. It is difficult for me to hide my fear
6. When I'm happy, my feelings show.
7. I can feel emotions in my body.
8. I've learned it is better to hold in my anger than to show it.
9. No matter how nervous or upset I am, I tend to keep a calm on the outside.
10. I am a person that shows my emotions.
11. I have strong emotions.
12. I am sometimes unable to hide my feelings, even though I would like to.
13. Whenever I feel negative emotions, people can easily see exactly what I am feeling.
14. There have been times when I have not been able to stop crying even though I tried to stop.
15. I experience my emotions very strongly.
16. What I'm feeling other people can see on my face.

Gross, J.J., & John, O.P. (1997). Revealing feelings: Facets of emotional expressivity in self-reports, peer ratings, and behavior. *Journal of Personality and Social Psychology, 72*, 435-448.

Emotion Regulation Questionnaire for Children and Adolescents

For each statement below, please indicate your agreement or disagreement.

Response Items: **strongly disagree disagree half and half agree strongly agree**

1. When I want to feel happier, I think of something different.
2. I keep my feelings to myself.
3. When I want to feel less bad (sad, angry, or worried), I think of something different.
4. When I am happy, I am careful not to show it.
5. When I am worried about something, I make myself think about in a way that helps me better.
6. I control my feelings by not showing them
7. When I want to feel happier about something, I change the way I am thinking about it.
8. I control my feelings about things by changing the way I think about them.
9. When I'm feeling bad (sad, angry, or worried), I'm careful not to show it.
10. When I want to feel less bad (sad, angry, or worried) about something, I change the way I'm thinking about it.

Gullone, E., & Taffe, J. (2011). The emotion regulation questionnaire for children and adolescents (ERQ–CA): A psychometric evaluation. *Psychological Assessment*, *24*(2), 409–417. http://doi.org/10.1037/a0025777

Appendix C: Extended Correlation Table

Table 1. Extended Correlations for Study Variables in the Total Sample												
		1	2	3	4	5	6	7	8	9	10	11
1	Age	_										
2	Peer Closeness	-.19	_									
3	Risk Behaviors	**.22***	.00	_								
4	Social Competence	.10	.09	**-.23***	_							
5	Self-report (positive)	-.18	.02	-.17	**.42****	_						
6	Self-report (negative)	-.20	-.01	.05	-.19	**.31****	_					
7	Self-report (experience)	-.01	-.04	.00	**.28****	**.45****	**.31****	_				
8	Reappraisal	.01	-.04	**-.20***	**.35****	.02	**-.23***	.05	_			
9	Suppression	.07	-.13	-.10	.12	**-.29****	**-.32****	-.06	**.46****	_		
10	Baseline Heart Rate	-.26	.03	-.12	-.15	_.04	.05	-.11	-.04	.05	_	
11	Heart Rate (*alone*)	-.03	.03	-.05	**.22***	.18	.00	.10	-.08	-.00	**-.24***	_
12	Heart Rate (*peer*)	.14	.05	.06	.18	-.12	.05	-.03	.04	.05	**-.58****	**.24***
13	Joy (*alone*)	-.07	**-.28****	.03	.05	.19	.10	.04	.09	.02	.07	.12
14	Joy (*peer*)	**.31***	-.02	.07	.03	-.01	.02	-.11	.06	-.00	.02	.09
15	Anger (*alone*)	-.04	-.04	.01	.18	**.25***	.07	.18	.05	-.04	-.12	.04
16	Anger (*peer*)	.17	-.14	.03	-.14	.09	.08	.02	-.13	-.10	-.16	-.10
17	Surprise (*alone*)	-.23	.04	.05	.10	.11	-.07	.02	.11	-.09	-.01	.02
18	Surprise (*peer*)	-.08	.08	.05	-.15	**.23***	.18	.01	-.20	**-.28****	-.04	-.06
19	Fear (*alone*)	-.12	.04	-.10	.18	.12	.02	.03	.03	-.04	-.07	.16
20	Fear (*peer*)	.15	.01	.00	-.11	.12	.05	-.10	.09	-.10	-.05	-.14
21	Contempt (*alone*)	-.15	-.18	-.07	-.01	.13	.09	-.09	.02	.04	.04	05
22	Contempt (*peer*)	-.17	-.03	.10	-.11	.17	**.22***	-.02	**-.23***	**-.21***	-.01	.01
23	Disgust (*alone*)	.09	-.18	.05	.11	.19	.00	.09	.03	-.03	-.11	.01
24	Disgust (*peer*)	-.03	-.05	.10	-.01	.12	.05	-.01	.00	-.06	.13	.20
25	Sadness (*alone*)	.02	.06	-.13	.13	-.02	.04	.05	.17	-.05	.11	.19
26	Sadness (*peer*)	-.16	.05	-.06	.03	.16	.11	.08	-.04	-.11	.02	.01
27	Confusion (*alone*)	.19	.02	-.01	**.20***	**.23***	.02	**.21***	.16	.12	-.13	.01
28	Confusion (*peer*)	.01	-.05	.01	-.06	.07	.14	.07	-.17	-.11	-.12	-.03
29	Frustration (*alone*)	.11	-.07	-.06	.18	**.22***	-.05	.15	.11	.06	-.07	.03
30	Frustration (*peer*)	.09	-.14	-.02	-.06	.16	**.21***	.11	-.14	-.10	-.10	-.08
31	Positive Affect (*alone*)	-.21	**-.22***	-.12	.09	.14	.13	-.09	.00_	-.02	.06	.18
32	Positive Affect (*peer*)	.17	.15	.02	.06	.07	-.05	-.03	-.03	-.12	-.04	.15
33	Negative Affect (*alone*)	.08	-.00	-.03	.06	.12	.08	.07	-.06	-.03	.04	.01
34	Negative Affect (*peer*)	-.13	-.01	.06	**-.25***	.15	**.24***	.10	-.15	-.18	.04	-.04
35	Neutral Affect(*alone*)	.03	.13	-.06	.19	.19	-.13	.04	.17	.07	-.02	-.03
36	Neutral Affect (*peer*)	-.03	.00	-.10	-.06	**.21***	.15	.07	.08	-.06	-.02	-.02
37	Reaction Time (*alone*)	.06	.07	-.07	.18	.10	-.07	.11	.13	.11	-.10	-.03
38	Reaction Time (*peer*)	.27	.04	**-.24***	-.10	-.13	.09	-.02	-.05	-.14	-.17	-.05
39	IGT Accuracy (*alone*)	.08	.08	.06	.07	-.08	.12	-.01	-.04	-.12	-.05	.05
40	IGT Accuracy (*peer*)	-.02	.08	-.08	.16	.01	-.07	-.05	.08	.06	.21	-.07
41	IGT Efficiency (*alone*)	-.04	.12	.08	.09	-.12	.04	-.06	-.10	-.08	-.05	.09
42	IGT Efficiency (*peer*)	-.06	.08	-.11	.17	-.04	-.00	-.02	.07	.12	.16	-.14

		12	13	14	15	16	17	18	19	20	21	22
12	Heart Rate (*peer*)	_										
13	Joy (*alone*)	-.00	_									
14	Joy (*peer*)	.01	.20	_								
15	Anger (*alone*)	-.07	**.28****	-.01	_							
16	Anger (*peer*)	**-.23***	-.04	-.01	**.28****	_						
17	Surprise (*alone*)	.08	.19	-.07	**.31****	-.06	_					
18	Surprise (*peer*)	**-.22***	-.02	.01	.14	**.50****	.19	_				
19	Fear (*alone*)	.11	**.54****	.20	**.29****	-.06	**.49****	.11	_			
20	Fear (*peer*)	-.18	.02	**.36****	.11	**.34****	.11	**.62****	.14	_		
21	Contempt (*alone*)	.10	**.58****	.13	**.40****	.09	**.25***	.01	**.42****	.05	_	
22	Contempt (*peer*)	-.12	.18	**.24***	**.23***	**.44****	.09	**.35****	.09	**.35****	**.29****	_
23	Disgust (*alone*)	.07	**.52****	.05	**.49****	**.26***	**.38****	.17	**.32****	.08	**.42****	**.27***
24	Disgust (*peer*)	-.09	.12	**.31****	.11	**.33****	-.03	.16	-.03	.11	.07	**.35****
25	Sadness (*alone*)	.19	.04	.13	**.27****	-.10	**.40****	.03	**.25***	.15	**.45****	.01
26	Sadness (*peer*)	-.20	-.03	-.13	.21	**.43****	.12	**.47****	.10	**.47****	.11	**.58****
27	Confusion (*alone*)	.11	.04	.10	**.69****	.21	**.24***	.05	.12	.13	**.31****	.13
28	Confusion (*peer*)	-.13	-.08	-.10	**.27***	**.81****	-.06	**.47****	-.09	**.24***	.02	**.51****
29	Frustration (*alone*)	-.06	**.27****	.08	**.87****	.19	.12	-.03	**.21***	.07	**.49****	.15
30	Frustration (*peer*)	-.18	.02	-.01	**.35****	**.85****	-.05	**.38****	-.03	**.28****	.12	**.60****
31	Positive Affect (*alone*)	.09	**.72****	.14	**.24***	-.05	.03	-.06	**.43****	-.08	**.61****	.16
32	Positive Affect (*peer*)	.07	.12	**.78****	-.01	-.18	.07	-.04	**.26***	**.21***	.04	.15
33	Negative Affect (*alone*)	-.00	.15	**.27****	**.52****	**.22***	**.26***	**.21***	**.21***	**.29****	**.46****	**.32****
34	Negative Affect (*peer*)	**-.35****	.14	.05	**.30***	**.63****	.09	**.53****	.09	**.41****	**.22***	**.61****
35	Neutral Affect(*alone*)	.07	**.23***	.09	**.30****	-.11	**.40****	-.04	**.25***	.14	**.29****	.05
36	Neutral Affect (*peer*)	-.18	.12	**.27****	.13	.18	-.03	**.23***	.13	**.26***	.09	**.20***
37	Reaction Time (*alone*)	.11	.13	.01	**.22***	-.18	.13	**-.22***	.19	-.17	**.28****	.11
38	Reaction Time (*peer*)	.01	-.05	**.27****	-.06	.12	-.16	.01	.06	.04	-.03	.12
39	IGT Accuracy (*alone*)	.10	.03	.16	.04	.02	.14	.09	.14	.06	.06	.17
40	IGT Accuracy (*peer*)	-.02	-.05	**-.24***	-.01	**-.23***	.11	-.19	-.00	-.13	.09	-.02
41	IGT Efficiency (*alone*)	.08	.04	.12	.01	-.02	.11	.14	.13	.03	.07	.17
42	IGT Efficiency (*peer*)	.00	-.03	**-.28****	-.04	-.21	.05	-.19	-.00	-.17	.09	-.05

		23	24	25	26	27	28	29	30	31	32	33
23	Disgust (*alone*)	_										
24	Disgust (*peer*)	.08	_									
25	Sadness (*alone*)	**.30****	-.14	_								
26	Sadness (*peer*)	.18	.14	.05	_							
27	Confusion (*alone*)	**.44****	.09	**.54****	.15	_						
28	Confusion (*peer*)	.20	**.25***	-.13	**.64****	.17	_					
29	Frustration (*alone*)	**.35****	.11	**.36****	.14	**.75****	.16	_				
30	Frustration (*peer*)	**.29****	**.22***	-.06	**.56****	**.27***	**.89****	**.28****	_			
31	Positive Affect (*alone*)	**.35****	.08	.14	-.01	.03	-.00	**.30****	.05	_		
32	Positive Affect (*peer*)	-.03	**.25***	.18	-.17	.05	**-.25***	.05	-.18	.09	_	
33	Negative Affect (*alone*)	**.45****	.13	**.52****	**.28****	**.56****	**.25***	**.53****	**.29****	**.26***	.13	_
34	Negative Affect (*peer*)	**.22****	**.43****	-.11	**.48****	.14	**.53****	.20	**.56****	.06	-.03	**.32****
35	Neutral Affect(*alone*)	**.36****	.04	**.38****	.01	**.35****	**-.24***	**.29****	-.12	.14	.16	-.01
36	Neutral Affect (*peer*)	.05	**.28****	.09	**.21***	.15	.09	.19	.15	.05	**.26***	.12
37	Reaction Time (*alone*)	**.23***	-11	**.28****	-.14	**.33****	**-.22***	**.26***	-.15	.15	-.04	.08
38	Reaction Time (*peer*)	.04	.14	-.02	.05	.06	.05	-.03	.11	.05	.19	-.05
39	IGT Accuracy (*alone*)	.05	-.08	.04	-.03	.02	.11	.02	.13	.01	.18	.06
40	IGT Accuracy (*peer*)	-.08	-.13	.14	-.02	.00	-.14	.06	-.14	.09	-.11	.03
41	IGT Efficiency (*alone*)	.08	-.08	.00	.02	-.06	.07	-.02	.06	.08	.16	.01
42	IGT Efficiency (*peer*)	-.07	-.13	.14	-.03	-.01	-.10	.03	-.12	.13	-.17	.01

		34	35	36	37	38	39	40	41	42
34	Negative Affect (*peer*)	_								
35	Neutral Affect(*alone*)	-.04	_							
36	Neutral Affect (*peer*)	**.23***	**.35****	_						
37	Reaction Time (*alone*)	-.15	**.50****	-.10	_					
38	Reaction Time (*peer*)	.04	-.03	**.33****	.20	_				
39	IGT Accuracy (*alone*)	-.03	.06	.03	-.17	-.10	_			
40	IGT Accuracy (*peer*)	-.08	.18	**-.30****	.14	**-.29****	**.32****	_		
41	IGT Efficiency (*alone*)	-.06	.07	.07	-.15	.06	**.88****	.21	_	
42	IGT Efficiency (*peer*)	-.07	.17	**-.30****	.18	**-.31****	**.25***	**.92****	.20	_

Curriculum Vita

Tennisha Natasha Riley was born on March 8, 1985, in Columbia, South Carolina and is an American citizen. She graduated from Lovejoy High School, Hampton, Georgia in 2003. She received her Bachelor of Science in Psychology with a minor in Child Development from Florida State University, Tallahassee, Florida in 2006. She received a Master of Arts in Marriage and Family Therapy from LaSalle University, Philadelphia, Pennsylvania in 2009 and subsequently worked as a multisystemic family therapist for four years. She received a Master of Science from Virginia Commonwealth University in 2015.