

Emotion Dysregulation

L M Hilt, J L Hanson, and S D Pollak, University of Wisconsin at Madison, Madison, WI, USA

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Glossary

Amygdala: An almond-shaped brain structure located in the temporal lobe, which is important in emotional responding.

Dopamine: An important neurotransmitter (chemical messenger) in the brain, which has been implicated in motivation and reward, mood, attention, and learning.

Emotion dysregulation: A maladaptive pattern of regulating emotions that may involve a failure of regulation or interference in adaptive functioning.

Emotion regulation: A set of attentional, cognitive, behavioral, social, and biological processes

that act to modulate, manage, or organize emotions.

Hippocampus: Horseshoe-shaped structure adjacent to the amygdala, implicated in memory functioning and contextual processing.

Nucleus accumbens: The reward and positive-affect center of the brain, involved with approach-related behavior.

Prefrontal cortex: The anterior section of the brain, which is central to the top-down control of attention, inhibition, emotion regulation, complex learning, and theory-of-mind processing, the prefrontal cortex.

Introduction

Adolescence is a fascinating developmental period because of the remarkable changes that occur. The social, biological, and psychological worlds of children develop dramatically during adolescence, evoking a variety of emotions. For example, adolescents may experience joy with their newfound autonomy and frustration with the added stress this brings. As with any time in development, emotions must be regulated in order to achieve one's goals. The hormonal and brain changes that occur during adolescence make such regulation challenging. Emotion dysregulation may occur if emotions are experienced as intense and overwhelming. Additionally, if emotion-regulation strategies are not learned, well practiced, are overly rigid, or fail, adolescents may exhibit behaviors associated with emotion dysregulation, including prolonged depressed mood, chronic anxiety, and risky behaviors.

In order to define emotion dysregulation, it is first helpful to define emotion regulation. Although researchers do not agree upon a single definition of this construct, two common points are worth noting. One key element is that emotion regulation is not one function, but more likely involves a set of processes or systems (e.g., attentional, cognitive, behavioral, social, biological). Second, these processes act to modulate, manage, or organize emotions to help individuals meet the demands of their environment. Emotions may be positive (e.g., happy, proud) or negative (e.g., sad, anxious) in valence. Emotions also vary in intensity, with the same stimulus evoking different responses in individuals. For example, a picture of a dog might evoke joy for a dog-lover and fear for someone afraid of dogs. Even the same person may experience different emotions depending on the context. If someone's dog has just died, seeing a picture of a dog could evoke sadness and longing, for example.

Emotion regulation refers to any process that acts upon the emotion. For example, imagine that an adolescent girl sees two of her peers whispering and snickering during lunch. This event may trigger multiple emotional reactions, including the experience of anxiety and sadness. Consider the variety of

processes this girl could engage in and how they might affect her emotions; she could dwell on and brood about the experience, prolonging her sadness; she could think about the situation differently (e.g., as having nothing to do with her), diminishing her sadness; she could do something to distract herself from her emotions (e.g., eat lunch), temporarily alleviating her anxiety; and/or she could worry about what the girls are saying, maintaining her anxiety. There are many more possibilities and each one may lead to a cascade of interactions within the adolescent and her interaction with the environment, contributing to further regulation.

Ideally, individuals have a variety of emotion-regulation strategies and are able to flexibly apply them to different situations in order to adapt to the demands of the environment and achieve their goals. However, when individuals have not learned how or when to apply effective strategies, when strategies are not applied flexibly, when the strategies fail, or when strategies are overused, emotion regulation patterns may interfere with adolescents being able to achieve their goals (e.g., get along with others, feel satisfied, etc.). This is referred to as emotion dysregulation. Emotion dysregulation still involves attempts at regulation, but the process leads to maladjustment rather than adjustment. For example, emotion dysregulation may result in poor interpersonal relationships, difficulty concentrating, feeling overwhelmed by emotions, or inability to inhibit destructive behaviors. Emotion dysregulation is often associated with unhappiness, poor interpersonal relationships, and in severe cases, the development of psychopathology (e.g., depression, anxiety, substance abuse).

Processes of Emotion Regulation and Dysregulation

With much still to learn regarding the developmental antecedents of emotion dysregulation, it is important to realize that emotion regulation is not one single process but rather composed of numerous component processes. At the most basic level, these processes include (1) reading or understanding emotional signals, (2) sorting or categorizing the emotion

signals as positive or negative to generate a response, and (3) enacting a behavior response.

The first component involved in the emotion regulatory cascade is the adolescent's perception of some change in the environment. Sensory stimuli from the external environment are perceived, processed, categorized through the visual system, and relayed to the central perceptual circuitry in the brain, including the occipital cortex, the superior temporal gyrus, and the fusiform gyrus. Early perceptual evaluation aids in assessing whether the stimulus is positive or negative and what kind of environmental change the adolescent desires. Emotion dysregulation may occur during this first step if adolescents are somehow biased in processing information. For example, some adolescents easily notice negative stimuli but have a harder time noticing positive stimuli. This, in turn, can affect categorization and behavioral responses (e.g., an adolescent may decide to avoid a situation because he or she perceives it as negative rather than approach it or vice versa, depending on the bias in information-processing style).

Once a stimulus has been processed, the individual generates an emotional response, attaching valence to stimuli (i.e., deciding if it is positive or negative). This complex step involves aspects of emotional categorization, associative learning, memory, and reward processing. After a stimulus is perceived it must be categorized, with the recognition and categorization of others' emotional states being central to functioning in the social world. Perceptual evaluations across development create an accumulation of stored associations and memories that impart meaning and motivate behavior. This associative learning may be comprised of simple stimulus-response relationships, wherein the individual associates specific emotion-related cues with certain outcomes. Such associations may also be more elaborate where an adolescent learns relationships between emotional signals and general rules or categories that guide his or her behavior in novel situations (e.g., noticing a facial feature, such as a grimace, and immediately concluding that it is an indication of physical threat, without taking into account other contextual cues). Importantly, these associations become the background knowledge and beliefs that the adolescent holds about his or her emotional world, aiding in the ability to predict others' emotions in certain contexts. Associative learning may be particularly important during development for the regulation of emotion, as adolescents must learn to change their behavior in response to other people's negative emotional states such as anger or disapproval. In addition, these associations may be important for adolescents as they moderate their behavior and desire independence in response to feedback from a parent, teacher, or peer. With pleasurable and positively valenced stimuli, reward processing, in brain regions like the nucleus accumbens, elicits an appetitive (i.e., urge toward a stimulus) and emotional response. Aberrant reward processing is of particular importance to those interested in emotional dysregulation, as psychopathology such as pediatric bipolar disorder may involve excessive pleasure seeking during mania or anhedonia (the inability to experience pleasure) during depression.

The third step of emotion regulation involves generation of a behavioral response. This requires mainly executive functions such as inhibitory control. During adolescence, an individual's behavioral responses are changing, becoming

increasingly flexible at both adapting and inhibiting prepotent responses based on changing environmental contingencies. Memory processes also influence this component of emotion regulation, as an adolescent relies on his or her increasing knowledge about the probability of success or failure of particular response options, based on previous experiences. To detail an example related to this component of emotion regulation and how it may lead to dysregulation, aggressive children are relatively inflexible in their ability to access behavioral responses and instead tend to rely on a single response. For example, during an ambiguous peer provocation, an aggressive child will infer hostile intent and respond aggressively. Aggressive children also have a difficult time changing to a new response if the initial one is not successful. For example, if an aggressive child wants a turn at a game, he may yell at another child and not get a turn and continue to become frustrated, rather than thinking of other behavioral responses such as asking nicely for a turn in a few minutes or asking an adult to help intervene. Additionally, the rates of aggressive behavior are negatively associated with the number of responses generated, suggesting that aggressive children may rely too heavily on their dominant (and often maladaptive) responses in any particular social situation rather than accessing less salient (but perhaps more prosocial) response options.

Early Development

Before further discussing emotion dysregulation in adolescence, it is important to first understand some of the early developmental factors that set the stage for later emotion regulation patterns. Realizing the difficulty of adolescence and all of the transitional changes during this developmental period, early risk factors only compound these challenges.

Biology

Very young infants demonstrate reliably distinct patterns of emotional expression, reactivity, and self-soothing behaviors. These patterns, known as temperament, are thought to reflect natural, or inherited/biological predispositions. Some infants are born with a tendency to experience negative affect and distress (e.g., sadness, anger, and fear) and may have more difficulty in adaptively regulating emotion. Other infants are born with a propensity to react strongly to novel situations and may appear to be shy as children. Some infants also lack attentional control and may have difficulty in sustaining attention or disengaging attention. Although these temperamental characteristics are believed to be inherited, exposure to substances such as alcohol and drugs during fetal development may also influence emotional expression and activity level. For example, infants exposed to cocaine prenatally are often more irritable. Children with certain temperamental characteristics (e.g., proneness to negative affect, higher reactivity, and poor attentional control) are more likely to have problems with regulating emotions later on.

Social Learning

Interactions with caregivers very early in life seem to be particularly important for understanding whether children

develop adaptive emotion-regulation patterns or maladaptive emotion-dysregulation patterns. Other than having some control over what they look at and what they touch, infants must rely on adults for much of their emotion regulation. Studies with infants and their caregivers have shown that unresponsiveness from caregivers leads to emotion dysregulation. On the other hand, infants whose caregivers respond to their distress signals by soothing them and respond to their positive signals by engaging them, are more likely to demonstrate effective emotion regulation. One area of research has focused on maternal depression. Mothers who are depressed tend to be less emotionally available to their infants, and demonstrate less responsivity and synchrony with their infants. These infants seem to have more difficulty with emotion regulation compared to infants of nondepressed mothers.

Early childhood also offers the child an opportunity to learn about emotions and regulation from others. Children observe what their caregivers do to change negative emotional states (e.g., distract, soothe, problem-solve). They also develop cognitive skills, including language to talk about emotions. By age 3, children are typically able to mask negative emotions under some conditions, demonstrating increased emotion-regulation capacities. Exposure to situations that allow for modeling of effective emotion regulation strategies by adults is likely important for emotional development during early childhood.

In addition to modeling, parents may affect children's emotion-regulation development through other mechanisms, including the way they discuss emotional topics and the contingencies they place on behavior. Some parents are acutely aware of their children's emotions, label them in conversations, and coach their children on emotion-regulation strategies. Other parents are not as aware of their children's emotions, do not label them in conversations, and try to control their children's emotions themselves rather than teach them regulation strategies. Children whose parents are accepting and responsive to their emotions are often able to adaptively regulate their emotions. However, children whose parents punish or disregard their emotions often have more difficulty regulating their emotions.

Maltreatment, Abuse, and Neglect

Extant research has underscored how child maltreatment is a significant risk factor for adolescent maladjustment and emotional dysregulation. Adolescents who have suffered early adversity, such as maltreatment, are three times more likely to suffer a mood disorder, four times more likely to show a disruptive disorder, and 2–4 times more likely to have an anxiety disorder than their nonabused counterparts. Even if they do not have a diagnosable disorder, children exposed to maltreatment are likely to have elevated symptoms of depression, anxiety and posttraumatic stress, and suicidal ideation. These risks are greater for females. For example, girls with a history of maltreatment are seven to nine times more likely to suffer some type of affective psychopathology (e.g., depression, anxiety, and posttraumatic stress-related symptoms).

While mood swings are common in adolescence and are not the result of child maltreatment, there is a connection between child maltreatment and more serious adolescent

emotional dysregulation. For example, research shows that adolescents maltreated as children have a greater risk of violent and nonviolent delinquency, more often use threatening behaviors or physical abuse against their dating partners, and have more arrests as a juvenile or adult. In addition, adolescents who were maltreated as children display poorer social competence than nonmaltreated peers. They tend to inaccurately infer emotional reactions and have trouble with interpersonal interactions involving peers and dating partners. We do not yet fully understand why this early experience causes specific emotional dysregulation in adolescence, but this knowledge is paramount to moving the fields of developmental psychopathology and affective neuroscience forward.

Summary

Several aspects of early child development may impact emotion regulation and dysregulation in adolescence. Infants are born with temperaments that may make it easier or more difficult to regulate emotions throughout life. Certain temperaments (e.g., proneness to negative affect, higher reactivity, and poor attentional control) make later emotion dysregulation more likely. Social learning, especially from caregivers early in life, may also impact emotion regulation. Caregiver responsiveness, modeling, and discussion of emotions can set the stage for the development of patterns of emotion regulation and dysregulation. Additionally, some early childhood experiences like maltreatment, abuse and neglect, seem to have a profound impact on the development of emotion dysregulation patterns throughout life.

Adolescence

The brain and body develop tremendously during adolescence. Along with this, the peer context becomes ever important. All of these changes require adaptation and regulation, and adolescents have increasingly developed emotion-regulation capacities. Early adolescents' emotions are more labile than the emotions of children or adults. Because adolescence itself is a challenging time, emotion regulation during adolescence is even more challenging than it may be at other times in development. This section highlights four main areas of adolescent development that impact emotion regulation: stress, the brain, puberty, and peer context. Some gender differences emerge during adolescence, and these are highlighted here as well.

Stress

Contemporary research indicates that adolescence *can be* a time of 'storm and stress' for some. Though not all adolescents will experience difficulty during this developmental transition, many will suffer from increased conflicts with parents, mood disruptions, and risky behavior. These increasing challenges occur at certain points during adolescence, and successful adaptation in dealing with this stress is a key component of the developmental transition.

Hypothalamic–pituitary–adrenocortical axis

Stress, whether physical or psychological in nature, activates the hypothalamic–pituitary–adrenocortical (HPA) axis.

The HPA axis is a major part of the neuroendocrine system and controls many body processes, including the stress reaction. Through the chemical cascade of corticotropin-releasing hormone (CRH) from the hypothalamus and adrenocorticotropic hormone (ACTH) from the anterior pituitary, stressful stimuli result in the release of glucocorticoids, specifically cortisol, into the bloodstream. Although stress-induced activation of the HPA axis can be adaptive (i.e., it prepares us for fight-or-flight), repeated, exaggerated, or prolonged reactivity of this neuroendocrine axis can cause or be symptomatic of neurobiological dysregulation. Such alterations have been linked to negative health outcomes and also psychopathology. In particular, many studies have focused on associations between dysregulation of stress response systems and depression and other psychopathology in adolescence. The exact direction and magnitude of the association, however, is still unclear, as inconsistent results have been found in research employing differing study designs and which demonstrate large individual differences.

Emerging research in both nonhuman samples and human populations has found that the HPA axis undergoes significant changes during adolescence. There is a normative increase in HPA activity, with increases in baseline, or basal, cortisol output seen near the onset of puberty. These alterations appear to be especially important because the functioning of the HPA axis is important for coping processes and responses to future stressors. Neuroendocrinologists have also investigated changes in reactivity cortisol or cortisol output in response to a specific laboratory manipulation like a strange situation or a public-speaking task. Though some inconsistencies exist, cortisol responses to laboratory stressors appear to increase during adolescence. Interestingly, infancy and early childhood appear to be periods of stress hyporesponsivity or buffering, with few laboratory situations causing significant alterations in this hormone during childhood.

Psychosocial experience of stress

Equally important as the biological component of stress, is adolescents' psychosocial experience of stress. With adolescence comes more autonomy, and that is typically accompanied by increased stress. Developmental research has confirmed that stress exposure increases in adolescence. There are some gender differences in the types of stressors that adolescents experience. For example, girls tend to report more

stress relating to friends, while boys tend to report more stress relating to school. Additionally, adolescent girls seem to experience more stress than adolescent boys, particularly in the interpersonal domain. This may partially explain why girls have higher rates of certain forms of psychopathology, such as depression, compared to boys.

The Brain

The burgeoning field of affective neuroscience has helped to more fully delineate the neurobiological machinery involved in emotion regulation (and dysregulation). Research with neuroimaging in typical adults, neurologically damaged patient populations, and nonhuman animal samples has underscored how emotion regulation involves major contributions from a number of important brain structures, including the amygdala, hippocampus, and prefrontal cortex (see [Figure 1](#)). Less work has been done specifically with adolescents.

The amygdala

The amygdala is an almond-shaped structure in the brain. Many studies of the amygdala have focused on its role in emotional responding. Neuroimaging studies have found that the amygdala responds to emotional stimuli (e.g., angry or fearful faces or upsetting pictures). Importantly, these types of studies have found greater activation in the amygdala in adolescents during the processing of emotional stimuli such as fearful faces compared to children and adults.

Recent research has broadened the conceptualization of the amygdala and detailed how this brain structure is involved in a myriad of functions including memory, learning, and attention. Broadly, the amygdala can be conceptualized as playing an integrative role: bringing together simple behaviors with more sophisticated ones. These processes are particularly important when dealing with the interpretation of complex information and learning relative to previous exposure to similar events.

The hippocampus

The hippocampus is a horseshoe-shaped structure adjacent to the amygdala. It has been implicated in memory functioning. New memories are processed in the hippocampus before being stored in the cortex as long-term memories. The hippocampus is also important for learning and remembering space (e.g., the

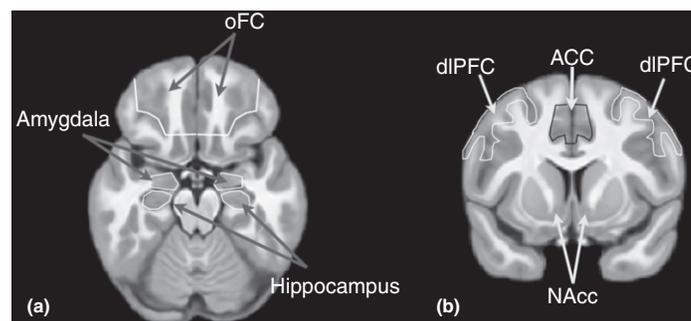


Figure 1 Brain regions important for adolescent emotion regulation. Panel A shows an axial slice with the oFC, amygdala, and hippocampus. Panel B shows a coronal slice with the dlPFC, NAcc, and ACC.

layout of city streets in a downtown area). It has also been implicated in a variety of other functions such as control of neuroendocrine functions and modulation of emotional behavior. Recent work indicates that the hippocampus may be specifically involved with depression and anxiety.

Of late, researchers have been particularly interested in the hippocampus because of how this brain structure is affected by contextual manipulations and stress. In nonhuman animal studies, short periods of stress alter the dendrite patterns of the hippocampus (i.e., shrinking the hippocampus), with additional contextual manipulations, such as exercise or environmental complexity, exerting comparable though opposite effects (i.e., growing the hippocampus). With recent research detailing the importance of context in adolescent risk-taking and decision-making, the hippocampus may be of particular importance to understanding adolescent emotional and motivational processes. A small body of research has demonstrated unique alterations of the hippocampus during adolescence, with volumetric decreases occurring in the head of the hippocampus and increases occurring in the medial portions of the hippocampus.

The prefrontal cortex

The prefrontal cortex (PFC) is the anterior section of the brain's frontal lobes. Central to the top-down control of attention, inhibition, emotion regulation, complex learning, and theory-of-mind processing, the prefrontal cortex is a heterogeneous brain circuit composed of many important subdivisions. Of critical note for understanding emotion dysregulation are the dorsolateral prefrontal cortex (DLPFC) and the orbitofrontal cortex (OFC). The DLPFC is crucial in attention, working memory, and cognitive control processes, with damage to this region leading to impairments in planning, goal attainment, and problem-solving ability. Neuroimaging research has found that this region plays a role in exerting top-down control in emotion regulation (such as reappraising negative stimuli), is involved in visuospatial working memory of salient stimuli, and is activated during successful inhibition of irrelevant stimuli. On the other hand, the OFC is primarily involved in valuation of stimuli and aspects of emotion recognition. Damage to this brain region has been linked to deficits in socioemotional regulation. The OFC is activated by emotional stimuli such as faces and pleasurable and painful touch. Functional neuroimaging studies point to the OFC as supporting behaviors such as inhibition, appropriate responses to other people's moods, and self-regulation of social-emotional behavior.

In terms of development, longitudinal neuroimaging studies suggest that the DLPFC and OFC are two of the last regions in the brain to fully develop in humans, as changes in the OFC and DLPFC are seen until 20 years of age or later. Early in development, these regions increase in volume. This change is due to a process, called dendritic arborization, which involves portions of neurons called dendrites expanding, to facilitate behavioral flexibility. Near the start of adolescence, these regions exhibit smaller volumes. This shrinking in volumes has been associated indirectly with the phenomena of pruning, where unneeded portions of neurons die related to increasing behavioral proficiency. Behavioral and neuroimaging research have confirmed these ideas. For example,

gambling tasks aimed at tapping into the functioning of the OFC have found developmental improvements, with significant increases in adaptive decision-making seen in adolescence even after controlling for cognitive abilities such as working memory capacity or inductive reasoning. These results suggest that the OFC is still maturing during adolescence.

Other cross-sectional studies have found that children, in comparison to adults, failed to activate the DLPFC during a Go/NoGo task designed to examine inhibitory control. In this task, participants must press a button when one stimulus appears (e.g., an 'X') and withhold a response when another stimulus appears (e.g., a 'Y'). This reduced or lack of activation early in development underscores how immature cognitive control networks in childhood and adolescence may be more susceptible to interference. Only one functional neuroimaging study has investigated developmental functional changes in the PFC. It found that children tend to activate portions of the PFC in a more diffuse way when exercising inhibitory control.

Other important brain regions

Affective neuroscientists have also begun focusing on additional brain circuitry involved with reward processing and conflict monitoring, specifically the nucleus accumbens (NAcc) and anterior cingulate cortex. The NAcc is involved with approach-related behaviors such as reward and positive emotion. Recent fMRI research has found some unique patterns of activity across children, adolescents, and adults when anticipating or receiving rewards. When anticipating rewards, adolescents had less activity compared to adults in the NAcc in anticipation of a reward. Interestingly, when receiving a reward, adolescents had greater activity in the NAcc compared to adults during a gambling task. In regard to emotion dysregulation, one study found that behaviorally inhibited adolescents had increased NAcc activity (compared to noninhibited adolescents) in anticipation of larger incentives, regardless of whether the incentive was positive or negative. This result might be indicative of heightened motivation to avoid making errors and a vulnerability to psychopathology such as major depression or an anxiety disorder. These cross-sectional studies point to major alterations occurring in reward circuitry during adolescence. With further longitudinal study, it is likely that activity in these regions may peak in adolescence and then fall in adulthood.

Also, a recent focus for research examining emotion dysregulation is the anterior cingulate cortex (ACC), which is involved with conflict monitoring and/or error detection in relation to an emotional state. This region of the brain may be especially important for adolescent socioemotional regulation. With increasing amounts of contact with peers, adolescents may be dealing with numerous conflicting social signals and cues. Interestingly, adolescents show heightened activity in the anterior cingulate when examining angry faces, but less activity than adults in the anterior cingulate when viewing happy faces. Other research has found that children aged 8–12 years have less activation of the ACC than adults during effective response inhibition on a go/no-go task. Because adolescence is a time of increased sociability, this brain region may be activated in response to social conflict or peer rejection. Novel research paradigms examining social exclusion in

a neuroimaging environment support this notion and have found that the amount of activity in the ACC was related to greater distress during a game where an adolescent participant was excluded.

Summary of brain development research

The research detailed here is still very much in its infancy, with cross-sectional designs greatly outnumbering longitudinal approaches. Importantly, cross-sectional study on structural brain development initially reported decreasing volumes across development in many studies with large sample sizes. The individual variability in the brain was so great that it was not until large longitudinal research was completed that the true 'inverted-U' developmental trajectory (with arborization, or dendrite branching, early in development related to increasing volume, and then pruning later in development leading to decreasing volumes) was realized. The current belief in the field of developmental affective neuroscience is that adolescents tend to engage emotional circuitry like the amygdala rather than inhibitory-control regions like the OFC and DLPC. This may result in more difficulty regulating emotion.

In addition to longitudinal followup, it is important to emphasize the lack of knowledge regarding how these brain circuits interact. There are major connections between the PFC and amygdala still developing in the adolescent rodent, for example. We are still beginning to understand how these fibers are changing over adolescence in humans. The advent of more sophisticated imaging techniques, such as diffusion tensor imaging, and additional analytic techniques, such as functional connectivity for functional imaging data, will hopefully help close these gaps in our knowledge.

Puberty

Puberty represents the 'start' of adolescence, the onset of sexual maturation, and major changes in the neuroendocrine axes. Starting in the hypothalamus, moving to the pituitary, and then onto the periphery, hormones, such as dehydroepiandrosterone, cortisol, estrogen, and testosterone, all surge during puberty. Such changes may directly or indirectly influence emotional states through rising hormone levels, alterations in the brain's emotional circuitry, or increasing psychosocial challenges associated with a changing behavioral repertoire. Puberty is an important developmental event especially in regard to emotion regulation, as puberty has been linked with changes in arousal and motivation, behavioral adaptation, and vulnerability to psychopathology.

Many aspects of arousal, motivation, and emotion have been linked with pubertal maturation (as opposed to age). For example, adolescents in more advanced stages of puberty seek out excitement and stimulation and may engage in more dangerous behaviors compared to adolescents at earlier stages of puberty. Interestingly, similar trends have been noted in a wide variety of nonhuman animal species, as a natural increase in exploratory and reward-seeking behavior is seen at puberty. In terms of emotions, pubertal development seems to be associated with the functioning of emotional relationships, such as the development of romantic interest and sexual motivation along with increasing parent-adolescent conflict. Variations and early timing in pubertal

onset have also been associated with increased moodiness and negative affect such as anger, frustration, aggressive behavior, and delinquency.

Recent research has also found that laboratory studies of emotion regulation are related to pubertal status. For example, adolescents at more advanced pubertal stages show greater emotional reactivity, remember more emotional words, and have higher eye-blink startles compared to less pubertally advanced children. With the strengthening connection between emotional processes and variations in puberty, it is not surprising that emotional dysregulation and increased rates of psychopathology have been associated with aberrant pubertal processes. Pubertal stage has been strongly associated with anxiety and depression, eating disorders, and substance abuse.

Importantly, these effects may or may not be directly a result of rising hormones. Initial research examining the role of pubertal hormones on psychopathology failed to find a relationship between gonadal steroids and depressive symptoms. However, a more recent population-based study found a linear relationship between gonadal steroids (e.g., estrogen or estrogen + testosterone) and symptoms of depression in a large sample of adolescent girls. Many have asserted how gonadal hormones, such as estrogen, testosterone, or DHEA may affect important neurochemical systems involved with affective psychopathology such as γ -aminobutyric acid (GABA), serotonin, and/or dopamine. Alterations in dopamine near puberty may be particularly important, as this neurotransmitter has been implicated in motivation and reward, mood, attention, and learning.

Turning to gender differences, research has linked aberrant pubertal development to different outcomes in girls compared to boys. For example, early maturation has been linked to body dissatisfaction, increased rates of self-reported psychological distress and negative mood, and also more psychopathology such as depression in girls. Late maturing girls also have increased social problems. In males, this relationship is more complicated, as early pubertal development has been associated with increased aggression, deviant behavior, and psychopathology. However, earlier timing and advanced pubertal development have also been linked with positive outcomes, such as enhanced self-esteem and body image, and decrease in social problems and attention problems.

In sum, the research reviewed here details the emerging link between emotion dysregulation and pubertal variations. However, there are many major unanswered questions. In particular, the role of intermediary factors and interactive effects is still not clear. For example, one study found that early pubertal maturation did not put girls at risk for increased behavioral problems, but rather it was the interaction of behavioral problems prior to entry into puberty and early timing which was related to increasing behavioral problems. Other studies have found that pubertal status interacts with emotional state in predicting emotional reactivity. In addition, inconsistencies still exist in the literature. As detailed earlier, risk taking, sensation seeking, and novelty seeking are correlated more strongly with puberty than age; while at the same time, levels of fear and emotional reactivity also increase at puberty. Finally, little research in humans has examined exactly how puberty may affect brain development.

This area of study is critical to understanding the effects of puberty on behavior, as many gonadal hormones modulate the development of the prefrontal cortex, hippocampus, and amygdala.

Peer Context

Beginning in early adolescence, children tend to shift their social time and energy from parents to peers. Adolescents disclose more in friendships and rely on friends for primary social support. Regulation of emotional expression is important for developing and maintaining friendships. In order to be a good friend, individuals must not only label and manage their own emotions, but they must be able to identify others' emotions and anticipate their behavioral responses.

The ability to regulate emotions is directly related to the number of friends and quality of friendships that adolescents have. As you might imagine, children who are able to compromise during conflict (i.e., balance their goals with their emotional behavior) have more friends than children who are dysregulated and retaliate or are verbally aggressive during peer conflicts. Additionally, children who are able to effectively regulate their emotions tend to behave in more prosocial ways with others and may be able to comfort their friends, leading to higher friendship quality. Children who are emotionally dysregulated tend to be socially withdrawn or aggressive, and they are likely to be rejected by their peers.

Just as emotion regulation is important for the development and maintenance of friendships, peers can affect adolescents' emotion regulation through various social learning mechanisms. One process involves homophily or selection of peers who are similar. Adolescents often spend time with friends who have similar behaviors, including similar emotional behaviors. For example, adolescents who tend to engage in more aggressive behaviors tend to spend time with other adolescents who aggress. This may normalize and reinforce emotion dysregulation. Another process involves contagion, or socialization of behaviors among peers. Several behaviors have been demonstrated to spread among peer groups, including deviant behaviors (e.g., substance use, illegal activities), weight management behaviors, self-injurious behaviors, and depression. With contagion, emotion dysregulation may be modeled and reinforced among peer groups.

There are a few notable gender differences among adolescents regarding the peer context. Girls tend to spend more extended time in dyadic interactions (e.g., talking with their best friend) compared to boys who tend to spend more time socializing in larger groups. Perhaps as a result of this, girls tend to disclose more in their friendships compared to boys. Intimacy and social support tend to be protective in terms of emotion dysregulation; however, there appear to be some trade-offs to girls' interpersonal orientation. Compared to boys, girls tend to spend more time talking with friends excessively about their problems. This emotion-regulation style of co-ruminating is associated with increases in symptoms of anxiety and depression for girls. Thus, research in the peer context suggests that adolescent peer relationships have important implications for emotion regulation and dysregulation.

In sum, the interpersonal context of development shifts to a focus on peers during adolescence. Girls tend to focus on

interacting with peers one-on-one, while boys tend to focus more on hanging out in large groups. Emotion regulation is necessary for the development of healthy peer relationships. Additionally, peers affect the development of emotion regulation in each other, and emotion dysregulation patterns may be maintained via peer interactions.

Summary

Children experience more stress in adolescence compared to earlier period in childhood. This may be a result of increasing activity in the HPA axis which regulates the stress response. There are many other changes in the neuroendocrine system and the brain during adolescence that affect emotion regulation. Additionally, the psychosocial and biological changes of puberty also impact emotion regulation. Finally, the peer context becomes a central part of adolescents' lives, and both affects and is affected by emotion regulation.

Forms of Emotion Dysregulation in Adolescence

Adolescence is characterized by increases in several forms of psychopathology, most of which are thought to develop, at least in part, as a result of emotion dysregulation. This section reviews some of the most common forms of serious emotion dysregulation in adolescence. Some of these are diagnosable mental disorders (e.g., depression, anxiety, eating disorders), while others involve behaviors that may or may not be associated with a mental disorder (e.g., risk taking, nonsuicidal self-injury).

Depression and Anxiety

Moodiness or sullenness may be common in adolescence. It is only when moods are severe and chronic that an adolescent might be experiencing a clinical syndrome like depression or anxiety. Depression and anxiety are sometimes referred to as internalizing disorders, especially when present in childhood and adolescence, because of their overlap and common component of emotional overcontrol of negative emotions. Depression is characterized by low mood, irritability, diminished interest in usual activities, feelings of guilt, hopelessness, and low self-esteem, difficulty concentrating, and physical changes such as weight gain or loss and difficulty sleeping. Children and adolescents may appear more irritable than sad when depressed, and no two individuals with depression may have the same symptoms, because only some symptoms are required for a diagnosis. Anxiety disorders are characterized by intense apprehension, fear or terror, recurring fears and worries, and avoidance of feared situations. Adolescents with internalizing disorders tend to report difficulty in understanding their emotions and use more maladaptive emotion-regulation strategies compared to adolescents without psychopathology. We detail subsequently some of the attentional, perceptual, and cognitive biases that contribute to emotion dysregulation in depression and anxiety, followed by a discussion of some maladaptive emotion-regulation patterns associated with these disorders.

A robust finding among children and adolescents with anxiety disorders is an attentional bias for threatening

information. One of the primary paradigms used to test for this attentional bias is the dot-probe task. In this task, adolescents sit in front of a computer, and two words are presented briefly on the screen. When the words disappear, a dot replaces one of the words. Adolescents press a button as soon as they see the dot. Presumably, they will be faster when the dot replaces the word they were focusing on. For each trial in the task, one of the words is neutral and the other is threat-related. Adolescents with anxiety disorders are quicker to detect the dot probes replacing threat words compared to neutral words in the same position, suggesting that they are paying more attention to threatening stimuli. Children and adolescents without psychopathology and those with depression do not show this bias.

A robust finding among children and adolescents with depression is a memory bias for negative information. One of the paradigms used to assess this is an adjective recall memory task. In this task, adolescents are presented with a large number of words, one at a time, on a computer screen. They are told that they should repeat the word to themselves and think about it. They are also told that they will have to write down all the words later. The word list comprises positive trait adjectives (e.g., intelligent), negative trait adjectives (e.g., lonely), and neutral words. Depressed adolescents tend to recall more negative than positive adjectives, while adolescents without psychopathology tend to recall the same number of each or more positive adjectives.

These biases in attention and cognition are likely to influence the regulation of emotion in adolescents with internalizing disorders. The biases suggest that negative information is more readily available for adolescents with depression and anxiety, and they must work to regulate their negative emotions. Unfortunately, adolescents with internalizing disorders have a harder time using adaptive emotion regulation strategies (e.g., reappraising a situation, problem solving), most likely because of their attentional and cognitive biases.

Adolescents with internalizing disorders tend to get stuck in patterns of perseverative thinking, making it difficult for them to effectively regulate their negative emotions. One style of perseverative thinking is called rumination. It involves passively dwelling on one's negative emotion and brooding about how bad one feels. Adolescents who ruminate frequently are likely to have high levels of anxiety and especially, depression. Rumination involves rehashing past events wishing they had gone better (e.g., thinking about a peer interaction that did not turn out as one hoped). Because depressed adolescents recall more negative memories, they are more likely to ruminate, perpetuating a cycle of rumination and depression. Additionally, girls tend to ruminate more than boys, and this may partially explain why girls have higher rates of depression compared to boys starting in adolescence. Anxious adolescents are likely to also engage in another form of perseverative thinking called worry. Worry involves thinking about future events and wondering what will happen or anticipating bad things that might happen. Because anxious adolescents are more likely to pay attention to threatening information, they may worry more. The worry tends to keep their anxiety present, just like rumination keeps depression present. Adolescents may think that they are doing something about their negative emotions by ruminating or worrying, but both processes are unproductive and prevent problem-solving and other adaptive

emotion-regulation strategies from being used. Thus, rumination and worry are cases of emotion dysregulation, because they serve to maintain a negative affect for long periods of time and prevent more adaptive strategies from being used.

New research is examining the neural correlates of emotion regulation in depressed and anxious adolescents. Some work with fMRI has demonstrated enhanced amygdala activation during attention and memory tasks among depressed and anxious adolescents compared to healthy adolescents. Work in genetics has suggested that adolescents with internalizing disorders may have dysfunction within the serotonin system. Some of the newest research is looking at other genes such as the brain-derived neurotrophic factor gene and also combining genetics with neuroimaging. This work is still very new, but will likely help our understanding of the biological systems involved in emotion regulation and dysregulation with these common disorders in adolescence.

Judgment and Decision-Making

During adolescence, a dramatic increase in death and disability occurs, along with increases in binge drinking, suicide, smoking, violent and other criminal behavior, and casual sex. Researchers interested in these problem behaviors during this developmental transition have focused on emotional dysregulation, specifically reward-related processing, in an attempt to understand these escalations. These alterations are not due to reasoning, planning, or information processing, as adolescents (by around the age of 16) have similar perceptions and estimates, as adults, of dangerousness associated with risky behaviors. Adolescents also behave like adults, when the saliency of a risky or dangerous decision is increased.

With no broad behavioral differences aiding in understanding the increases in risky decision-making during adolescence, many researchers have turned to potential neurobiological explanations in circuitry involved with reward and emotion regulation. Thinking broadly about adolescence and ideas of storm and stress, few direct neurobiological-behavior linkages have been found, and neurobiology-behavior relationships likely involve complex direct, indirect, and interactive pathways. Knowledge about structural and functional brain development during adolescence holds powerful potential to unravel this complex question, by elucidating unique brain-behavior links during this period. Many have asserted how the increases in sensation seeking commonly seen in adolescence may be linked to changes in patterns of dopaminergic activity during this developmental transition. With a central role in affective and motivational regulation, dopamine may play a critical role in alterations in risk and decision-making processes. In brain circuitry important for socioemotional regulation, the remodeling of the dopaminergic system involves an initial postnatal rise and then, starting at around 9 or 10 years of age, a subsequent reduction of important components of this system such as the number of dopamine receptors in portions of the prefrontal cortex. This research conducted in rats found that these developmental alterations exhibit a strong gender difference, with changes being much more pronounced among males than females. These findings are suggestive of unique alterations in dopamine, a key neurotransmitter for reward functioning during adolescence, though it should be

interpreted with caution due to possible translational differences in animal and human functioning.

Understanding how important neurotransmitters in adolescence, such as dopamine, influence and activate pivotal neural circuitry, such as the NAcc, prefrontal cortex, and amygdala hold untold promise for understanding alterations in the destructive decision-making and emotional dysregulation common in adolescence. However, this neurobiology may interact with the changing social contexts confronting adolescents during development. The increase in peer-directed behavior may also have neurobiological roots, as social acceptance by peers may be processed in ways similar to other rewards, including nonsocial rewards. For example, a large overlap exists between the neural circuits that mediate social information processing and the brain regions involved with reward processing.

In regard to social context, it is important to underscore that one of the hallmarks of adolescence is that destructive decisions and increased risk taking occur more commonly with peers. An adolescent's peer group is related to that adolescent's own alcohol or illicit drugs use and sexually activity. In addition, research on automobile accidents indicates that the presence of same-aged peers in a car driven by an adolescent driver was related to increases in the risk of a serious accident. Laboratory examinations of the effects of peers in risk taking during adolescence have found the presence of friends doubled risk-taking among adolescents, but had no effect on the adults. Importantly, when subjects were alone, the levels of risky driving were comparable across the groups. Understanding how context, specifically, the presence of peers, may affect the activity of important neural circuitry may be pivotal for understanding the emotional dysregulation and the alterations in decision-making seen during adolescence. Maturational changes in regions like the PFC, a central node of the cognitive control system, likely contribute to the decline in risk taking seen between adolescence and adulthood, as these emotional regulatory regions permit the individual to resist impulsive sensation-seeking behavior as well as the influence of peers, diminish risk taking.

Related to the importance of studying early experiences because of their effects on the trajectory of emotion dysregulation, a great deal of research at both the human and nonhuman level have found associations between maltreatment, emotional dysregulation, and substance use disorders. In human samples, a strong association has been found between child maltreatment, such as physical and sexual abuse, and substance abuse in both adolescence and adulthood. Two studies in twins add support to this growing body of research, as victims of childhood sexual abuse had significantly increased risk of substance abuse after controlling for genetic influence of risk.

Research in rodents underscores how early stress affects acquisition, maintenance, and reinstatement of drug use implicating the risk for substance abuse seen in populations that face early stress. Understanding the neural correlates of this vulnerability will aid in further understanding the development of addiction, and could also aid drug addiction prevention and treatment strategies for those who have suffered early life stress.

Other Examples of Adolescent Emotion Dysregulation

There are several other forms of emotion dysregulation in adolescence. Two of the more common forms that have

not yet been discussed are eating disorders and nonsuicidal self-injury (e.g., cutting). Eating disorders (especially bulimia) and nonsuicidal self-injury share the common feature of engagement in a specific behavior (i.e., bingeing/purging and bodily injury, respectively) to alter one's emotional state. Therefore, these behaviors are most often done specifically for emotion regulation purposes.

Bulimia nervosa involves recurrent binge-eating episodes (eating very large amounts of food in a discrete period of time and feeling out of control) and inappropriate compensatory behaviors (usually purging, but may also include the use of laxatives or excessive exercise). Adolescents with bulimia are likely to have high levels of alexithymia (i.e., difficulty identifying and communicating emotional states). This may contribute to dysregulated emotion, and bingeing may be used as a way to numb overwhelming negative emotional states.

Similarly, adolescents who self-injure may do so to numb negative emotional states. In fact, the majority of adolescents who self-injure do so to relieve negative emotional states. For example, if an adolescent is feeling very anxious, he or she may find that cutting relieves anxiety. This behavior may quickly become habitual, because it negatively reinforces (i.e., takes away) anxiety. There is also some evidence that self-injury results in a release of endorphins in the brain, so the act of cutting, for example, may actually produce a pleasurable sensation for some individuals. In addition, some adolescents say that they self-injure in order to feel something, even if it is painful. These adolescents report feeling emotionally numb and use the self-injury to feel emotion. Clearly, self-injurious behavior serves a function for adolescents. Self-injurious behavior causes damage to one's body tissue and may be rather dangerous. For these reasons, self-injury is considered a form of emotion dysregulation.

Interestingly, eating disorders and self-injury commonly occur together, providing further support to the idea that both behaviors may serve a similar function (i.e., to regulate emotions). Girls are more likely than boys to experience eating disorders. One potential reason is the emphasis on ultra-thin bodies of women displayed in the media that are impossible (and unhealthy) to attain. Many girls report dissatisfaction with their bodies, especially in adolescence when weight gain is a normal part of development. Body dissatisfaction is one risk factor for the development of eating disorders. Girls may also self-injure more than boys, although the research on this is mixed, with some studies finding that it is more common among girls, and other studies finding that it is equally common among adolescent boys and girls.

Summary

Emotion dysregulation may take on many different forms during adolescence, ranging from typical moodiness to severe forms of psychopathology such as depression and substance abuse. Emotion regulation patterns associated with depression and anxiety include ready access to negative information (e.g., attention to threat or memory for negative self-relevant information). In addition, adolescents with depression and anxiety tend to engage in perseverative patterns of thinking like

rumination and worry that maintain and exacerbate their negative emotions.

Engagement in risky behaviors is common in adolescence, especially for boys. When this risk taking is severe, it may involve criminal behavior and serious emotion dysregulation. Risk taking is more likely to occur in the presence of peers. Neurobiological explanations include a focus on the dopaminergic system in the brain and the development of the prefrontal cortex.

Binge-eating and self-injury are other forms of emotion dysregulation commonly seen during adolescence. These behaviors are often engaged in to decrease negative emotions. Although this function may be served temporarily (e.g., anxiety may be reduced following a binge), these behaviors are dangerous, and more adaptive forms of emotion regulation (e.g., problem solving, relaxation) would be preferable for healthy development.

Conclusions

Adolescence is a time of increased stress, including many changes in brain development, physical appearance, and peer context, making regulation of emotion challenging. It is typical for adolescents to experience moodiness, and sometimes they experience more severe forms of emotion dysregulation such as an eating disorder or depression. Early factors such as temperament, social learning, and maltreatment history impact the development of emotion regulation and may set up trajectories for dysregulation. Certain attentional and cognitive biases, thinking patterns, and neurobiological processes are associated with emotion dysregulation in adolescence. It will be important for future research to disentangle whether these biases and processes are present before the development of psychopathology and if so, whether interventions can change them to prevent more serious emotion dysregulation.

See also: Anxiety Disorders; Brain Development; Depression and Depressive Disorders; Disruptive Behaviors and Aggression; Eating Disorders; Emotional Development; Executive Function; Hormones and Behavior; Impulsivity and Adolescence; Maltreatment and Adolescence; Motivation; Nonsuicidal Self-Injury; Peer Relations; Puberty and Adolescence: An Evolutionary Perspective; Risk-Taking Behavior; Social Cognition; Stress.

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Relevant Websites

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- <http://www.s-r-a.org/> – Society for Research on Adolescence.
- <http://www.time.com/time/magazine/article/0,9171,994126,00.html> – Time Magazine – What Makes Teens Tick?
- <http://www.waisman.wisc.edu/childemotion/> – Child Emotion Lab – Waisman Center, University of Wisconsin – Madison.