16. The Regulation of Sleep-Arousal, Affect, and Attention in Adolescence: Some Questions and Speculations

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Pubertal maturation includes an enormous array of changes in social and biological domains. Among these changes are developmental shifts in the control of sleep, arousal, affect, and attention – including both physiologic and behavioral changes. One major theme running through these various developmental changes is the relatively increased influence of executive functions (the use of higher cognitive processes involving regions of prefrontal cortex to guide behaviors according to social rules and long-term goals). The integration of higher cognitive processes with emotional regulation (e.g., learning to inhibit or modulate arousal, attention, and behavior to serve higher cognitive goals) creates the basis for *social competence* – perhaps the most important outcome variable in adolescent development. However, increased cognitive abilities to override lower levels of regulation also confer a greater capacity for cognitive ideas or attitudes to cause *dysregulation* at subcortical levels. In a number of ways, adolescence thus appears to represent a vulnerable period regarding the maturational integration of cognitive and emotional processes. It also appears that this highest level of cognitive-emotional integration is most sensitive to the effects of sleep deprivation or inadequate sleep. Within this general frame a few specific questions are considered, which may be addressed by current or future lines of investigation: (1) What are the neurobiologic underpinnings of these maturational changes (and the likely involvement of alterations in prefrontal cortex [PFC] and limbic circuitry)? (2) Why do some adolescents appear to be particularly vulnerable in these domains (and why may vulnerability in affect regulation confer vulnerability toward sleep deprivation effects)? (3) What is the potential to prevent some types of dysfunction through early cognitive-behavioral or educational interventions in vulnerable adolescents?

Preface (Or, Why This Chapter Digresses So Far from Sleep Patterns)

This chapter focuses on a model of affect regulation emphasizing the developing links between cognitive and emotional processes during adolescence. The relevance of this model to a book on adolescent sleep patterns may not, at first, be readily apparent. However, the model itself grew out of 10 years of investigating the links between sleep-arousal regulation and affective dysregulation (primarily through psychobiologic studies in child and adolescent depression). The bridge from sleep patterns to this cognitive-emotional model is built on two premises. (1) The aspects of affect regulation that require the integration of high cognitive and emotional processing are *particularly sensitive to inadequate or insufficient sleep*, and may represent one of the most significant consequences of poor sleep patterns. (2) These aspects of affect regulation are critically important in the development of social competence and represent a *highly vulnerable period in adolescent development.* Clinical studies designed to test hypotheses directly along these lines are in progress (and some preliminary data are presented here). However, most of this chapter attempts to step back and consider a broader overview of the cognitive-emotional development, and it does not return directly to the link to sleep-arousal regulation until the end. The model is in a preliminary form, makes numerous speculative jumps across domains, and is offered not as a source of explanations, but primarily as a means to generate further questions and discussion.

Defining Adolescence

Adolescence encompasses a complex array of changes that do not fit into any single category or domain of measures. A definition that captures the key aspects of this process relevant to this chapter is: Adolescence is that awkward period between sexual maturation and attaining adult status in society. This conceptualization helps to introduce five points about adolescence that fit a developmental model of cognitive-emotional integration.

1. Adolescence exists within the boundaries of two contrasting domains: it begins with physical changes (sexual maturation) but ends in the realm of social-cultural determinants. Further, there is evidence that the timing of physical maturity and the attainment of adult status in society have moved in opposite directions in recent history. The mean

age of menarche in the United States and Europe has decreased from 15.5 years in the late nineteenth century to 13 years at the current time (Petersen & Crockett, 1985; Rutter & Rutter, 1993). A recent longitudinal study found that 15% of middle-class American girls had reached menarche by 11.7 years of age (Ge, Conger, & Elder, 1996). Yet the average age of leaving school, marrying, beginning a career, and becoming a parent has increased over this same interval (Modell & Goodman, 1990). Historically, puberty coincided with taking on adult roles, whereas in contemporary society many sexually mature 12- to 13-year-olds will not assume adult responsibilities or status for another 10–15 years. Lengthy periods with sexually mature bodies (and sexually active brains) in the context of still-developing frontal lobe (executive) functions, as well as ill-defined social roles, create special challenges and vulnerabilities – particularly with respect to emotion and arousal regulation.

2. The *awkwardness* so strongly associated with adolescence is, in many ways, closely related to the incomplete emergence of *social competence* combined with the new drives, impulses, emotions, and physical changes occurring with puberty (as described in the third point). Social competence, here, is conceptualized as the integration of cognitive and emotional skills involved in the self-regulation of behavior according to learned rules, societal constraints, and the pursuit of long-term goals. There are three primary components to developing these abilities: (a) the cognitive skills needed to process complex abstract information (particularly with respect to learned social rules, holding long-term goals in working memory, imagining future likelihoods-consequences, making complex plans, strategizing, etc.); (b) the cognitive power to use these skills to guide behavior (learning to inhibit, modify, or delay behaviors linked to impulses, drives, or other subcortical influences, as well as initiating and persisting with sequences of behaviors to achieve goals); and (c) a fluency in using these abilities together in a variety of complex social situations. The integration of these higher cognitive skills with lower levels of influence (including drives and emotions) is associated with the maturation of regions of the prefrontal cortex (PFC), executive functions, and affect regulation. This chapter focuses on the close links between these developing regulatory systems and neurobehavioral systems underlying sleep-arousal regulation and attention.

3. Adolescents encounter a new set of challenges at puberty with the activation of subcortical circuits (and their cortical connections) involved in reproductive physiology and behavior. These changes

activate new drives, impulses, emotions, and arousal patterns at a point when most adolescents have a limited cognitive ability to exert control over behavior. These new emotions and drives control and possess a direct influence on cognitive processes (e.g., girls spending increasing amounts of time *thinking about* boys). The establishment of new connections between cognitive processes (executive functions), and these newly activated drives-emotions-arousals represent a potentially important period of neural plasticity relevant to affect regulation and social competence. That is, the particular experiences (and early habits) of the individual as these new patterns of interconnections are being established may have long-term influences across neurobehavioral systems involved in affect-arousal regulation, social competence, and adolescent vulnerabilities to some types of psychopathology.

4. The increase in cognitive abilities (and cognitive power over lower levels of influence) that emerges during adolescence also confers new vulnerabilities regarding the capacity to override lower-level control systems. For example, adolescents develop the ability to hold a goal in working memory with sufficient focus and motivation to go without eating or sleeping for long periods of time in pursuit of the goal. To extend this example, a goal to be extremely thin in pursuit of social status brings with it the vulnerability of severe self-deprecation of food or extreme levels of exercise to the detriment of health. While short-term periods of overriding drives and impulses may lead to some rewarding experiences, this pattern may lead to ignoring physiologic drives over sustained intervals, providing additional routes to developing pathology.

5. Individual differences (either genetic or acquired very early in the developmental process) in affect and arousal regulation may lead to additional vulnerability during adolescent development. Specifically, this chapter focuses on evidence for two factors that may influence the development of affect dysregulation in adolescence: (a) a low threshold to activate threat-related arousal; and (b) a negative affective bias in cognitive and attentional processing.

Cognitive-Emotional Interface from a Literary Perspective (Or, What Happens When Teenage Brains Fall in Love?)

Before proceeding with a more analytic and neurocircuitry-level approach to the early integration of these cognitive-emotional processes during adolescence, it may be helpful to consider a few literary

descriptions of adolescent cognitive-emotional turmoil as these neurobehavioral systems become activated during romantic experiences.

First, consider the most frequently retold description of adolescent tempest: Shakespeare's *Romeo and Juliet*. From an objective perspective, it is the story of two adolescents who, having exchanged less than 100 words, decide they are mortally in Love, and would give up not only sleep and food but also sacrifice their lives, their families, and the world rather than exist without each other. This play, in its variations over the centuries, has struck a deep emotional chord for millions of people – to a large extent because it captures something universal (albeit extreme) about this set of experiences.

A less dramatic but poignant example is given by Gutterson in *Snow Falling on Cedars*, describing an innocent but completely enamored 14-year-old boy: "He noticed her fingernails, the shape of her toes, the hollow place at her throat. It made him unhappy when he thought about her lately and he had passed a lot of time, all spring long, mulling how to tell her about his unhappiness. He'd sat on top of the bluff at South Beach thinking about it in the afternoons. He'd thought about it during school. His thoughts yielded no clue how to talk to her . . . words evaded him completely . . . he couldn't stand another moment without explaining his heart to her . . . he was in pain. . . . He could still feel this pain 20 years later."

A humorous, but equally touching, example is given by Ray Bradbury in *One Timeless Spring*, which describes the experience as a 12-year-old boy struggling with the physical and emotional changes of early puberty. The boy decides that his parents must be poisoning his food, and he envisions an elaborate plot against him, which includes his teachers. He fights the changes in every possible way, avoiding foods prepared by others, even resorting to induced vomiting. Later, he discovers Clarisse, a girl his age whom he has been (increasingly) noticing – they begin walking together and he experiences the following scene:

"Clarisse's hand bumped mine as we walked along the trail. I smelled the moist dank smell of the ravine and the soft new smell of Clarisse beside me. Very quietly, she put her arm around me. I was so surprised and bewildered I almost cried out. Then, trembling, her lips kissed me, and my own hands were moving to hold her and I was shaking and shouting inside myself. The silence was like a green explosion. The water bubbled in the creek bed. I couldn't breathe. I knew it was all over. I was lost . . . forever, now, and I didn't care. But I *did* care, and I was laughing

and crying all in one, and there was nothing to do about it. . . . I could have gone on fighting my war with Mom and Dad, and school and food and things in books, but I couldn't fight this sweetness on my lips."

There are several points about the states described in these passages which are relevant to our later discussion about cognitive-emotional regulation in adolescents. These areas are being increasingly studied by social scientists, and are extremely complex issues in their own right; however, it may be useful to briefly sketch a few of these points here:

1. Early romantic experiences are emotionally powerful and can completely overwhelm most cognitive processes.
2. Many of the experiences are associated with high levels of arousal – even the slightest thought, memory, or association with the "object of desire" can send the heart racing and the brain bathing in new transmitters.
3. Early romantic experiences have profound effects on attentional processes. During these periods, the individual often cannot avoid thoughts directed toward the "coveted other." Even in the middle of competing activities, or any quiet moments, attention quickly returns to thoughts, images, memories, or fantasies, about the desired partner (and, given number 2, this results in frequent and long periods of elevated arousal). James Leckman at Yale University has interviewed students in the early stages of romantic involvement, finding that the obsessional nature of their thought processing was comparable with patients meeting criteria for obsessive-compulsive disorders – many were incapable of going an hour without thinking about their desired partner. Further, the degree of functional impairment (difficulties with concentration, changes in appetite, sleep, school-work difficulties) can frequently reach a clinical threshold in adolescents in the throngs of an initial romance.
4. Any sign of encouragement, reciprocation, or actual contact with the desired person creates an enormous surge of positive affect and *increased sense of self-worth.*
5. Any sign of rejection, lack of reciprocation, or actual separation-loss is strongly associated with enormous levels of negative affect and a *decreased sense of self-worth.*

Neural Plasticity and Sensitive Periods of Development

There has been increasing interest in the field of developmental neuroscience in the principle of critical or sensitive periods of development. There is well-documented evidence of early periods of sensitivity to experimental input in several neurobehavioral systems. The best-investigated example is in the development of binocular vision (Singer, 1986; Greenough, Black, & Wallace, 1987; Miller, Keller, & Styker, 1989). A short interval of time (corresponding to when cortical neurons are crossing over for the two eye fields) is critical for establishing the pattern of interconnection relevant to binocular vision. Well-controlled studies have shown that patching one eye for several days during the sensitive period can result in permanent changes in the visual cortex. Patching one eye for longer intervals prior to or following the sensitive period does not produce these deficits. In brief, what happens is that neurons that "should" become connected to inputs from the patched eye instead develop connections to inputs from the active eye. Later, instead of a *balance of inputs* from each eye, there is always greater influence from the unpatched eye, resulting in suboptimal binocular vision.

The general principle here may be critically important as it applies to other neurobehavioral systems: the particular experiences of the individual during a period when neural systems are first establishing interconnections set the foundation for some aspects of the pattern of later connections. A number of models in developmental neuroscience have focused on this principle. In the model of Greenough (Greenough & Black, 1992), this is called "experience-expectant" learning, meaning that brain processes involved in the overproduction and subsequent pruning of connections *expect* or anticipate certain types of experience during the critical period of development. As a result, the experiences during that period have large and long-standing influences on that particular neurobehavioral system, producing structural changes that may be difficult to alter with later experience.

Analogous findings are seen in some areas of language development. Although the sensitive period occurs over a broader interval of time, the ability to discriminate or produce certain types of sounds relevant to language production becomes fixed by early exposure to a particular language. The most frequently cited example is the finding that Japanese infants easily distinguish *R* versus *L* sounds, but this ability is lost in older children exposed only to the Japanese language (which does not use these distinctions). Similar findings have been shown in

other languages. More importantly, the ability to speak fluently in a language has been shown to be extremely difficult in a language learned after puberty – pronunciation patterns and accent are nearly impossible to master after pubertal development.

A full discussion of the complex issues (and controversies) surrounding sensitive periods in development is beyond the scope of this chapter. However, the general principles may be critical to understanding a vulnerable period in cognitive-emotional development – how an individual develops higher cognitive control over affective responses relevant to social competence and social-emotional "fluency." The particular experiences (and affective and arousal state) when the first interconnections are being established between higher cognitive processes and affective regulation may "set" some aspects of the lasting patterns of connection between higher cognition and emotion. These patterns may be much more amenable to change early in development and quite difficult to change later in adulthood (analogous to language fluency). If indeed there is a sensitive period for developing social competence or emotional fluency analogous to visual or language development, this raises a set of important implications regarding early intervention, treatment approaches for some types of psychopathology, and a series of research questions about the specific mechanisms, neurobehavioral systems, and timing involved in the structuring of the systems during the critical period.

Studies from Early Child Development Relevant to the Cognitive-Emotional Interface (Or, How to Get Johnny to Put Away His Toys)

Before moving to more specific speculations about critical periods in the adolescent development of cognitive-emotional integration, it is worth reviewing some studies addressing the earlier developmental roots of cognitive-emotional regulation. Some key investigations in this area have been performed under the rubric of "the development of self-control" in preschool ages. The work of Kochanska and colleagues (Kochanska, DeVet, Goldman, Murray, & Putnam, 1994; Kochanska, Murray, Jacques, & Koening, 1996) shows a fascinating pattern of findings regarding the early development of self-regulatory capacities. This work examines two specific aspects of early self-regulation: (1) the ability to inhibit (by internal volition) a class of prohibited behaviors (e.g., not touching, eating from an off-limits location), and (2) the ability to produce

a class of requested behavior (e.g., cleaning up the toys after a play session). Investigations into the acquisition of these skills have emphasized the importance of an optimal link between the relevant cognitive processes and the appropriate emotional processes. That is, to reliably produce these behaviors (in the absence of direct supervision), it is necessary to link functionally the cognitive knowledge of the boundary of principle with sufficient affect to motivate remembering and producing the behavior without immediate threat of punishment or imminent reward. Even more important, the process of learning the skill requires experiences of emotional salience to be coupled with the cognitive experience (e.g., a parent's affectively laden response to the child producing the requested or prohibited behavior). The particular way in which parents impart the affective cues (facial expression, tone of voice, verbal threat, or actual punishment) exerts marked influences on the way the child learns the skill. Either too much affect or too little can interfere with skill acquisition. Too much affect apparently interferes with the cognitive aspects of learning while too little affect produces insufficient motivation to internalize the skill. Further, as Kochanska et al. (1996) demonstrated, the optimal level of affective arousal varies considerably across children – with fearful or highly reactive children learning best with relatively low levels of affective input. Clearly, the acquisition of self-regulation and self-control requires an optimal balance of cognitive *and* affective processes. The same issues are relevant to learning to produce prosocial or requested behaviors or a long sequence of steps toward a goal. The cognitive processes include understanding the goal or requested behavior, and linking this to the affective influence to provide sufficient motivation to produce the necessary behaviors (despite distraction or competing shorter-term goals).

The central point here, relevant to adolescent development, is that there is every reason to believe that more complex levels of self-regulation and self-control involve similar processes linking higher cognitive processes with affective states, rewards, and punishments. For example, learning behavioral control with respect to abstract rules or codes of moral behavior requires even higher levels of abstract thought to be linked to affective systems in the guidance of more complex behaviors. Similarly, the goals being held in working memory become more complex and require a greater sequence of behavioral steps, planning, and strategy to achieve the goal (e.g., graduating *cum laude* versus cleaning up the toys). The selection of optimal behaviors in these contexts requires inhibiting many options while augmenting a selected few in the appropriate sequence of what one is supposed to do (according

to social context or to achieve a long-term goal), *and* this requires *affective regulation*, not simply knowing what to do. These processes almost certainly involve interconnections of higher-order abstract processing (in areas of prefrontal cortex) with neurobehavioral systems involved in affect and motivation. Clearly, these higher-order connections initially develop in adolescence, as these areas of PFC mature and begin to harness the more intense affective states during puberty.

Damasio (1995) and others argue that, even in adulthood, these higher-order cognitive processes cannot be separated from their emotional links. Damasio's research group has studied patients with cortical lesions at the linkage point between higher-order cognitive processes and limbic circuits. These patients show completely normal performance on complex cognitive tasks and can even describe appropriate social responses in objective questions; however, in real-life situations they show marked impairments in social functioning (Damasio, 1995). Damasio and others have convincingly argued that the highest level of cognitive processing *requires* affective input. The connections between these systems are among the last areas of the brain to develop, showing significant changes into late adolescence and early adulthood (Pennington & Welsh, 1995).

Vulnerability to Affect Dysregulation

Our group has been involved in a large program of research examining the developmental psychobiology of child and adolescent depression. We have been investigating a stress-diathesis model of early onset depression, building on evidence for a genetic vulnerability combined with a set of adverse early experiences leading to a syndrome of affective dysregulation (see Dahl & Ryan, 1996; Dahl, 1996). A full discussion of the model will not fit in this chapter; however, there are two major themes related to vulnerability that are relevant to the model. First, there is increasing evidence that one component of the story is related to early anxiety symptoms and a very early pattern of low threshold to activate threat-related arousal (depressed infants and young children show a large threat and arousal response to neutral or novel stimuli) (Kagan, Reznick, Snidman, Gibbons, & Johnson, 1988; Davidson, 1994). These children show early traits of shyness, withdrawal, and fear (Kagan et al., 1988), have higher rates of anxiety disorders at school ages (Biederman et al., 1995), and have elevated rates of anxiety disorders in their families (Hirshfeld, Rosenbaum, & Biederman, 1992).

A second major theme regarding vulnerability is a negative affective bias in cognitive and attentional processing. There are various ways that a negative attentional bias may confer vulnerability toward developing an affective illness. Briefly, there are three sets of data supporting this concept: (1) Rothbart and colleagues showed that infants with difficulty breaking off visual attention toward a novel or threatening visual cue showed increased anxiety and depressive symptoms as children (Rothbart, Posner, & Rosicky, 1994); (2) Nolen-Hoeksema and colleagues demonstrated that children with a tendency to ruminate about negative or stressful events had higher rates of depressive symptoms in early adolescence (Nolen-Hoeksema, Girgus, & Seligman, 1992; Nolen-Hoeksema, Parker, & Larson, 1994); and (3) Seligman and colleagues (1984) have presented data showing that children with negative attributional style in interpreting events (taking undue blame for problems, insufficient credit for successes) predicted depression. Although each of these lines of investigation addresses quite different elements of negative bias, there is a more general theme across these studies regarding a tendency to shift mental processes in a direction toward negative affect. A tendency to link cognitive processes with negative affect may strengthen the connections between these systems through early periods of development.

We have hypothesized (Dahl & Ryan, 1996) that one pathway to early onset depression may evolve from strong connections between goal-directed cognitive processes and negative affect. Specifically, we have been interested in the role of negative affective biases in cross-temporal processing in goal-directed behaviors and social interactions. For example, when a young adolescent considers going to a social event, some of the cross-temporal processing involves the remembering of similar social events in the past and projecting these memories into images of future events; if this cross-temporal processing is biased toward negative affect, the adolescent is more likely to remember bad events (or interpret past events as negative), and to imagine that the upcoming social event will also be a negative experience. In other words, if negative affect creates a shadow or bias of the scanning of past experiences into future likelihoods (high cortical functions), then the behavioral outcome is likely to be failure to initiate behaviors toward similar events. We have termed this process anticipatory anhedonia, whereby adolescents will not initiate goal-directed or social behaviors because they imagine they will go poorly (associated with unpleasant affect). On the other hand (in contrast to depressed adults who show anhedonia or the inability

to experience pleasure), many depressed adolescents will enjoy experiences such as social events if they are taken to or encouraged to go to such events (even though they will not initiate behaviors toward attending these events). Over time, however, lack of initiation toward pleasurable or goal-directed behaviors may result in a more traditional form of anhedonia.

Links to Sleep-Arousal Regulation (Or, Back to Sleep)

During adolescence, the pendulum of sleep and arousal regulation tends to get pushed very hard in one direction – toward high arousal and away from sleep – for several reasons. These reasons include adolescents' social schedules, school start times, employment hours, stressors, and sleep and circadian changes at puberty. As presented in this chapter, there are several additional factors leading to frequent and sustained elevations of emotional arousal during adolescence. These factors appear to be particularly marked in some individuals who may have a genetically based decrease in their threshold to activate arousal in response to threat or novelty, resulting in more frequent elevations in arousal with even mild to moderate stressors. Further, negative cognitive biases (a second source of vulnerability to depression) further amplify these problems: diverting internal attention toward threatening, distressing, or painful memories and anticipating negative events in future interactions. One specific example of these tendencies is the pattern of distressing cognitive ruminations at bedtime in depressed adolescents. Although the images and memories are uncomfortable, the adolescent repeatedly revisits them in the interval before falling asleep. It is a bit like pressing one's tongue against a toothache – even though it hurts, they do it again and again, replaying the mental tape of the remembered or imagined stressful experience. These distressing images cause increases in arousal at a time when the sleep and circadian physiology are trying to push arousal to nadir levels to meet other physiologic needs. This creates yet another route of sleep disruption-deprivation and pushes arousal to higher levels. As with the many other sources of decreased sleep and elevated arousal described earlier, there is a capacity for a vicious cycle.

With multiple sources of elevated arousal and decreasing opportunities for sleep, many adolescents end up with profound imbalances in sleep-arousal regulation, which returns the discussion to the consequences of sleep deprivation.

The Consequences of Sleep Deprivation

As has been argued elsewhere (Dahl, Matty, Birmaher, Al-Shabbout, Williamson, & Ryan, 1996; Schlesinger, Redfern, Dahl, & Jennings, 1998), there is increasing evidence that sleep deprivation effects are particularly prevalent in measures of higher cortical functions (Horne, 1993). Further, we have shown in pilot studies that the tasks that simultaneously challenge cognitive and emotional processing appear to be particularly sensitive to sleep deprivation effects. We recently extended this work to a more easily quantifiable domain, looking at higher cognitive processes and another subcortical regulatory system – the maintenance of postural balance – which confirmed our predictions regarding sleep deprivation effects. That study (Schlesinger et al., 1998) showed that, in young healthy university students, one night of sleep deprivation caused no significant effect on performance of either an inhibitory cognitive or postural balance task; however, there was a marked effect on the ability to perform both the cognitive task and the balance task simultaneously after sleep deprivation. In a similar way, sleep deprivation may impair the ability to perform both a cognitive and emotional task at the same time. In summary, there appears to be a vicious negative cycle with sleep deprivation impairing cognitive-emotional regulation, impaired cognitive-emotional regulation leading to increased stress and arousal, and stress and arousal further interfering with sleep, leading to further impairments in affective regulation and emotional well-being.

The Role of Attention (Or, How Can We Teach Highly Aroused-Stressed Kids to Relax?)

In the middle of neurobehavioral systems interconnecting in the regulation of cognition, affect, and behavior, the control of attention sits center stage. In many ways, attention is the selective pattern of linking higher cognitive processes with specific inputs and outputs. In particular, the anterior or executive attentional network (involved in voluntary or effortful control of attention) appears to play a critical role in the patterning of linkage or connections between neurobehavioral systems. These processes are quite amenable to learning or cognitive-behavioral therapy – that is, one can intervene to alter patterns of attention or how attention is used in maladaptive ways. Teaching or training children to avoid

the tendency to overattend to threatening stimuli may have positive effects on both mood and sleep-arousal imbalances so commonly slanted toward high arousal and sleep deprivation in adolescents. If children or adolescents learn to expect that bad things will happen, tend to remember the negative things that occurred (out of proportion to the positive ones), and dwell on the negative implications regarding self-worth, these may contribute enormously to poor regulation of emotions and possibly development of psychopathology, such as depression. Early intervention to alter these patterns of cognitive-emotional linkages may prevent some of these vicious cycles. These strategies may also be effective in having a positive effect on sleep-wake patterns among troubled adolescents. Cognitive-behavioral interventions focused on the interval preceding sleep onset may have effects not only on mood but also on the frequently observed difficulties with sleep onset seen in adolescent depression (Dahl et al., 1996).

Clinical programs (early intervention-prevention with high-risk populations) are in early stages of progress and will help to answer at least some of the questions and speculations outlined in this chapter. Similarly, studies involving the use of f-MRI are also being conducted to examine more specific models of the underlying neurocircuitry involved in affect dysregulation in adolescent depression. Other studies using sleep deprivation as a probe to examine affect regulation are also being conducted.

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