



Changes in Anxiety, Affect, and Emotion Regulation among Sleep-Restricted Healthy Adolescents: An Experimental Investigation

Radhika Reddy, Ph.D., Christine Jackson, B.S., and
Candice A. Alfano, Ph.D.

DISCLOSURES

- I have no actual or potential conflict of interest in relation to this project.

Rationale

- Relatively little research has focused on the effects of sleep restriction/deprivation on affective functioning
- Now well-known that inadequate or disrupted sleep serves as a unique risk factor for the development of a range of psychiatric illnesses across the life span
- Specific mechanisms of the effects of sleep on affective functioning remain relatively unexplored

Experimental Sleep Deprivation in Youth

- A small number of studies examining effects on affective functioning
- Compared to a control (rested) condition, adolescents ages 10 through 16 who were partially sleep deprived evidenced:
 - Less reported positive affect (Talbot et al., 2010)
 - No difference in reported negative affect (Talbot et al., 2010)
 - Patterns in vocal cues: Decreases in positive emotion and increases in negative emotion (McGlinchey et al., 2011)

Experimental Sleep Deprivation in Youth

- Increased emotional reactivity to negative image stimuli (Leotta et al., 1997)
- Sleep restriction causes problems in affect and poorer emotion regulation (Baum et al. 2014)
 - Limitations:
 - Relied on a 3 question measurement of this construct
 - Parent and adolescent report → therefore more the perception

Limitations of Sleep Deprivation Research

○ Limitations:

- Vast majority of research to date has been conducted in adult samples
 - Results cannot necessarily be generalized to youth
 - Youth may be more susceptible to the effects of sleep deprivation on emotional functioning (McGlinchey and colleagues, 2011; Dagsys et al., 2011)
 - Adolescence = period of increased risk for emotional/behavioral problems
 - Emotional development is a progressive process spanning into young adulthood
 - Increased sleep need during earlier periods of development
 - Adolescents chronically sleep deprived
- Only one study has directly examined the impact of sleep restriction on emotion regulation (Baum et al., 2014)



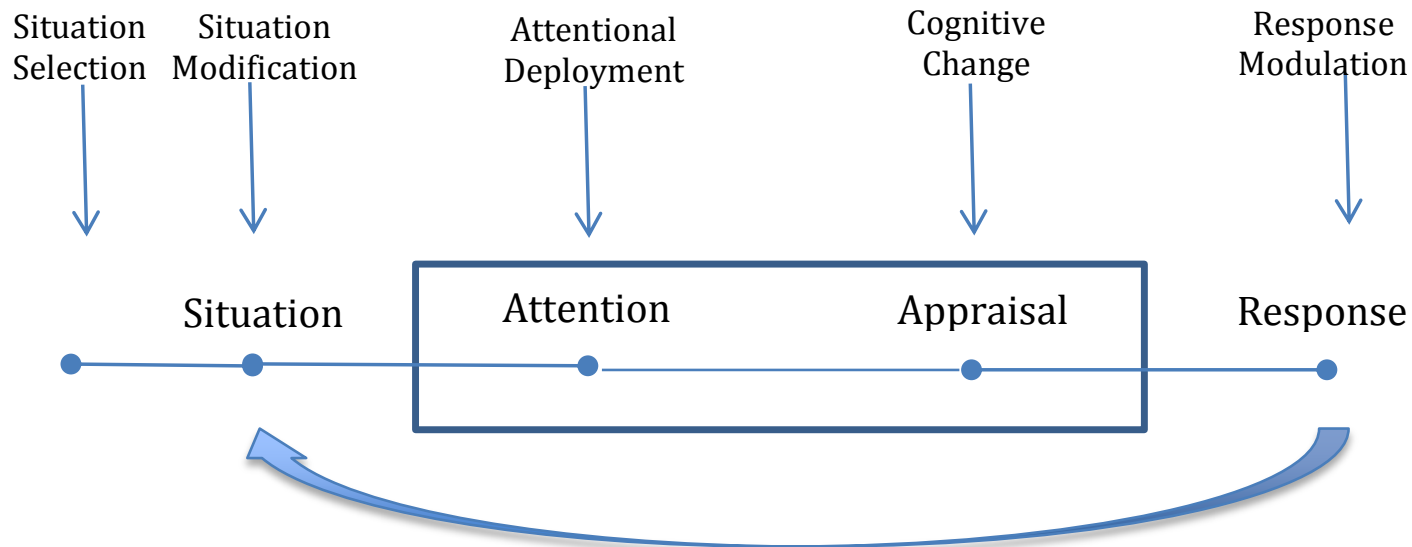
Emotion Regulation

- defined as “the processes by which we influence which emotions we have, when we have them, and how we experience and express them” (Gross, 2002, p. 282).
- involves changes in the “latency, rise time, magnitude, duration, and offset of responses” in three key, often interrelated domains: behavioral, experiential, or physiological (Gross, 2002).
- Adolescence = favorable time period to examine emotion regulation
 - heightened emotional arousability associated with the onset of puberty
 - have not yet achieved adequate development of regulatory competence

Gross's Process Model of Emotion Regulation

Elucidates the five different points in which emotion regulation strategies can have their primary impact on the process in which emotions are produced

Figure 2.



Process Model of Emotion Regulation (Gross & Thompson, 2007)

Emotion Regulation

- reappraisal associated with a “healthier profile” of social, cognitive, and short-term affective consequences as compared to suppression (John & Gross, 2004)
- Emotion dysregulation is prominent in various forms of psychopathology
 - anxiety, depression, eating, and substance-related disorders (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Suveg & Zeman, 2004)

Current Study

- Adolescent Sample (Ages 13-17)
- Between groups experimental design
 - Acute Sleep restriction (4 hours)
 - Idealized Sleep (9.5 hours)
- Extend on prior findings regarding effects of sleep on affective functioning
- Explore potential mechanisms (emotion regulation)



HYPOTHESES

Aims

- 1). Affect
- 2). Emotional Reactivity
- 3). Emotion Regulation
- 4). Mediating Role of Emotion Regulation

Aim 1: Affect

- **Positive Affect (PA)**
 - PANAS-C (Laurent et al., 1999)
 - Restriction < Idealized
- **Negative Affect (NA)**
 - PANAS-C (Laurent et al., 1999)
 - Restricted = Idealized
- **State Anxiety (A-State)**
 - STAIC (Spielberger, 1973)
 - Restricted > Idealized
- **Trait Anxiety (A-Trait)**
 - STAIC (Spielberger, 1973)
 - Restricted = Idealized

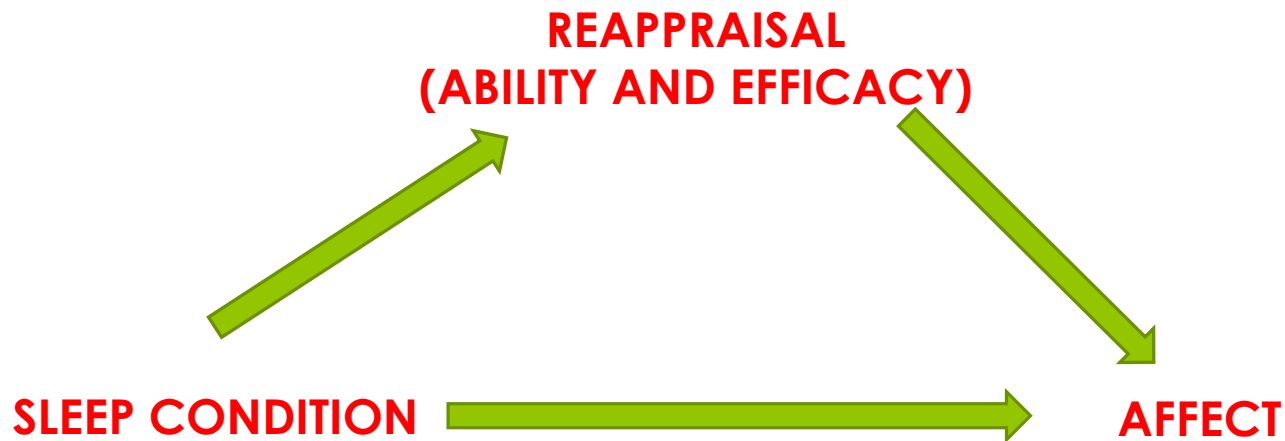
Aim 2: Emotional Reactivity

- Assessed via Self-Assessment Manikin (SAM) arousal/valence in response to IAPS images
- **Negative Images**
 - Restriction > Idealized (more negative valence, higher arousal)
- **Neutral Images**
 - Restricted = Idealized (similar valence & arousal)
- **Positive Images**
 - Restricted = Idealized (similar valence & arousal)

Aim 3: Emotional Regulation

- Assessed via Self-Assessment Manikin (SAM) arousal/valence in response to negative IAPS images, in a reappraisal task.
- **Reappraisal Ability**
 - Restricted < Idealized (quantity of reappraisal statements generated)
- **Reappraisal Efficacy**
 - Restricted < Idealized (difference in SAM valence ratings between reappraised vs. viewed images)

Aim 4: Mediating Role of Emotion Regulation



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METHOD

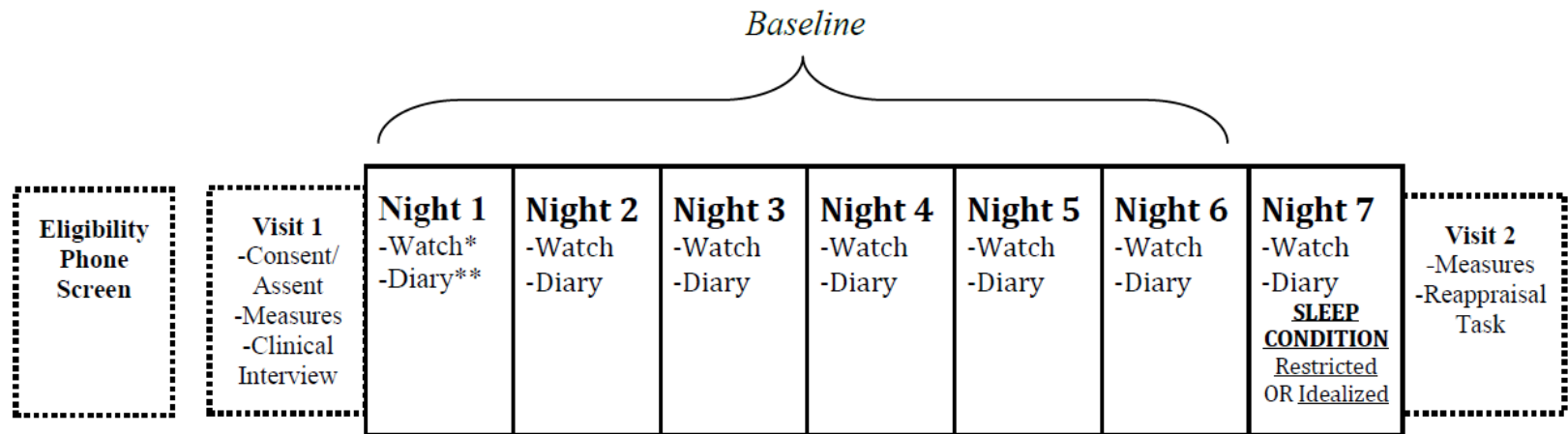
Participants

- N = 42 adolescents
 - Ages: 13-17 ($M = 14.86$, $SD = 1.32$)
 - Gender: 18 male, 24 female
 - Ethnicity:
 - 57.1% Caucasian
 - 23.8% African American
 - 14.3% Asian
 - 4.8% of mixed race
 - 16.7% Hispanic
 - 83.3% Non-Hispanic

Participants

- Inclusion criteria were:
 - a) absence of current psychiatric disorder or significant emotional/behavioral problems
 - b) absence of lifetime history of Major Depressive Disorder;
 - c) absence of any suicidal thoughts, behaviors, or previous attempts;
 - d) absence of diagnosis or suspicion of a sleep disorder,
 - e) absence of a chronic medical condition potentially affecting sleep (e.g., atopic dermatitis, pain-related syndromes);
 - f) absence of the use of any medication or supplement potentially impacting mood/sleep (e.g., stimulants, anti-histamines, illicit substances);
 - g) enrollment in a mainstream classroom;
 - h) English-speaking; and
 - i) maintaining a regular sleep schedule during the week of actigraphy and compliance with the assigned sleep condition.

Study Timeline



*Watch = Actigraph Watch **Diary = Nightly Diary

Measures- Eligibility Evaluation

Clinician Based Measures

Kiddie Schedule for Affective Disorders and Schizophrenia for School-Age Children-Present and Lifetime Version (K-SADS-PL; Kauffman et al., 1997).

BEARS Sleep Screen (Owen et al., 2005)

Actigraphy

A wrist actigraph is a small watch-sized device that is worn on the non-dominant hand 24 hours a day and measures movement.

Measures- Eligibility Evaluation

Parent-Based Measures

General Information Sheet

Revised Children's Anxiety and Depression Scale, Parent Report (RCADS-P; Chorpita, Yim, Moffit, Umemoto, & Francis, 2000)

Child Behavior Checklist For Ages 6-18 (CBCL; Achenbach, 1991)

Children's Sleep Habits Questionnaire (CSHQ; Owens, Maxim, Nobile, McGuinn, & Msall, 2000)

Child-Based Measures

Revised Children's Anxiety and Depression Scale (RCADS; Chorpita et al., 2000)

Sleep Self Report (SSR; Owens et al., 2000)

Youth Self Report (YSR; Achenbach, 1991)

Daily Sleep Diary: completed after first visit

Measures: Laboratory-Based Assessment following Experimental Night

Positive and Negative Affect Schedule for
Children (PANAS-C; Laurent et al., 1999)

State-Trait Anxiety Inventory for Children
(STAIC; Spielberger, 1973)

Epworth Sleepiness Scale (ESS; Johns, 1991)

Adolescent Cognitive Reappraisal Task

Adolescent Cognitive Reappraisal Task

- Used to assess both emotional reactivity and regulation
- Viewed 40 images from International Affective Picture System (IAPS; Lang et al., 2008)
 - 8 positive view
 - 8 neutral view
 - 12 negative view
 - 12 negative to be reappraised
- Order of images in task was randomized

Sample of IAPS Images

Positive



Neutral

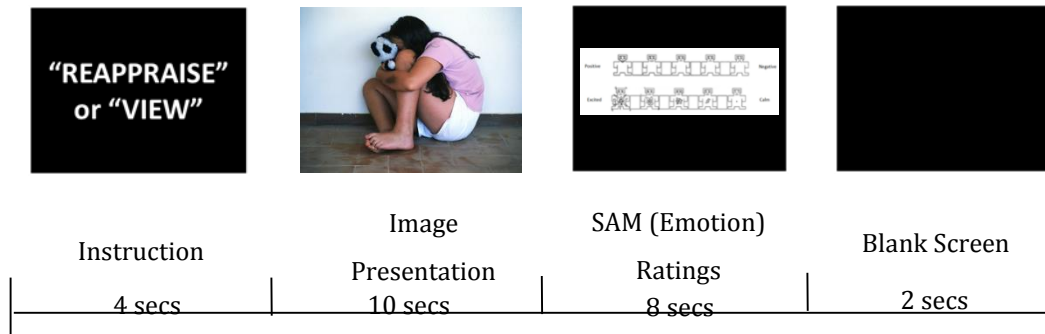


Negative



Adolescent Cognitive Reappraisal Task

- Procedure
 - Training of Technique
 - Practice
 - Task Administration



1). It's not real

"It's just a movie"

"They're only actors"

"It's photoshopped"

Ex: She is just an actress in a movie pretending to be scared.

2). Things will get better over time

Ex: "The girl will go play with her friends later that day and have fun"


3). There's a more positive explanation


Ex: "She is tired after playing in the playground with friends and has fallen asleep."





Affective Rating Form


- The Self-Assessment Manikin (SAM) (Bradley & Lang, 1994)


1. Positive  Negative

Excited 

2. Positive  Negative

Excited 

3. Positive  Negative

Excited 

4. Positive  Negative

Variables Derived

- Emotional Reactivity
 - Positive Image Reactivity
 - Positive Images Valence (avg valence ratings)
 - Positive Images Intensity (avg intensity ratings)
 - Neutral Image Reactivity
 - Neutral Images Valence (avg valence ratings)
 - Neutral Images Intensity (avg intensity ratings)
 - Negative Images Reactivity
 - Negative Images Valence (avg valence ratings)
 - Negative Images Intensity (avg intensity ratings)
 - Reappraised Negative Images Valence (avg valence ratings)
 - Reappraised Negative Images Intensity (avg intensity ratings)

Variables Derived

- Reappraisal Ability
 - based on the actual reappraisal statements provided by participants
 - Coded by research staff
 - Could range from 0 to 6
- Reappraisal Efficacy
 - subtracting the mean valence rating from the “View” images from the mean valence rating for the “Reappraise” images.
 - difference score that reflected reduction in negative emotion produced by use of reappraisals (higher score = higher reduction in negative emotion)

Summary of Laboratory-Based Assessment

Construct Assessed	Measure/ Task
Affect	Positive and Negative Affect Schedule for Children (PANAS-C) State-Trait Anxiety Inventory for Children (STAIC)
Sleepiness	Epworth Sleepiness Scale (ESS)
<i>Emotion Regulation</i>	
Reappraisal Ability	Adolescent Cognitive Reappraisal Task
Reappraisal Efficacy	Adolescent Cognitive Reappraisal Task
<i>Emotion Reactivity</i>	
Positive Image Reactivity	IAPS image ratings
Neutral Image Reactivity	IAPS image ratings
Negative View Image Reactivity	IAPS image ratings
Negative Reappraised Image Reactivity	IAPS image ratings

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RESULTS

Preliminary Analyses/Equivalence of Groups

- No differences in:
 - **Baseline Affect and Sleepiness Variables**
(ESS, PA, NA, A-STATE- A-TRAIT) [F (5, 36) = .165, η^2 = .022, p = .974]
 - **Demographics**
 - Age [t (40) = .563, p = .577]
 - Gender: χ^2 (1) = .389
 - Ethnicity: χ^2 (4) = 4.863, p = .302
 - **Baseline Sleep Duration(TST)** [t (40) = -.358, p = .722]
 - Entire Sample M = 7.88 hours, SD = 0.89
 - Restricted: M = 7.83, SD = 0.95
 - Idealized: M = 7.93, SD = 0.85

Preliminary Analyses-Validity of Sleep Manipulation

- Total Sleep Time (TST):
 - Restricted < Idealized, [$t(40) = -21.36, p < .001$]

Restricted M (SD)	Idealized M (SD)
4.62 (0.69)	9.30 (0.73)

- Subjective Levels of Sleepiness (ESS)
 - Restricted > Idealized [$F(1, 39) = 18.89, \eta^2 = .326, p < .001$]

Restricted M (SE)	Idealized M (SE)
11.94 (0.92)	6.26 (0.92)

- Effectiveness of sleep manipulation = valid

Analyses

- A series of multivariate general linear models (w/ sleep condition as between subjects factor) grouped by:
 - 1) Affect scales (PANAS PA and NA, STAIC A-State and A-Trait)
 - 2) Specific PANAS-C items
 - PA items
 - NA items
 - 3) Emotional reactivity
 - 4) Reappraisal variables
- Baseline covariates included if appropriate
- Significant multivariate effects were followed by examination of univariate tests

AFFECT

- Analysis:
- DVs:
 - T2 PANAS-C Positive Affect
 - T2 PANAS-C Negative Affect
 - T2 STAIC A-State
 - T2 STAIC A-Trait
- T1 versions of these variables were covariates
- Multivariate effect was significant [$F(4, 33) = 9.32, \eta^2 = .531, p < .001$]

AFFECT

- Positive Affect
 - Restricted < Idealized ($p = .002$)
- Negative Affect
 - No group differences ($p = .110$)
- State Anxiety
 - Restricted > Idealized ($p < .001$)
- Trait Anxiety
 - Restricted > Idealized ($p < .01$)

Negative Affect- Floor Effect

Negative Affect(NA)			
	Overall	Restricted	Idealized
	Mean (SD)	Mean (SD)	Mean (SD)
Sad	1.03 (0.16)	1.05 (0.23)	1.00 (0.00)
Frightened	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Ashamed	1.03 (0.16)	1.05 (0.23)	1.00 (0.00)
Upset	1.15 (0.43)	1.26 (0.56)	1.05 (0.22)
Nervous	1.44 (0.68)	1.42 (0.84)	1.45 (0.51)
Guilty	1.05 (0.22)	1.11 (0.32)	1.00 (0.00)
Scared	1.05 (0.22)	1.05 (0.23)	1.05 (0.22)
Miserable	1.10 (0.38)	1.21 (0.54)	1.00 (0.00)
Jittery	1.41 (0.75)	1.47 (0.91)	1.35 (0.59)
Afraid	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Lonely	1.03 (0.16)	1.05 (0.23)	1.00 (0.00)
Mad	1.13 (0.41)	1.21 (0.54)	1.05 (0.22)
Disgusted	1.08 (0.35)	1.05 (0.23)	1.10 (0.45)
Blue	1.13 (0.41)	1.21 (0.54)	1.05 (0.22)
Gloomy	1.15 (0.43)	1.26 (0.56)	1.05 (0.22)

Emotional Reactivity

- Analysis

- 8 DVs (based on SAM ratings)

- Positive Valence Positive Intensity
 - Neutral Valence Neutral Intensity
 - Negative Valence Negative Intensity
 - Reappraised Negative Valence Reappraised Negative Intensity

- Multivariate effect was not significant [F (8, 33) = 0.842, $\eta^2 = .170$, $p = .573$]

- No group differences in valence or arousal for image categories
 - Marginal finding for negative images ($p = .061$)
 - Restricted rated more negative valence

Emotion Regulation (Cognitive Reappraisal)

- Analysis
 - DVs: *Reappraisal Ability* and *Reappraisal Efficacy* scores
- Multivariate effect nonsignificant [$F(2, 39) = 0.138, \eta^2 = .007, p = .872$]
 - No group differences in reappraisal variables
- Cognitive reappraisal reduced negative valence ratings across groups

Emotion Regulation (Cognitive Reappraisal as a Mediator)

- Used bootstrap tests for indirect effects, as suggested by Preacher and Hayes (2008)
- Four separate models were run, one each for the following dependent variables: PANAS-C PA, PANAS-C NA, STAIC A-State, and STAIC A-Trait.
- IV = sleep condition
- Mediators = reappraisal variables
- Covariates = T1 affect variables

Emotion Regulation (Cognitive Reappraisal as Mediator)

Table 8
Summary of Multiple Mediator Model Analyses

Model	Independent Variable (IV)	Mediator (M)	Dependent Variable (DV)	Indirect Effect b (SE)	95% CI
1	Sleep Condition	Reappraisal Ability	T2 PANAS-C PA	.168 (.601)	- .502 - 2.434
		Reappraisal Efficacy		.160 (.833)	-1.175 - 2.351
		TOTAL		.329 (.931)	-1.058 - 2.976
2	Sleep Condition	Reappraisal Ability	T2 PANAS-C NA	.053 (.182)	-.154 - .744
		Reappraisal Efficacy		.011 (.139)	-.125 - .500
		TOTAL		.065 (.216)	-.207 - .859
3	Sleep Condition	Reappraisal Ability	T2 STAIC A-State	-.004 (.151)	-.375 - .246
		Reappraisal Efficacy		.013 (.144)	-.118 - .507
		TOTAL		.009 (.209)	-.364 - .527
4	Sleep Condition	Reappraisal Ability	T2 STAIC A-Trait	.032 (.136)	-.124 - .516
		Reappraisal Efficacy		.042 (.224)	-.370 - .559
		TOTAL		.075 (.241)	-.364 - .632

Note: T2= Time Point 2 (Post-Experimental). The following covariates were also included:
 Model 1- Time 1 PANAS-C PA; Model 2- Time 1 PANAS-C NA; Model 3-Time 1 STAIC A-State;
 Model 4- STAIC A-Trait.

ALL Confidence Intervals Contain "0"

- emotion regulation was not a mediator



DISCUSSION

Aim 1: Effects of Sleep on Affect

Positive Affect

- Sleep restriction → decreased positive affect
 - Hypothesis supported
- Consistent with other studies

Decreased Positive Affect

- Possible Explanations:
 - Sleepiness and mood are interrelated (Woodson, 2006)
 - Sleepiness → decreased receptivity to positive emotions
 - Sleep loss reduces the positive effect of goal-enhancing events (e.g., unexpected opportunities to work towards a goal) (Zohar et al., 2004)

Negative Affect

- Sleep restriction did not impact negative affect
 - Hypothesis supported
- Mixed findings in research literature, both in adults in youth

Negative Affect

- Possible explanations for discrepancies
 - Contextual influences of affect
- Specific measure used to assess negative affect
 - floor effect for negative affect items on the PANAS-C
- Overall, premature to conclude that sleep restriction does not impact negative affect

State Anxiety

- Sleep loss → increase in state (transitory) anxiety
 - Hypothesis supported
- Consistent with other studies in both teens and adults

- Possible Explanations:
 - stress-related neurobehavioral effects resulting from sleep loss
 - physiological processes (e.g., disruption in functioning of the hypothalamic-pituitary-adrenal axis)

Trait Anxiety

- sleep restriction → increases in trait anxiety scores
 - Hypothesis NOT supported
- possible explanations for this finding:
 - mood-dependent memory biases
 - expectancy effect
 - measurement artifact?
- One other study in adults did find acute sleep loss to adversely affect trait-like anxiety (Kahn-Greene et al., 2007)

Aim 2: Effects of Sleep on Emotional Reactivity

Emotion Reactivity

- Sleep restriction did not result in changes in emotional reactivity in response to positive or neutral IAPS images
 - Hypothesis supported
- Consistent with most prior research

Emotional Reactivity

- Sleep restriction did not result in changes in emotional reactivity in response to negative images
 - Hypothesis NOT supported
- Consistent with some, but not other research
 - The group difference in valence ratings for negative images did show a trend toward significance ($p=.061$) in the hypothesized direction
- Overall sleep restriction does not meaningfully impact subjective emotional reactivity to emotionally-evocative or neutral stimuli.
- worthwhile to concurrently examine reactivity assessed via behavioral and physiological domains
 - Do not have to correlate!
- current study focused on the experiential aspect of emotional reactivity

Aims 3-4:

(3) Effects of Sleep on Emotion Regulation

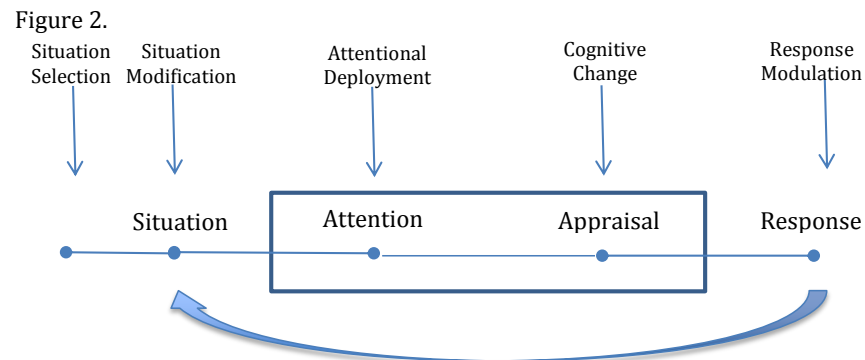
(4) Emotion Regulation as Mediator of Sleep Condition and Affect

Emotion Regulation

- restricted sleep did not result in decreased reappraisal ability or efficacy
 - Hypotheses were not supported
- emotion regulatory variables did not mediate the effects of sleep condition on affective functioning
 - Hypothesis not supported
- Inconsistent with prior research (e.g., Baum et al., 2014)

Emotion Regulation

- Inconsistent with prior research (e.g., Baum et al., 2014)
- Possible Explanations:
 - Reappraisal may be resistant to moderate sleep loss.
 - Operationalization of emotion regulation
 - Spontaneous versus cued
 - Other emotion regulatory strategies could be differentially impacted by sleep loss.



Process Model of Emotion Regulation (Gross & Thompson, 2007)

Implications

- More evidence for link between inadequate sleep and anxiety
 - Evidence for causation
 - Highlights need for adequate sleep
- Adolescence = chronic sleep deprived period
- Adolescence = heightened emotional arousability/difficulties with self-regulation of emotions (Steinberg, 2005)
 - May be especially vulnerable!

Implications for Treatment

- Treatments for adolescents with disorders related to anxiety/and or mood might consider the inclusion of a sleep component (e.g., psycho-education on sleep, sleep hygiene).
- Inclusion of cognitive reappraisal technique in treatment for affective disorders

Additional Limitations: Sample

- Threat to External Validity: Generalizability
 - current sample consisted of only healthy adolescents
 - Findings cannot readily be generalized to other (e.g., clinical) samples.
 - Many teens cannot attain 7 hours of sleep to participate
- Small sample size
 - Future studies using alternative designs and larger samples are needed

Additional Limitations:

- Possible expectancy effects
 - Withhold true aim of study
- Include measure that is not expected to differ between groups
- Inclusion of objective indices

Additional Limitations: Reappraisal Task

- Image Selection
 - Negative IAPS images used in the study may not have been evocative enough
 - Inclusion of more threatening stimuli may elicit stronger negative reactions that then have more potential to be down-regulated
- Ecological Validity
 - Reappraisal task took place in the laboratory setting
 - Participants may respond differently in a more naturalistic environment.
 - Spontaneous vs. cued use of cognitive reappraisal skills
 - Possible lack of personal relevance
- Reappraisal may have been used towards all images

Conclusion

- One night of modest sleep restriction sleep has adverse effects on positive affect and anxiety.
- A lack of effect on emotional reactivity and emotion regulation in response to emotionally-evocative and neutral stimuli
- Overall, findings add to a growing body of research suggesting the deleterious effects of sleep loss on affective functioning among healthy adolescents.
- Future research should replicate and elucidate the specific mechanisms of these effects.



QUESTIONS/COMMENTS?
THANK YOU!!!

Participant Flow Chart

