Behavioral Circadian Rhythms in Relation to Sleep and Mood in Older Adults

Conclusions
- There is a significant link between circadian rhythms and sleep in older adults.
- The disruption of circadian rhythms can lead to sleep disorders and depression.
- Promoting healthy sleep habits can help improve circadian rhythms and overall well-being.

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Conclusions
- Behavioral rhythms (e.g., sleep habits) are essential.
- Circadian rhythm disruptions may indicate the presence of sleep disorders or mood disturbances.
- The study highlights the importance of understanding circadian rhythm regulation in older adults.
- Further research is needed in this area (e.g., sleep behavior, cholesterol level, age)

Background

Research
Background

Behavioral Rhythms

Role of Age
(in circadian rhythms, sleep & mood)

Protective Factors

Risk Factors
Behavioral Rhythms

Chronobiology

chronopsychoLOGY LAB
The study of the effect of time on biological events, especially repetitive or cyclic phenomena in individuals.
• Foundation of the field - 1700s

• Work of the French scientist de Mairan

• Studied daily leaf movements of a plant

• Daily raising and lowering of the leaves continued even when the plant was placed in an interior room (not exposed to sunlight) ....internal clock
The study of the effect of time on psychological events, especially repetitive or cyclic phenomena in individuals.

"Think in the morning, act in the noon, read in the evening, and sleep at night."

- William Blake
Increasing awareness of role of time in daily functioning...

Ted Talk -2010

Smithsonian - Jan 2013
Duration of Cycles

- **Ultradian:** Occurs more than once a day (eating, changes in affect)
  - Circadian: Occurs approx. every 24 hours (sleep-wake cycle, body temperature)
  - Infradian: Occurs more than every 24 hours and less than yearly (menstrual cycle, SAD)
  - Circannual: Occurs approx. yearly (hibernation cycle in animals, bird migration, anniversaries)
Behavioral Circadian Rhythms

behavioral rhythms

| social rhythms |
| lifestyle regularity |

schedules

habits

rituals

routines
Behavioral Rhythms: External Cues

(Zeitgebers)
Theoretical Framework: Dysfunction

Social Zeitgeber Theory
(Ehlers, Frank, & Kupfer, 1988)
Role of Age
(in circadian rhythms, sleep & mood)

Protective Factors

Risk Factors
Risk Factors

Sleep Changes

or does it?

Circadian Rhythm Changes

Phase Advance
- Body Temperature
- Daily Activities

Decreased Zeitgeber Sensitivity/Exposure

Decreased Amplitude?
(Mask, 2005)
Sleep Changes

or does it?
Sleep Across the Lifespan

Ohayon, Carskadon, Guilleminault, et al., 2004

Meta-analysis of quantitative sleep parameters (childhood to old age)

• less total sleep time
• more awake time
• less efficient sleep
• less slow-wave sleep

****changes most notable across ages 18-40, 40-60
It is Not "Age Per Se"

- If 50% of older adults complain of significant sleep disturbance, there's 50% that do not complain.
  
  (Vitiello, 2006)

- Sleep can be conceptualized as a geriatric syndrome
  
  (Vaz Fragoso & Gill, 2007)
multifactorial in origin

dementia, caregiving, bereavement, health conditions, decreased activity, medications, primary sleep disorders
Circadian Rhythm Changes

Phase Advance
- Body Temperature
- Daily Activities

Decreased Zeitgeber Sensitivity/Exposure

Decreased Amplitude?
(Monk, 2005)
Phase Advance: Body Temperature

- circadian rhythm of body temperature parallels sleep-wake cycle

- temperature rises = alertness; temperature drops = sleepiness

Monk, 1991
The graph shows the average temperature over the course of the day for young males and old males. The graph highlights the "afternoon temperature "dip"" and differentiates between the wake maintenance zone and the sleep propensity zone.
Phase Advance: Behavioral Activities

• Older adults engage in activities earlier in the day

• Significant age differences (p < .001 for all activities except 1st and 2nd television program [p < .05]).
Circadian Rhythm Changes

Phase Advance
  - Body Temperature
  - Daily Activities

Decreased Zeitgeber Sensitivity/Exposure

Decreased Amplitude?
(Monk, 2005)
Older adults may be less sensitive to light due to changes in lens opacity, pupil size, or retinal function.

(Welsh & Ptacek, 2010)

Older adults tend to be exposed to less bright light particularly less evening light.

(Youngstedt et al., 1998)
Circadian Rhythm Changes

Phase Advance
- Body Temperature
- Daily Activities

Decreased Zeitgeber Sensitivity/Exposure

Decreased Amplitude?
(Monk, 2005)
Protective Factors

Lifestyle Regularity

Greater lifestyle regularity linked to positive outcomes across age groups.

Better sleep outcomes:
- More efficient mental performance (Horne et al., 2019)
- Improved mood (Cain et al., 2016)

Faster depressive symptoms:
- Enhanced social support (Horne et al., 2019)
- Improved mood (Cain et al., 2016)

Aging as Protection Against Poor Mood

Greater overall emotional well-being & stability associated with age.

Cain et al., 2016

Income in old age:
- Higher levels of social support (Horne et al., 2019)
- Improved mood (Cain et al., 2016)
Lifestyle Regularity

Regularity of behavioral rhythms exists along a continuum of age.

- Chaotic, random timing of events
- Remarkable consistency in the timing of their daily activities

- Increases with age, across the age spectrum (ages 19 to 92; Monk et al., 2002)
- Within (ages 20 to 40; Monk et al., 1994; age 60+; (Monk et al., 2006)
Lifestyle Regularity

Greater lifestyle regularity linked to positive outcomes across age groups

Better sleep outcomes
(Brown et al., 1996; Carney et al., 2006; Monk et al., 2003; Zisberg et al., 2010)

Fewer depressive symptoms
(Ehlers, 1998; Monk et al., 1991; Monk et al., 2010)
Aging as Protection Against Poor Mood

Greater overall emotional well-being & stability associated with aging

(Carstensen et al., 2011)

Socioemotional selectivity theory: investing greater resources in emotionally meaningful goals, activities, relationships

(Carstensen, Isaacowitz, & Charles, 1999)
Research
Behavioral Rhythms

Background
- Study Background
  - Functional magnetic resonance imaging (fMRI) is a non-invasive imaging technique that provides information about brain function and structure.

Study Arms
1) Manipulate the arousal level and measure the effect on brain activity.
2) Assess the impact of external factors on the brain's activity.

Methods
- Population
- Sample Size
- Assessment Tools
- Data Analysis

Results
- Aim 1
- Aim 2
- Aim 3
Background

Study Background

• Levels of behavioral regularity have typically been aggregated over a period of a week or longer.

• What remains unclear is whether deviations in the timing of behaviors on a daily basis are sufficient to entrain sleep outcomes.

Study Aims

1) Quantify the extent that older and younger adults’ sleep outcomes fluctuate on a daily basis.

2) Examine extent daily/weekly timescales of behavioral regularity predict sleep outcomes in younger and older adults.
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Methods

**Study Design**
- Daily process modeling and study design

**Daily Measures**
- Social Rhythm Metric - 17
  - Math: Crocker, Parks, Peterson, 2003
  - Used to assess daily routine and schedule
- Sleep Diary
  - Cullen, Rust, & Mass, 1991
  - Used to assess sleep patterns

**Procedure**
- Participants were recruited from the South Central Pennsylvania area
- Study materials completed online
- Paid in participants who completed the study were awarded $10 compensation
- Undergraduate students received course credit
- 58 younger (18-34) and 56 older (55+) participants

**Exclusionary Criteria**
- Currently working shift work
- Unable to complete study materials using a computer
- Currently on vacation or plan to take a vacation during the next two weeks
- Diagnosed with a mental disorder
- Drug disorder other than tobacco use
- Engaged in substance abuse
- Pregnant

**Participants**

**Younger**
- Age: 20 (28.5%)
- 75% female
- 54% either
- 50% African-American
- 80% college educated
- Not single
- Not a smoker
- Not a diabetic
- Not on drugs

**Older**
- Age: 60 (74%)
- 69% female
- 16% African-American
- 52% college educated
- Single
- Smoker
- Diabetic
- On drugs
Study Design

- Daily process microlongitudinal study design

Baseline  14 days of daily measures
Daily Measures

• **Social Rhythm Metric - 17**
  (Monk, Flaherty, Frank, Hoskinson, & Kupfer, 1990)
  • 15 daily activities + 2 person-specific
  • Time of activity, persons present, level of other involvement
  • Using algorithm calculate SRM score (0-7)

• **Sleep Diary**
  (Lichstein, Riedel, & Means, 1999)
  • Sleep onset latency
  • Sleep efficiency
Procedure

- Participants were recruited from the North Central Florida area and online.

- Study materials completed online

- First 30 participants who completed the study were awarded $10 compensation

- Undergraduate students received research credit

- 50 younger (18-30) and 50 older (60-95) adults
Exclusionary Criteria

1) currently working shift work
2) unable to complete study materials using a computer
3) visual deficits that preclude participation
4) currently on vacation or plan to take a vacation during the next two weeks
5) diagnosed with a dementia disorder
6) sleep disorders other than insomnia (periodic limb movement disorder, sleep apnea)
7) are currently pregnant.
Participants

Younger

- Age 20 (SD=2.85)
- 72% female
- 72% white
  - 16% Asian
  - 12% African American
- 80% college educated
- 14% live alone
- 96% single
- health rating 3.84/5
- 86% good sleepers

Older

- Age 68 (SD=6.73)
- 62% female
- 90% white
  - 6% Asian
  - 4% African American
- 92% college educated
- 29% live alone
- 2% single
- health rating 3.48/5
- 40% good sleepers
Results

**Aim 1**
- Interindividual variability (the variation across an individual's own model) was calculated using the intraclass correlation coefficient (ICC).
- The effect of running a well-structured, multilevel model (MMLM) for each sleep variable.

**Aim 1**

**Aim 2**
- Hierarchical multilevel model building.
  - **Level 1 (within-person level):**
    - Are daily sleep patterns regulated with total and deep sleep over the year?
  - **Level 2 (between-person level):**
    - Are lower levels of regulatory control detected over the two scales associated with better sleep quality?

**Aim 2: SOL**

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**Results**
- Between 40 - 45% of the variability in sleep was due to within-person variation.
- Disregulation of activities on a weekly (not daily) level predicted sleep most linearly in 40 - 0.23, 40 - 0.19 and sleep efficiency 30 - 0.09, 30 - 0.06.
- Age interaction: younger adults with more sleep time in activities on a weekly basis took longer to fall asleep and spent less time asleep relative to bed.

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Aim 1

- Intraindividual variability (fluctuations around an individual’s own mean) was calculated using the intraclass correlation coefficient (ICC).

- Derived by running a null, predictor-free, multilevel model (MLM) for each sleep variable.
Aim 2

• Hierarchical multilevel model building

• Level 1 (within-persons level)
  • “Are days with more/less regularity associated with better/worse sleep outcomes for that night?”

• Level 2 (between-persons level)
  • “Are higher levels of regularity overall (averaged over the two weeks) associated with better sleep overall?”
## Aim 2: SOL

<table>
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<th>Model 4</th>
<th>Model Fit</th>
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<tr>
<td>Lifestyle regularity (WP)$^b$</td>
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Model Fit: 11333.75 (9)***
### Aim 2: SE

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<tr>
<td>age X Lifestyle regularity (WP)(^b)</td>
<td>-0.01</td>
<td>0.01</td>
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</table>

| Intercept                                      | 36.47    | 6.06*** |
| Residual                                       | 71.02    | 2.98*** |
| Linear Time                                    | -        | -  |
| Lifestyle regularity (WP)\(^b\)                | 0.00\(^5\) | 0.00\(^5\) |

| Model Fit                                      |          |     |
| -2 log-likelihood (df)                         | 8957.08 (8)*** |   |
Results

- Between 63 - 85% of the variability in sleep was due to within-person variations.

- Dysregulation of activities on a weekly (not daily) level predicted sleep onset latency ($b=0.22$, $SE=0.10$) and sleep efficiency ($b=-0.09$, $SE=0.04$).

- Age interaction: younger adults with more disruption in activities on a weekly basis took longer to fall asleep and spent less time asleep while in bed.
Napping

Day-to-day variability in nap duration predicts medical morbidity in older adults


Background
- Age-related increase in napping & health conditions
- Typically investigated using categorical or mean values

Goal:
- Assess whether day-to-day variability in nap duration is predictive of poorer health
- Napping is highly variable behavior
- Measures of central tendency may not be sufficient

Rationale:

Participants
- 103 community-dwelling, 60+ years
- Mean age: 73
- 94% White, non-Hispanic
- 56% Female
- College-educated (mean = 16 years)
- 71% Married
- Mean number of health conditions = 2
- Sleep classification = 58% good sleepers

Procedure
- Recruit North Florida, compensated $30
- Study entry completed: demographics, health status, and behavior questionnaire
- 14 days completed sleep diary
- Concurrently, wore actiwatch for 14 days

Results

Step 1
- Confirm that napping is a variable behavior

Step 2
- Determine association between variability in nap duration & health conditions

-
Day-to-day variability in nap duration predicts medical morbidity in older adults

Background

• Age-related increase in napping & health conditions
• Typically investigated using categorical or mean values

Goal: assess whether day-to-day variability in nap duration is predictive of poorer health

Rational: napping is highly variable behavior (measures of central tendency may not be sufficient)
Participants

- 103 community-dwelling, 60+ years
- Mean age=73
- 96% White, non-Hispanic
- 64% Female
- College-educated (mean=16 years)
- 71% Married
- Mean number of health conditions=2
- Sleep classification=58% good sleepers
Summary:

- Recruited North Florida, compensated $30
- Study entry: completed Demographics, health status, and behaviors questionnaire
- 14 days completed sleep diary
- Concurrently, wore actiwatch for 14 days
Results

Step 1

Confirm that napping is a variable behavior

Step 1: Variability in napping

- calculated the intraindividual standard deviation (SD) for nap duration from sleep diary & activity watch data
- 44-50% of the total amount of variability was due to fluctuations within individuals for sleep diary & actigraphy napping (compared to 56% & 50% between persons)

Step 2

Determine association between variability in nap duration & health conditions

Step 2: Nap & Health Association

- Bivariate correlations between nap & health variables
- Multiple hierarchical regression analyses

Step 2: mean nap & variability in nap entered, accounted for 15% of variance in health conditions (mean nap n.s. p>.81)
Step 1: Variability in napping

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Determine association between variability in nap duration & health conditions

Step 2: Nap & Health Association

- Bivariate correlations between nap & health variables
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Step 2: Nap & Health Association

- Bivariate correlations between nap & health variables

<table>
<thead>
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<th>Health conditions</th>
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- Multiple hierarchical regression analyses

Step 2: mean nap & variability in nap entered, accounted for 15% of variance in health conditions (mean nap n.s. $p=.81$)
Table 2

*Bivariate Correlations Between Age, Objective and Subjective Nap Variables, and Number of Health Conditions (N = 103)*

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Step 2: Nap & Health Association

- Bivariate correlations between nap & health variables

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Study Background
Co-PI: Kelly Stanek, Ph.D.; CARSCA grant (UA College Academy for Research, Scholarship, and Creative Activity)

- Need to develop innovative strategies to aid in the diagnosis & treatment of mental health disorders in older adults
- Exposure to light is a factor implicated in etiology of many disorders (depression, obesity, sleep disorders, poorer QOL)

Study Aims
Develop, evaluate, disseminate subjective measure for assessing light in older adults

Using 14 day protocol evaluate concurrent criterion validity with self-report measures (depression, sleep, health) & objective measures
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Stress & Health
**Study Background**

- Socioeconomic disparities in physical & mental health
- Differences in stressor severity & appraisal accounts for SES differences in outcomes
  Goal: examine disruption of routine in response to stressors across varying levels of SES
- Mechanism: R03, secondary data analysis
Study Background

- Socioeconomic disparities in physical & mental health
- Differences in stressor severity & appraisal accounts for SES differences in outcomes
  Goal: examine disruption of routine in response to stressors across varying levels of SES
- Mechanism: R03, secondary data analysis
Study Method

MID-LIFE IN THE UNITED STATES
A National Study of Health and Well-Being
ages 25-74

THE MIDUS II PROJECTS

PROJECT 2
(Daily Diary Study)
8 days of daily experience obtained via phone interviews.
(e.g., time use, physical health symptoms and substance use, work productivity, psychological distress)
4 days of salivary cortisol

PROJECT 3
(Cognitive Functioning)
Phone-based cognitive battery
(e.g., episodic verbal memory, working memory, verbal ability and speed, fluid intelligence/reasoning, speed of processing, episodic verbal memory/forgetting)
Face-to-face assessment of cognitive capacities

PROJECT 4
(Biomarkers)
2-Day Clinic Visit:
Biomarkers—neuroendocrine, cardiovascular, immune, bone
Physical exam
Medical history
Medications
Sleep assessments
Laboratory challenge study—heart-rate variability, blood pressure, cortisol

PROJECT 5
(Neuroscience)
Affective reactivity & recovery:
• baseline electroencephalography (EEG)
• task-related EEG
• task-related electromyography (EMG; eyelink startle response, post auricular startle reflex, corrugator supercilli activity)
• structural MRI of neuroanatomy
• task event-related fMRI
Conclusions

- Timescale is important (e.g., SRM daily vs. weekly)
- Variations within individuals are also of interest (especially when concerned with developmental processes/health conditions)
- Use of multiple levels of analysis (e.g., subjective, objective, physiological)
- Role of age