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Sleep-Wake State Tradeoffs, Impulsivity and Life History Theory

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Abstract: Evolutionary ecological theory predicts that sleep-wake state tradeoffs may be related to local environmental conditions and should therefore correlate to alterations in behavioral life history strategies. It was predicted that firefighters who slept more and reported better quality sleep on average would exhibit lower impulsivity inclinations related to slower life history trajectories. UPPS impulsivity scores and self-reported sleep averages were analyzed and indicated a negative association between sleep variables and urgency and a positive association with premeditation. Perseverance, and in some cases premeditation, however, disclosed an unpredicted marginally significant positive association between increased and emergency nighttime waking-related sleep deprivation. Sensation seeking was not associated with sleep variables, but was strongly associated with number of biological children. This research contributes to understanding the implications of human sleep across ecological and behavioral contexts and implies further research is necessary for constructing evolutionarily oriented measures of impulsivity inclination and its meaning in the context of life history strategies.

Keywords: sleep, life-history theory, impulsivity, firefighters

Introduction

Humans, like other animals, spend a great deal of their daily energy and time budget sleeping. Sleep provides necessary maintenance and repair as a counter to waking activities of reproduction and production (Siegal, 2005). Therefore, a fundamental tradeoff exists between the asleep and awake states, and certain risky or resource poor environments may result in shifts directing time away from sleep toward waking activities (Worthman, 2008; Worthman and Melby, 2002). Impulsivity, a measure of future discounting and risk inclination, is associated with fast life history strategies (Figueroedo et al., 2006). This research proposes that sleep quantity and quality, as altered by ecological conditions of
resource or mating stresses, may queue alterations in future discounting as measured by impulsivity inclinations.

Sleep

Anthropological insight into human sleep has been primarily restricted to cross-cultural work on typical sleep environments and childcare practices (Worthman and Melby, 2002). Aside from a few notable exceptions, relatively little work has been done by evolutionists on sleep ecology and associated behavioral and psychological outcomes (Ferreira de Souza Aguiar, Periera da Silva, and Marks, 1991; J. McKenna, 1986; J. McKenna and McDade, 2005; Worthman, 2008; Worthman and Brown, 2007; Worthman and Melby, 2002). Anderson (1998) explains that this bias, at least among primatologists, is presumably due to persistent research interests in daytime behavioral profiles. As such, a large gap exists in our understanding of sleep and associated behavioral and psychological outcomes among humans and other primates.

Sleep is commonly viewed as a daily anabolic state of repair and maintenance. The circadian sleep rhythm, linked to the biological twenty-four hour clock in humans, regulates our sleep-wake states partially through melatonin and partially through a homeostatic drive. The rhythm plays roles in regulating bodily processes and functions including body temperature, hormone secretion, urine production, blood pressure, and the sleep-wake cycle (Arendt, 2006). There are two independent pathways whereby adequate species-specific sleep improves physiological functions: sleep quality and sleep quantity. An overarching biological perspective details the role of sleep in homeostatic drive, which ultimately optimizes all biological and neurological functions and systems (Benington, 2000). Conversely, inadequate sleep quantity and quality exhibits significant behavioral and physiological consequences (see Banks and Dinges, 2007, for review), including decreased cognitive state regulation (Saper, Cano, and Scammell, 2005), diminished immunological functioning (Opp, 2009) and impaired executive functioning (Nilsson et al., 2005). Awake time, by comparison, seems essentially designed to achieve the major evolutionary goals of production and reproduction and therefore a trade-off between sleep and waking exists.

Indeed, the two states of human existence, awake and asleep, can be thought of as competing systems in which the organism is either breaking down molecules for energy (catabolic and awake) or constructing molecules, organs, and tissues from smaller units (anabolic and asleep) (Rodéhn, 1999; Shneerson, 2005). The daily phases can be described in the following ways: The sleeping state exists to rebuild and rejuvenate systems that are catabolized, damaged, or require growth due to wakefulness activities of production and reproduction. Because these phases achieve different tasks, and because they are mutually exclusive, it can be observed that due to the principle of time allocation, time used for one state cannot then be used for the other. Thus, if an organism spends more time sleeping it will have less time for production and reproduction. However, because sleep builds, grows and repairs the body, lack of sleep results in negative physiological, and perhaps risky, behavioral consequences.
Impulsivity and Life History Theory

Impulsive behaviors include lack of premeditation before action, inability to complete tasks, urgent decision-making and discounting of costs associated with risky choices (Figueroedo et al., 2006). Impulsivity has been correlated to future discounting (Ostaszewski, 1997) and many other life history variables such as age at first sex, age at first birth (Miller, Flory, Lynam, and Leukefeld, 2003), number of sexual partners (McCoul and Haslam, 2001) and a vast array of risky sexual behaviors (Donohew et al., 2000; Robbins and Bryan, 2004). Risky impulsivity, which measures risk taking without premeditation, is a common cause of same-sex aggression and greater sociosexuality (Cross, 2010), important components of a fast life history strategy. Additionally, consistent with evolutionary theory, impulsivity decreases with age (Eysenck, Pearson, Easting, and Allsopp, 1985) and higher impulsive tendencies are found in men than women (Waldeck and Miller, 1997).

Personality psychologists have offered a framework, and some research supports, that personality consistency may exist in combination with contextual, state-dependent variations (Howard and Mason, 1994; Mischel, Mendoza-Denton, and Shoda, 2002; Nederkoorn, Guerrieri, Havermans, Roefs, and Jansen, 2009; Wingrove and Bond, 1997). Further, it has been posited that personality variation may be interpreted using a life history framework and that personality phenotypes may mediate risks of ecological uncertainty in securing reproductive opportunities (Quinlan, 2010). And indeed, Figueredo et al. (2006) found that a purified measure (a scale which is drawn from several existing measures to create a scale of both impulse behaviors and impulse control) of impulse control had a high, positive correlation with a slow life history, as measured by the K-factor battery questions. Figueredo’s work also links a deviance factor, of which impulsivity is an important component, to reduced executive functioning, a measure of the ability to set goals, plan, sequence, prioritize, and inhibit pace, etc., which are ultimately linked to low K-factor (Figueredo et al., 2006). Figueredo emphasizes that optimization of executive functioning requires impulsivity inhibition. And, as demonstrated above, sleep quantity and quality lessens executive functioning, which has a strong relationship with impulsivity (Bernier, Carlson, Bordeleau, and Carrier, 2010; Harrison and Horne, 1999, 2000; Stenuit and Kerhofs, 2008). Several studies also indicate a relationship between sleep deprivation and related impulsivity concepts such as risk taking and delay discounting (Acheson, Richards, and de Wit, 2007; Chaumet et al., 2009; B. McKenna, Dickinson, Orff, and Drummond, 2007; Reynolds and Schiffbauer, 2004; Schmidt, Gay, Ghisletta, and Van der Linden, 2010; Schmidt, Gay, and Van der Linden, 2008; Sicard, Jouve, and Blin, 2001; Venkatraman, Chuah, Huettel, and Chee, 2007).

Further, increased dopamine is strongly, positively correlated to impulsivity and future discounting (Pine, Shiner, Seymour, and Dolan, 2010). Therefore, a proximate connection exists in that higher levels of melatonin from exposure to more darkness at night, in part due to fewer nighttime interruptions, will cause dopamine to drop, thus inhibiting impulsive behaviors. Likewise, higher frequency of waking interruptions, particularly with light, will inhibit melatonin, resulting in rises in dopamine and concordant impulsive behaviors. This relationship may also support a state context-dependent attribute of impulse and predictions that impulsivity and risk inclination may be seasonally or
Firefighters are typically referred to as shift workers and by extension are exposed to unique occupation-specific environmental risks, including large variations in sleep quantity and quality. This research investigates the behavioral variation in impulsivity among firefighters, as both a trait and as state-dependent upon environmental circumstances. Life history theory supposes that increases in impulsivity and future discounting should be expected in risky, resource poor and unpredictable environments, ultimately resulting in a switch from a slow to fast life history strategy, which may be partly caused by the negative melatonin-dopamine relationship that exists in the presence of sleep loss. During hominid evolution, poor sleep was likely a reflection of more environmental danger and unpredictability. Thus, disturbed sleep is a proxy of local danger and uncertainty. It is therefore expected that nightly variations in sleep quantity and quality act as cues regarding local environmental circumstances about the resource richness and relative safety or danger of the productive and reproductive ecology. Such risky and stressful environments indicated by poorer overall sleep should result in faster life history strategies, as measured by variations in impulsivity inclinations by particular domains of higher urgency and sensation seeking and lower premeditation and perseverance. Firefighters exhibit highly variable fluctuations in sleep patterns resulting from random waking events due to unpredictable calls that require decisions and action related to emergencies and fire-related events. Thus, firefighters are a good study population for sleep-related research because external measures of ecological risk, such as call volumes and quantity and quality of sleep, vary unpredictably.

Materials and Methods

Participants and Location

Research was conducted among fire personnel at the CAL FIRE- Riverside Unit and Riverside County Fire Department. It is located in inland Southern California and houses over 1,600 employees, primarily represented by career emergency response fire personnel. This Unit defends approximately 7,300 square miles of land serving over 2.1 million residents. In 2009, the Unit responded to 115,718 emergency calls, representing one of the largest total call volumes in California. The vast expanse of Riverside County includes mountainous, desert, rural and densely populated towns and cities.

Personnel at each of the Unit’s 91 locations are trained to respond to a wide variety of emergency situations, including: structure fires, medical aids, traffic collisions, rescues, false alarms, and hazardous materials. In addition to local emergency call response, personnel are responsible for responding to major wildfire incidents throughout the entire State.

Sleep ecologies vary greatly across the Unit by individual station. This is due to station-specific variance in the number of assigned personnel, call type frequencies and overall call volume. Furthermore, each station has different sleeping arrangements where rest occurs in either open-barrack, semi-private barrack, or solitary sleep rooms. Sleep room acoustics, other distractions from room sharing, bed comfort levels, and room temperatures also differ.
Although most firefighters in the Unit have fixed weekly shifts, some variation exists. Typical shifts commence at 8:00 am and are 72 hours long, creating susceptibility to variable nighttime wakeful events for several consecutive nights. It is most common that a single crew, specializing in different call responses such as those in wildland firefighting, structure fires, or those with a paramedic on crew for medical calls, are responsible for responding to all calls specific to their training during both the day and night. Some stations, however, sleep more than one crew, and since nighttime alarms and dispatch information are heard station-wide, sleep interruptions can occur even for those who are not called for response.

Researchers were escorted by Battalion Chiefs to fire stations over a period of five weeks during June and July 2010 where on-shift personnel were invited to participate in a “sleep study” as part of a larger life history project. Most frequently, three men were on-shift per station during the time of station visits by the researchers. Because participation was limited by firefighters on-shift during the time in which researchers were visiting randomly selected fire stations, firefighters working longer overtime shifts may have been more likely to be sampled. Data analysis indicates, however, that 78% of respondents were within the normal limits of a three night working shift. Willing participants (n = 115) were instructed to log onto an online survey and answer a series of online questionnaires, including demographics, the Brief UPPS Impulsive Behaviors Scale (Keye, Wilhelm, and Oberauer, 2009), and an occupationally targeted sleep survey that included questions regarding quantity and quality of average sleep at the station. Data on call volume and call type frequency by station were provided by the Riverside Unit Emergency Command Center for their use as proxies for environmental stress and, by extension, environmental quality.

**Dependent Impulsivity Measure**

Keye and colleagues’ (2009) Brief UPPS impulsivity scale was adapted from the larger UPPS developed by Whiteside and Lynam (2001), which is derived from the Five Factor Model (FFM) of personality inventory (NEO-PI-R) (Costa and McCrae, 1992). The scale includes four distinct components: urgency, perseverance (lack of), premeditation (lack of) and sensation seeking. Urgency, the most understudied component, provides motivation to emotionally “alleviate” negative emotions and affect regardless of long-term consequences (Whiteside and Lynam, 2001). Lack of perseverance is defined as remaining on task to complete a project, regardless of its mundane nature or level of difficulty. Lack of premeditation describes a situation in which an individual acts with disregarded forethought to the consequences of a behavior. The last dimension, sensation seeking, is a measure of excitement and dangerous, risky activity seeking. These components suggest that impulsivity is more complex than one singular concept, but also suggests the possibility that traditional scientific uses of impulsivity may need to be broken down into their components in order to better understand their individual evolutionary significance.

**Independent Sleep Variables**

Predictors included one sleep quantity variable: 1). Self-reported average number of minutes slept per night; and three measures of sleep quality: 2). Psychological related
insomnia; 3). Physical pain (health) related insomnia; and 4). A sleep disorder frequency score. These were gathered via self-report, online surveys.

Two composite variables are designed to represent different aspects of sleep quality. Psychological sleep quality is measured by questions designed to gauge firefighter’s inability to sleep due to worry, bad dreams and difficulty falling asleep. Physical sleep quality is measured by health related reasons for insomnia, such as inability to sleep due to being too hot, snoring, pain, difficulty breathing, and a general low overall satisfaction of sleep. An increased score in these variables indicate higher sleep quality from less psychological or pain related insomnia. The sleep disorder quality measure is an additive score of the number of each participant’s medically diagnosed sleep disorders.

Results

Multiple linear regression in STATA v 10 was used to test the hypotheses that sleep quantity and quality are inversely related to impulsivity. Descriptive statistics of the sample and dependent sleep variables can be observed in Tables 1 and 2, respectively.

Table 1. Sample descriptive statistics

|                          | n  | mean | s.d. | min | max |
|--------------------------|----|------|------|-----|-----|
| Age                      | 115| 36.84| 7.15 | 22  | 54  |
| Number of years employed | 114| 13.44| 7.43 | 1   | 32  |
| Number of biological children | 113| 1.47 | 1.17 | 0   | 5   |
| Avg. number times         | 111| 3.18 | 1.44 | 1   | 10  |
| awoken for emergency     |    |      |      |     |     |
| call responses            |    |      |      |     |     |

Table 2. Dependent variable descriptive statistics

|                          | n  | mean | s.d. | min | max |
|--------------------------|----|------|------|-----|-----|
| Avg. number of minutes   | 113| 343.02| 95.53| 120 | 568 |
| slept each night at fire |    |      |      |     |     |
| station                  |    |      |      |     |     |
| Insomnia related to     | 112| 9.71 | 2.35 | 3   | 12  |
| psychological worry      |    |      |      |     |     |
| Insomnia related to      | 111| 15.21| 2.77 | 4   | 20  |
| physical pain            |    |      |      |     |     |
| Frequency of sleep       | 113| 0.15 | 0.50 | 0   | 3   |
| disorders                |    |      |      |     |     |

The Brief UPPS impulsivity instrument differentiates between four distinct conceptual variables that were used in analysis: urgency, perseverance, premeditation and sensation seeking. The four independent predictors of sleep quantity and quality were: 1.) The number of minutes slept on average per night at the station, 2.) Insomnia due to psychological worry, 3.) Insomnia due to physical pain, and 3.) The frequency of diagnosed sleep disorders. Control variables for the full model included number of biological children, number of years on the job, age, and the average number of station calls per night, which approximates unpredictable events of ecological stress and risk.

Diagnostic analysis of each model indicates the models did not diverge from the assumptions of multiple linear regression. The full regression models including all predictors on the four measures of impulsivity can be found in Table 3. The additive
composite sleep quality variable measuring psychological worry insomnia is composed of three Likert scale questions regarding the intensity of insomnia related to worrying at night, difficulty staying asleep and bad dreams. Of particular note, lower likert values signify lower sleep quality whether by insomnia from psychological worry or physical pain.

Regression analysis indicates that greater psychological worry insomnia results in higher urgency among firefighters ($\beta = -.60, p = .001$). This effect on urgency, however, is not seen with the other measures of sleep quantity or quality when all predictors and controls are used within the same model. However, physical pain related insomnia is predictive of higher urgency in independent analysis without concurrent psychological insomnia in the model ($\beta = -.41, p = .005$). Because of this result, and the fact that psychological and pain related insomnia are highly correlated ($r = .464, p = .000$), a formal detection tolerance test, otherwise known as variance inflation factor (VIF), was run to test for multicollinearity in Table 3, model 1. The VIF (1.74) did not deviate from regression analysis assumptions, indicating an unlikely multicollinearity issue in the model between psychological and physical pain sleep deprivation and all other variables. As an additional precaution test for multicollinearity, variables were mean-centered, which did not improve or significantly change model results. Therefore, insomnia from psychological worry accounts for more of the variance in urgency than does insomnia from physical pain.

Perseverance was not directly associated with sleep but it does have some possible relationship with extrinsic ecological risk as measured by nightly call volume. For example, although perseverance was not related to any measure of sleep quantity or quality in the full model, Table 3, model 2 illustrates a marginal relationship between perseverance and average number of nighttime emergency calls. In independent regression analysis, while holding average number of minutes slept per night constant, the number of nighttime waking response calls marginally increases perseverance ($\beta = .41, p = .090$), which is opposite of predicted theory. Similarly, when running each sleep quality measure in independent regression analysis, without other criterion variables and using the same control variables, models indicate a positive relationship with call volume and greater sleep quality as measured by lower psychological worry insomnia, ($\beta = .43, p = .007$); physical pain insomnia, ($\beta = .47, p = .052$); and sleep disorder frequency, ($\beta = .46, p = .053$).

More sleep per night results in higher premeditation ($\beta = .01, p = .015$). Conversely, those with more sleep disorders show marginally lower premeditation ($\beta = -1.03, p = .093$). While poorer sleep quality and quantity reduce premeditation as predicted, the number of nighttime calls, a measure of extrinsic risk, is associated with higher premeditation ($\beta = .51, p = .030$).

Sensation seeking, the final of the four impulsivity scale variables, was not directly related to any of the sleep variables in multiple regression analysis in the presence of the control variable of biological children. As such, having children strongly buffers against sensation seeking impulsive behavior. However, this finding is consistent with theory when running separate model analyses of each criterion variable in the presence of the same controls independent with both number of minutes slept ($\beta = -.88, p = .024$) and all three of the quality of sleep measures (psychological worry, $\beta = -.82, p = .041$; physical pain, $\beta = -.86, p = .041$; sleep disorders, $\beta = -.77, p = .031$).
Table 3. Multiple linear regression testing for effects of sleep quantity and quality on impulsivity

| Predictors | β     | std. err | t     | p     | model statistics |
|------------|-------|----------|-------|-------|------------------|
| **Model 1: Urgency** | | | | | |
| Avg. number of minutes slept | 0.00 | 0.00 | -0.07 | 0.948 | n=107 |
| Psychological related insomnia | -0.60 | 0.18 | -3.34 | 0.001 | R²=0.12 |
| Physical pain related insomnia | -0.14 | 0.16 | -0.83 | 0.408 | p=0.009 |
| Sleep disorder frequency | 0.65 | 0.71 | 0.91 | 0.365 | |
| station calls | 0.10 | 0.27 | 0.38 | 0.704 | |
| biological children | -0.02 | 0.35 | -0.06 | 0.953 | |
| years on the job | 0.03 | 0.08 | 0.36 | 0.717 | |
| age | -0.07 | 0.09 | -0.80 | 0.427 | |
| Constant | 22.60 | 3.75 | 6.03 | 0.000 | |
| **Model 2: Perseverance** | | | | | |
| Avg. number of minutes slept | 0.00 | 0.00 | -1.02 | 0.310 | n=109 |
| Psychological related insomnia | 0.07 | 0.17 | 0.40 | 0.692 | |
| Physical pain related insomnia | 0.19 | 0.15 | 1.26 | 0.211 | p=0.302 |
| Sleep disorder frequency | -0.44 | 0.67 | -0.66 | 0.511 | |
| station calls | 0.37 | 0.25 | 1.49 | 0.139 | |
| biological children | 0.23 | 0.32 | 0.70 | 0.483 | |
| years on the job | -0.05 | 0.07 | -0.77 | 0.441 | |
| age | 0.01 | 0.08 | 0.15 | 0.881 | |
| Constant | 16.37 | 3.47 | 4.72 | 0.000 | |
| **Model 3: Premeditation** | | | | | |
| Avg. number of minutes slept | 0.01 | 0.00 | 2.20 | 0.030 | n=108 |
| Psychological related insomnia | 0.10 | 0.16 | 0.67 | 0.504 | R²=0.054 |
| Physical pain related insomnia | -0.06 | 0.14 | -0.38 | 0.701 | p=0.092 |
| Sleep disorder frequency | -1.20 | 0.62 | -1.94 | 0.056 | |
| station calls | 0.51 | 0.23 | 2.21 | 0.030 | |
| biological children | 0.27 | 0.30 | 0.92 | 0.361 | |
| years on the job | -0.03 | 0.07 | -0.41 | 0.683 | |
| age | -0.01 | 0.07 | -0.20 | 0.844 | |
| Constant | 13.87 | 3.27 | 4.24 | 0.000 | |
| **Model 4: Sensation seeking** | | | | | |
| Avg. number of minutes slept | -0.01 | 0.00 | -1.34 | 0.183 | n=111 |
| Psychological related insomnia | 0.04 | 0.22 | 0.17 | 0.864 | R²=0.12 |
| Physical pain related insomnia | -0.05 | 0.20 | -0.27 | 0.788 | p=0.012 |
| Sleep disorder frequency | 1.17 | 0.85 | 1.38 | 0.171 | |
| station calls | 0.26 | 0.31 | 0.82 | 0.415 | |
| biological children | -0.79 | 0.41 | -1.90 | 0.060 | |
| years on the job | 0.01 | 0.09 | 0.11 | 0.916 | |
| age | -0.13 | 0.10 | -1.32 | 0.191 | |
| Constant | 25.44 | 4.40 | 5.78 | 0.000 | |

*Note:* Control variables in italics; β, unstandardized regression coefficient; p, two-tailed significance; Std. Err., standard errors; n, sample size; R², adjusted variance accounted for by all predictors.
Discussion

Sleep is an anabolic state of body maintenance and rejuvenation that is essential to optimal functioning. Waking exists to solve the challenges of production and reproduction, generally catabolic activities. A fundamental tradeoff therefore exists between the waking and sleeping states. Individuals should only tradeoff sleep quantity or quality in the presence of particular ecological constraints requiring greater investment in production and reproduction. Such ecological circumstances may involve social stress, resource depletion or high extrinsic risk. Life history theory consequently predicts that in the presence of lack of sleep or low quality sleep individuals should exhibit faster life history traits. One way this may be indicated is through impulsive behavior, related to future discounting. The Brief UPPS survey instrument was chosen because it encompasses more than sensation seeking in testing impulsivity, specifically adding dimensions of perseverance, premeditation and urgency. Analysis revealed that there were several observed relationships between sleep quantity or quality variables, including the presence of an independent measure of extrinsic risk (call volume), and the outcome impulsivity measures.

Urgency, derived from the neuroticism trait of the FFM, has been argued as a component of impulsivity intended to mediate negative emotions. However, while the UPPS uses questions designed to measure urgency, premeditation, perseverance and sensation seeking, it should be noted that other studies on impulsivity rarely directly measure or evaluate the psychological components of urgency and perseverance. These data support that sleep quality, as measured by insomnia resulting from psychological worry, increases urgent tendencies. Thus, individuals having a difficult time falling asleep or frequently waking due to excessive worrying are more likely to behave urgently. If this is indeed a component of impulsivity, it would indicate that social and ecological stress, translated into nighttime sleep deprivation, causes one to overestimate the time costs of waiting before acting, and instead preferring to act more urgently, which is in line with life history theory predictions.

Low sleep quantity and quality measures did not predict changes to perseverance in the full model. Since it is possible that correlational effects between the sleep variables and emergency call volume could make interpretation of independent variable effects in the main model difficult, independent regression analysis was done on each sleep outcome individually to better assess the possible effects of the extrinsic risk factor of call volume. These results highlight some marginal and significant relationships between the effects of the number of emergency calls on perseverance when combined with each sleep measure in separate regression analyses. In all cases, perseverance was positively affected by emergency call volume. This, of course, is opposite of predictions and is addressed further in light of similar premeditation outcomes.

As predicted, getting more sleep is significantly associated with higher premeditation. Evolutionary insight predicts that it is too costly to premeditate in the presence of risky, hazardous or perilous circumstances requiring immediate action. As a consequence, careful forethought preparations are forgone in favor of instant action to secure immediate survival in the presence of sleep deprivation amongst firefighters. Interestingly and also contrary to predictions, as was similarly found with perseverance,
higher emergency call volume was associated with higher premeditation scores. This highlights a consistent finding, which is that persistent exposure to greater extrinsic risk, as measured by call volume, results in both higher premeditation and higher perseverance. With respect to premeditation, the results indicate that both the number of minutes slept and call volume independently predict greater premeditation, both in the positive direction.

There may be several interpretations of the contrary results of call volume effects on perseverance and premeditation. Firefighters may habituate to risky, dangerous ecologies and adjust to high premeditation and perseverance in those circumstances where doing so saves their lives. Alternatively, this result could simply be a measure of intrinsic conscientious motivation of individuals, which may vary considerably by personality type in the presence of extrinsic risk or lack of sleep.

Understanding the exact nature of the reason for the sleep deprivation though is essential to predicting either a lack of perseverance or premeditation. This might imply that perseverance and premeditation are measuring something other than, or may not be components of, impulsivity. For example, a high perseverance score generally refers to sticking with a task to completion. The meaning of a low score is less clear, though it may correlate to multitasking. Evolutionary ecological theory may predict circumstances where sleep loss due to different reasons may actually result in multi-tasking (or frequent task switching) versus task focusing, independent of impulsivity. Indeed, the ability to ignore extraneous circumstances in order to achieve end goals to the exclusion of tangential tasks would be expected of most people in dangerous circumstances, and therefore perseverance may not always have the expected inverse relationship with urgency.

Such a reexamination of this variable, given evolutionary theory, may require reinterpretation of general hypotheses. For example, dangerous environments, requiring one to focus on the task at hand to the exclusion of other distractions, would predict higher perseverance scores in the presence of greater emergency call volumes, but insomnia due to psychological worry may not necessarily be so predicted. Data analysis, however, offers no support that the number of years on the job increases perseverance independent of all predictor variables, but holding all control variables constant, either in ($\beta = -.03, p = .657$) or apart from ($\beta = -.04, p = .585$) the number of nightly calls, therefore it appears that the circumstance of why one loses sleep is a key to understanding perseverance and that habituation might not be the answer. And although the number of years on the job may not result in habituation, residing at a station with higher call volumes does have some effect.

For example, when the number of emergency awakening events is higher for firefighters, premeditation increases. This supposes that premeditation becomes increasingly important for immediate survival when repeated risk is in the environment, queuing alternative behavioral strategies. Since sleep deprivation has been shown to decrease executive functioning in a variety of ways across the life course, repeated exposure to risk in the presence of compromised sleep during one nighttime sleep event requires a strategy to mediate compensated executive function as a buffer for an individual’s safety. Response time during transportation to emergency events offers time to invest in preparation and premeditation for forthcoming emergencies. Increased premeditation becomes especially critical as repeated exposure to danger is experienced during the night, or it may be that extreme levels of risk select for premeditation.
The lack of any significant relationship between sleep variables and sensation seeking was surprising in the context of life history theory; the only important variable in this analysis being the control variable of biological children. It could be that sleep has no effect on one’s inclination to seek out sensations, which is unlikely. One important factor is that these data are restricted to men who tend to self-select into high risk jobs that appeal best to individuals that are already at the high end of sensation seeking, thus making it difficult to pick up sample variation if the sensation-seeking variable is very narrow. Or, the answer may lie in the nature of the typical questions used to assess inclination for sensation seeking. For instance, one firefighter commented after taking the survey, “Why would I want to go skydiving? I risk my life every day for this job!” Clearly, however, number of biological children is an extremely important component of impulsivity with respect to sensation seeking, indicating that any studies attempting to look for sleep effects on risk inclination must control for this powerfully predictive variable.

No age effects on impulsivity components were observed. This is contrary to previous work, particularly in the area of sensation seeking. This analysis, however, is more finely tuned to pick up evolutionary effects than some of these other studies, because a control is used for the number of children, which is known to dampen risk inclination because of the costs to offspring quality. Since both age and biological children are in the model, when either is significant it is almost always biological children, because the real theoretical reason that age is significant in previous studies is because it correlates strongly with having biological children. Still, the number of biological children is clearly the more important of the two variables, given theory and outcomes. Consequently, future studies should pay greater attention to this control variable.

In conclusion, impulsivity components are variably associated with environmental uncertainty. Nightly average sleep acquisition signals environmental certainty, and individual firefighter behavioral strategies alter according to variations in time spent asleep and the quality of sleep one is able to achieve. As predicted by life history theory, lack of sleep minutes resulted in increased impulsivity, specifically in the lack of premeditation. Reduced insomnia from psychological-related worry buffers against urgent impulse. And fewer diagnosed sleep disorders improve premeditation. Thus, better sleep quality in these measures suggests a decrease in impulsive strategies for on-shift firefighters. Finally, as a corollary to this, better and more sleep aligns with a slower life history strategy.

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