ORIGINAL ARTICLE

Objective and Subjective Effort as a Function of Sleep and Energy

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Objective: The purpose of the present study was to examine the contribution of sleep related factors, including previous night sleep, past experience with sleep loss and current energy, to objective effort and the subjective experience of effort.
Method: 187 non-sleep-deprived college students from Baruch College completed a 1-hour computer assessment which included eight tasks: general sleep questionnaire, sleep diary, Stanford Sleepiness Scale, Profile of Mood States, reaction time task, Math Effort Task, and non-academic task selection question.
Results: Principal components analysis was used to identify 8 factors and form composite variables. Those factors were entered into hierarchical regressions to predict effort. Objective effort, but not subjectively rated effort, could be predicted and was most related to actual sleep and perceived energy. 10% of the variance of objective effort was accounted for by actual sleep, perceived energy, reaction time and interactions among these components.
Conclusions: Under non-sleep-deprived sleep conditions, objectively measured effort is affected by previous night's sleep and perceived energy. Objectively measured and subjectively rated effort, however, derive from different sources. The potential danger of reduced energy caused by even minimal sleep loss is that less effort may be applied in situations where maximal effort is expected or needed. Future research may clarify the mechanisms by which sleep affects effort and the effects of accumulated sleep loss on effort. **(Sleep and Hypnosis 2008;10(2):61-72)**

Key words: Energy, objective effort, subjective effort, college students

INTRODUCTION

Twenty-two percent of adults in the United States report that they consistently get less sleep than they need (1) and some believe that sleepiness interferes with daily activities that require effort, such as spending time with family and friends, engaging in sex, exercising and healthy eating (2). While the loss of sleep may be due to many factors, the reduction in engagement in activities requiring effort may be specifically due to fatigue, sleepiness or a reduction in energy.

Fatigue and sleepiness have been shown to impact effort-related behaviors and choices. Experimentally induced fatigue has resulted in the review of less material before decision making (3) and the selection of tasks demanding minimal effort despite low

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Accepted September 10, 2008

probabilities of success (4,5). Correlational studies have shown a relationship between fatigue and increased social loafing (6) and the selection of tasks requiring less effort (7). Sleepiness, too, has been associated with reductions in effort in work environments, as reflected by increased absences (8) and decreased motivation across five different occupations (9). Furthermore, experimentally induced sleep restriction, which often leads to sleepiness and fatigue, has been found to affect behaviors indicative of reduced effort. These include fewer attempts at problems (10) and reductions in work rate and item completion on performance tasks (11-14).

There may be a trait-like vulnerability with some individuals more sensitive to the effects of sleep loss while others have greater tolerance for the sleep loss experience (15) and sleepiness (16). Previous experience with sleep loss, may impact expectations regarding functioning with less than optimal sleep amounts. These expectations may also impact effort. In addition, those who experience frequent sleep loss may accumulate sleep debt leading to increased fatigue and sleepiness, which may in turn influence effort. Alternatively, those who regularly experience less sleep than they need may acclimate to the loss of sleep and show consistent effort without or despite sensations of fatigue, sleepiness or loss of energy.

Commonly, when effort has been measured following sleep loss, subjective measures of effort have been used in the absence of objective or behavioral indices. This interferes with a clear conception of how effort is affected by sleep loss, or the fatigue and sleepiness it engenders. Findings from subjective and objective assessments of effort after sleep loss have not been consistent (7,17-22).

The purpose of the present study was to explore the contribution of previous night sleep, past experience with sleep loss, expectations related to sleep loss and current energy on objectively assessed and subjectively rated effort in a non-sleep-deprived sample. It has been demonstrated that experimentally sleep-deprived and naturally sleep-restricted participants select tasks requiring minimal effort. Therefore, it is expected that participants who are not sleep restricted but who report low energy will be more likely to select low effort tasks. As demonstrated in studies involving sleep loss, it is also expected that behavioral indices of effort will be affected by low energy while subjective indices of effort will not be similarly affected. It is expected, too, that persons with extensive experience with sleep loss and who perform well under such conditions will be least affected by losses of energy.

METHOD

Participants

Participants in the study were 187 undergraduate students from the Introductory Psychology courses at Baruch College, City University of New York, evaluated during the 2002-2003 academic year. The demographics of the sample, and those of the Baruch College undergraduate population, are displayed in Table 1. The

Table 1. Demographic Characteristics of the Study's Sample (N= 187) and Undergraduate Population at Baruch College During the 2002-2003 Academic Year

Variables	Sample	Population
Gender (% female)	63.1	57.5
Age (years)		
M	22.6	24.3
SD	5.6	6.52
Median	21.0	22.3
Minimum	18.0	15.0
Maximum	61.0	63.0
% Under 25	80.7	67.2
Ethnicity (%)		
White	23.0	33.2
Hispanic	16.0	18.7
Black	11.2	18.7
Asian	42.3	29.1
Other	7.5	0.3

table illustrates the heterogeneity of the school population with regard to gender, age and ethnic background. The current sample was similarly heterogeneous, though Asian students were over-represented as compared with other ethnic groups.

Procedure

Participants were recruited for the study via sign-up sheets posted outside of the Psychology Department. These sign-up sheets informed potential participants that the study was "designed to evaluate sleep and performance" and that students would be "completing a computer-based assessment test" in exchange for credit toward the Introductory Psychology research requirement. Participants self-selected a morning (10:00am), afternoon (1:00pm), or evening (6:00pm) session, which consisted of 52, 66, and 69 individuals, respectively.

Upon arriving for the appropriate session, the procedure, approved by the Baruch College Institutional Review Board, was described to the participants. Students were informed that they could withdraw from the study at any time without penalty or prejudice. After providing signed informed consent, participants completed the laboratory assessment. No individuals refused to participate or withdrew their participation.

Laboratory Assessment

The computer lab was equipped with four Dell computers. A divider separated the computer terminals so that the participants were unable to see each other. The laboratory assessment was comprised of eight individual tasks (7). The tasks, presented in the same order to all participants as they appear here, included a registration questionnaire, a sleep diary, the Stanford Sleepiness Scale, the Profile of Mood States, a reaction time task, a Math Effort Task, a non-academic task selection question and a subjective effort question. All tasks required responses before participants could proceed to the next section of the assessment.

Registration Questionnaire. The registration questionnaire contained 71 questions concerning sleep history. Three questions regarding the participant's experience with sleep loss were particularly relevant. Participants were asked to respond to the question "How do you feel after you have slept less than usual?" on a scale from 1 (exhausted) to 5 (refreshed). Participants were also asked to respond to the question "If you don't get enough sleep, how active are you the next day?" on a scale from 1 (not very active) to 5 (very active). In addition, participants were asked to indicate whether or not the amount of total sleep time they usually had was a problem for them.

Sleep Diary. The sleep diary contained 32 questions concerning the person's previous night sleep and activities engaged in that day. Included were questions regarding feeling refreshed and attention span. Specifically, participants completed the phrase: "When you woke up this morning, you felt ___" and could choose from 1 (extremely exhausted) to 5 (extremely refreshed). Similarly, participants answered the question, "How would you rate your attention span today?" by choosing a response ranging from 1 (poor) to 5 (excellent).

Stanford Sleepiness Scale. The Stanford Sleepiness Scale (SSS; 23) measured alertness, awareness and sleepiness. Participants were asked to choose a statement that described their current state, with 1 reflecting the greatest alertness and 7 reflecting the greatest sleepiness.

Profile of Mood States. The Profile of Mood States (POMS; 24) asked participants to describe the intensity of moods they felt at that moment. Participants were presented with 65 words and responded on a scale of 0 (not at all) to 4 (extremely). Participants were supplied with a list of synonyms for each mood word. The POMS items were organized into six sub-scales: tension, confusion, anger, fatigue, vigor and depression. Example words from the six sub-scales are tense, confused, annoyed, active and hopeless.

Reaction Time Task. The simple reaction time task required participants to press the space bar as soon as they saw a 0.25 X 0.25-inch white square on the black screen. The square appeared in random locations on the screen for 0.5 seconds with an inter-trial interval ranging from 2 to 5 seconds. This task had 100 trials and lasted approximately seven minutes.

Math Effort Task. The Math Effort Task (MET; 7) presented participants with 40 addition problems. For each problem, participants were presented four numbers sequentially and asked to provide the sum of the numbers. All calculations were performed mentally.

Before each addition problem, participants chose a level of difficulty ranging from 1 (low difficulty) to 5 (high difficulty). Randomly generated numbers from a particular range of values determined each difficulty level. The simplest level, Level 1, included numbers 0 to 2; Level 2 included numbers 3 to 5; Level 3 included numbers 6 to 9; Level 4 included numbers 11 to 16; and Level 5 included numbers 21 to 59. Each number, approximately 2 X 1-inches, was displayed for 0.5 seconds with an inter-stimulus interval of three seconds. Effort was assessed through examination of the levels of difficulty chosen. Assessment of the test-retest reliability of MET difficulty resulted in an intraclass correlation coefficient of .78.

Task Selection Question. On the non-academic task selection question, participants chose one task, from a list of five tasks they would be willing to perform for the following twenty minutes. The specific question was as follows: "Each of the following tasks would take 20 minutes to complete. If you were asked to perform one of these tasks RIGHT NOW, which one would you choose? Please select only one task and click O. K." The order of the tasks was randomly chosen, and the same order was presented to all participants. Effort was assessed through examination of the levels of difficulty chosen.

Normative studies, evaluating the perceived difficulty of the tasks, were performed in advance of this study. The tasks were significantly different from one another with regard to perceived difficulty. The tasks were to (a) retrieve messages from an answering machine, (b) enter data into a computer, (c) schedule next week's meetings for the chairman of the department, (d) compose exam questions for an Introductory Psychology final exam and (e) help to design a research study to evaluate and reduce teenage and college alcohol abuse. Assessment of the test-retest reliability of the task selection question resulted in an intraclass correlation coefficient of .65.

Subjective Effort Question. The subjective effort question was the participant's report of effort applied to the assessment. Participants responded to the following question: "After completing the entire assessment, how much effort do you feel you put into the assessment?" Participants chose from 1 (no effort) to 5 (extreme effort). Assessment of the test-retest reliability of the subjective effort question resulted in an intraclass correlation coefficient of .52.

RESULTS

Data Analysis

All analyses were conducted using SPSS. Bonferroni adjustments were applied as necessary to keep family-wise alpha at the .05 level, thus protecting against Type I errors (25). A subset of the data was used to determine which variables loaded highly on the constructs under investigation, and the results were extrapolated to the entire sample of 187 participants. Hierarchical regression analyses were then computed to test the contribution of the sleep factors and energy factors to understanding effort, and were considered significant if $p < .01667$.

Basic Characteristics

General descriptive statistics for all variables are provided in Table 2. A paired t-test comparing total sleep time and optimal sleep time was significant, $t(186) = 10.03$, $p < .001$. Based on the means, this result suggests that participants reported sleeping approximately one hour less than what they believed they required. Differences between groups (gender, ethnicity, time of day) were examined, but no significant effects emerged in terms of the sleep, energy, or effort measures. (Descriptive statistics for the groups, as well as the correlations among all variables, can be requested from the corresponding author.)

Table 2. Overall Descriptive Statistics

	M	SD	Mdn	Min	Max
Sleep Measures					
Sleep problem (%)	50.8	50.1	100	0	100
No sleep nights/month	1.4	3.4	0	0	25
Less sleep nights/month	14.8	8.2	15	0	31
Optimal sleep time (hrs)	8.1	1.3	8	3	12.5
Refreshed after less sleep	2.1	0.9	2	1	5
Active after less sleep	2.6	1	3	1	5
Bed time	-0.5	1.4	0	-6	3
Wake time	-0.4	1.5	-0.5	-4	5
Sleep latency (min)	18.9	22.1	10	0	120
Awakenings	0.8	1	0	0	5
Time awake at night (min)	5.8	10.8	0	0	65
Total sleep time (hrs)	6.8	1.7	7	0	11.5
Energy Measures					
Sleepiness	3	1.2	3	1	6
Refreshed	3	1	3	1	5
Attention span	3.5	0.8	4	1	5
Reaction time (sec)	0.3	0.1	0.3	0.3	0.5
Tension	7	5.2	6	0	25
Confusion	6.6	4.8	5	0	23
Anger	4.9	6.5	2	0	36
Fatigue	8.5	6.6	7	0	25
Vigor	13	7.3	13	0	32
Depression	7.3	9.4	4	0	59
Total mood	21.2	30.9	16	-30	124
Effort Measures					
Task selection question	2.6	1.3	2	1	5
MET difficulty level	2.7	1.1	2.7	1	5
MET percent correct (%)	79.8	19.5	85	2.5	100
MET response time (sec)	5.5	3	4.9	1.5	18
Subjective effort question	3.2	0.9	3	1	5

Note. Sleep problem refers to having a problem with the amount of total sleep time typically received. Bed times were centered at 12am, such that positive scores meant going to bed before 12am. Wake times were centered at 8am, such that positive scores meant waking up after 8am. For all other variables, higher numbers indicate more of a given variable. MET = Math Effort Task.

Formation of Factors

Principal components analysis was used to extract factors (26). The criteria used to determine factors were Kaiser-Meyer-Olkin Measure of Sampling Adequacy greater than .50, eigenvalues greater than 1.0 and variable loadings greater than .40. These approximate standard criteria for the determination of factor formation (27).

The sample was split into two sets for construction and validation of the factors and components (28,29). Precautions against Type I errors included (a) the selection of 38 cases via systematic sampling for inclusion in the construction sample, (b) minimal modifications in terms of variables added or removed from the factors, and (c) use only of variables with theoretical interest (30,31). All of the factors specified in the construction sample were replicated in the validation sample of 149 cases, with minimal differences in variable loadings. All of the factors in the construction and validation samples were interpretable and did not need rotation. Therefore, the results reported below are based on the entire sample of 187 participants.

Five constructs were examined. The first was overall effort. Overall effort yielded two components called objective effort and subjective effort, which accounted for 33% and 21% of the construct's total variance respectively. The other constructs, which were hypothesized to impact effort, included previous night sleep, sleep loss history, expectations of performance after poor sleep (or performance expectations) and current

Table 3. Factor Component Loadings for Constructs

Constructs / Variables	KMO	Variance	Component 1	Component 2
Previous Night Sleep	.56	60.46%	Actual Sleep	Loss of Sleep
Bed time			.74	-.37
Sleep latency			.12	.53
Awakenings			.66	.39
Time awake at night			.69	.48
Total sleep time			.59	-.63
Sleep Loss History	.51	46.58%	Sleep Loss History	
Sleep problem			.83	
No sleep nights/month			.82	
Less sleep nights/month			-.21	
Performance Expectations	.53	51.98%	Performance Expectations	
Optimal sleep time			-.49	
Refreshed after less sleep			.78	
Active after less sleep			.84	
Current Energy	.85	69.20%	Perceived Energy	Reaction Time
Sleepiness			-.80	-.09
Refreshed			.78	-.02
Attention span			.77	.10
Fatigue			-.82	-.01
Vigor			.82	-.07
Reaction time			-.07	.99
Overall Effort	.60	53.71%	Objective Effort	Subjective Effort
Task selection question			.43	-.57
MET difficulty level			.77	.07
MET percent correct			-.41	.39
MET response time			.77	.12
Subjective effort question			.35	.73

Note. Bolded loadings (greater than ± .40) were retained for computing composite scores. KMO = Kaiser-Meyer-Olkin Measure of Sampling Adequacy. Variance = total variance accounted for by components.

energy. Previous night sleep yielded two components called actual sleep and loss of sleep, which accounted for 37% and 24% of the construct's total variance, respectively. Single-component constructs of sleep loss history and performance expectations were also included. Current energy yielded two components named perceived energy and reaction time (a behavioral assessment of energy), which accounted for 52% and 17% of the construct's total variance, respectively. The components and variable loadings for each of these constructs are presented in Table 3.

Prediction of Effort

The hierarchical regression analysis predicting overall effort (the average of objective effort and subjective effort) is displayed in Table 4. Step 1 included sleep loss history and performance expectations as predictors. Step 2 included actual sleep and loss of sleep as predictors. These steps did not achieve significance. Step 3 added perceived energy and reaction time as predictors. This step did achieve significance, indicating that a significant amount of the variance in total effort was explained.

Table 4. Hierarchical Regression Analysis Predicting Overall Effort from Sleep and Energy

Criterions	Step 1	Step 2	Step 3
Sleep loss history	.04	.03	.04
Performance expectations	.10	.09	.00
Actual sleep		-.10	-.14^t
Loss of sleep		.00	.04
Perceived energy			.20*
Reaction time			-.12^t
R^2_{change}	.01	.01	.05*
R^2_{total}	.01	.02	.07^t

Note. Standardized beta coefficients are reported. Bonferroni-corrected alpha was applied to the R^2 statistics.
$^t p < .10$. $*p < .05$.

Table 5. Moderation Analyses for Subjective Effort and Objective Effort

	Subjective Effort			Objective Effort		
Criterions	Step 1	Step 2	Step 3	Step 1	Step 2	Step 3
Perceived energy (PE)	.04	.05	.06	.22**	.20**	.20**
Actual sleep (AS)	-.05	-.05	-.06	-.15*	-.16*	-.17*
Reaction time (RT)	-.14^{t}	-.13^{t}	-.12	-.04	-.04	-.03
PE X AS		-.10	-.12		.13^{t}	.11
PE X RT		.02	.06		-.17*	-.15^{t}
AS X RT		-.05	-.07		.01	-.00
PE X AS X RT			-.10			-.07
R^2_{change}	.02	.01	.01	.06*	.04*	.01
R^2_{total}	.02	.03	.04	.06*	.10**	.11**

Note. Standardized beta coefficients are reported. Bonferroni-corrected alpha was applied to the R^2 statistics.
$^{t}p < .10$. $*p < .05$. $**p < .01$.

Inspection of the coefficients revealed that the only significant predictor was perceived energy, but actual sleep and reaction time did emerge as marginal predictors. However, this analysis was not able to clarify which aspect of overall effort was primarily affected, nor did it address the role of current energy as a mediator or moderator. Thus, additional analyses were conducted.

Mediation and Moderation

Tests of mediation show whether the relationship between a cause and an effect diminishes with the introduction of a third variable. The first step would be to establish a significant relationship between actual sleep and objective effort or subjective effort. Those correlations did not reach significance (ps = ns). No further steps to test for mediation were conducted.

Tests of moderation show whether the relationship between a cause and an effect changes in the presence of a third variable. To test for moderation, the first step is the creation of interaction terms. Actual sleep, perceived energy and reaction time were multiplied with each other to create three new variables representing the two-way interactions and a fourth new variable representing the three-way interaction. The main effects and these interaction variables were then entered hierarchically in the regression analyses.

Table 5 displays the results of the tests of moderation using objective effort and subjective effort as criterions. Moderation effects were found for objective effort. Specifically, the first step (main effects) was significant, with actual sleep and perceived energy as significant predictors. The second step (two-way interactions) was also significant. The perceived energy X reaction time interaction emerged as a significant predictor, and the perceived energy X actual sleep interaction was a marginal predictor. The third step (three-way interaction) did not achieve significance. For subjective effort, none of the steps achieved significance, and current energy was not a moderator.

Figure 1 displays the prediction of objective effort as a function of the perceived energy X reaction time interaction. At the

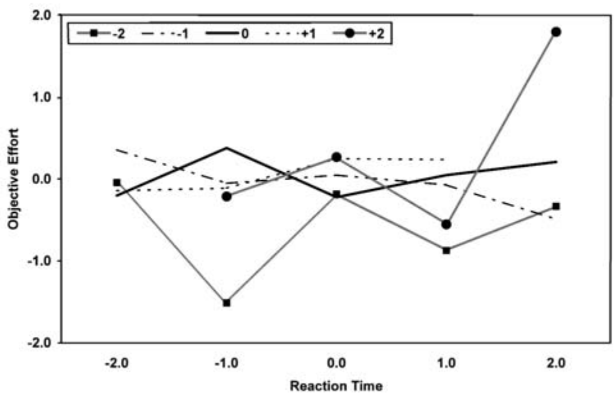

Figure 1. Interaction between perceived energy (as represented by lines) and reaction time in the prediction of objective effort. Positive numbers indicate faster reaction times and higher levels of energy and effort.

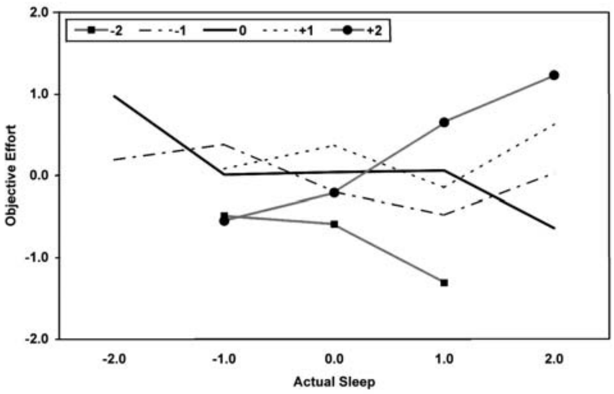

Figure 2. Interaction between perceived energy (as represented by lines) and actual sleep in the prediction of objective effort. Positive numbers indicate higher levels of sleep, energy and effort.

lowest level of perceived energy (z = -2), regardless of reaction times, objective effort was consistently low. At the average level of perceived energy (z = 0), regardless of reaction times, objective effort remained at average levels. At the highest level of perceived energy (z = +2), average levels of reaction time corresponded with average levels of objective effort, and at the fastest level of reaction time there was a substantial increase in objective effort.

Figure 2 displays the prediction of objective effort as a function of the perceived energy X actual sleep interaction. At the lowest level of perceived energy (z = -2), actual sleep was at average levels and objective effort was consistently low. At the average level of perceived energy (z = 0), lower levels of actual sleep resulted in higher-than-average objective effort, while higher levels of actual sleep resulted in lower-than-average objective effort. At the highest level of perceived energy (z = +2), lower levels of actual sleep corresponded with lower levels of objective effort and higher levels of actual sleep corresponded with higher levels of objective effort.

Perceived energy appears to be a moderator of reaction time and actual sleep as they relate to objective effort. Furthermore, perceived energy, actual sleep and reaction time accounted for 10% of the variance in objective effort (see Table 5, Step 2).

DISCUSSION

The present study explored the contribution of sleep and energy to effort in a non-sleep-deprived sample. The findings suggest that relationships between one's previous night sleep, current energy level and objectively measured effort exist even when the sample had, on average, one hour less sleep than what they considered optimal.

Five constructs of interest were derived using data reduction techniques. These constructs were previous night sleep, history of sleep loss, performance expectations, current energy and overall effort. Using hierarchical regression, components of current energy and previous night sleep were predictive of overall effort. Perceived energy moderated the impact of sleep on objective effort. There was no such effect for subjective effort.

Actual sleep and perceived energy accounted for 10% of the variance in objective effort. This suggests that in the absence of profound sleep loss, energy and sleep continue to influence effort-related choice behavior. These factors may have more profound effects under conditions of greater sleep loss or energy reduction. Additionally, it has been suggested that the cumulative impact of a variable or construct can be important and that a small contribution of variance in a single study may undervalue the contribution of the variable or construct in the long run (32). Over time, the cumulative impact of reduced energy and less effort expended by an individual may be greater than what can be determined in a single study. Similarly, the cumulative impact of numerous fatigued people accommodating their low energy by reducing effort may impact organizations and industries to a degree difficult to calculate in isolation.

Perceived energy variables (sleepiness, fatigue, vigor, feeling refreshed and attention span) were related to objective effort in this study. Other researchers have recognized the impact of fatigue and sleepiness on behavioral measures of effort (3,4). Measurement of physiological indices of energy, with concomitant measurements of perceptions of energy, could clarify how energy perceptions arise and influence the selection of behaviors requiring varying degrees of effort.

Multiple assessments of task demands and physiological state are likely made before determining how much effort to exert. Smith and colleagues (33), using EEG spectral analyses, found that participants deliberately and differentially allocate mental resources in response to the increased demands of the task. With finite energy resources, the direction of effort toward some goals and away from others serves a self-regulating function (21,34), which may improve physiological health and subjective well being (35). Reducing effort under conditions of low energy, like that observed in the present study, may be beneficial given the costs associated with performing high effort tasks under less-than-optimal conditions such as sleep loss (36).

Sleep loss history and performance expectations did not affect effort. Though a trait-like vulnerability to impairment caused by sleep loss may exist (15), such vulnerability was not observed in this study. Because participants had, on average, only one hour less sleep than what they considered optimal and were not severely sleep restricted, the limited range of sleep loss compromised the ability to identify those individuals whose sleep history and expectations may have additionally influenced their effort-related performance.

While objective measures of effort were predicted by previous night sleep and feelings of energy, subjective reports of effort were not. Objective effort and subjective effort appear to result from different sources. Subjective effort may reflect personality variables rather than sleep or energy. Research in this area may benefit from explorations of the contribution of personality to subjective assessments of effort under refreshed and fatigued conditions.

Future research can overcome the limitations of the present study. First, total sleep time was not objectively measured. There is a high accordance rate between physiological measures such as polysomnography and self-reports of sleep tendencies (37), but how much objective sleep is needed to cause a change in effort is unknown. Second, the presentation of the measures was not counterbalanced and it is unknown whether the particular sequence of presentation impacted the results. The order of tasks will require counterbalancing to assure that responses reflect energy or sleep factors rather than the effect of the preceding task.

Third, while the specific task selection questions have been found to reflect varying perceptions of difficulty in normative studies, it is possible that the choices represent other qualities as well. For example, the tasks might represent varying degrees of secretarial work, cognitive load or ability to provide stimulation. Though not presented here, these dimensions were assessed but no differential selection of tasks was found. Future research will benefit, however, if such additional dimensions are considered. Likewise, assessing responses to tasks that specifically tap into various dimensions of effort would be valuable. It may be that under fatigue, participants are more likely to select tasks that require greater effort if they involve physical activity than if they require greater cognitive load.

Fourth, math aptitude among the participants was unknown. It is also unknown how much math aptitude might have influenced the selection of more difficult math tasks. Future research in this area may consider assessment of math ability through the use of readily available tests such as the math component of the SAT. There is no reason to believe, however, that students who have low math aptitude and who may select easier math tasks are also more fatigued and report poorer previous night sleep. Fifth, while our sample was generally representative of the Baruch College undergraduate population, there was an over-representation of Asian students. No steps were taken to solicit individuals from this particular ethnic group. However, a solicitation of individuals from a wide range of ethnic groups might provide valuable information concerning energy, effort and performance. One recent study found that African Americans reported more physical fatigue than Caucasian Americans, and regardless of ethnicity, those who reported more ethnic discrimination also reported more fatigue (38). Whether fatigue is differentially reported by various ethnic groups or impacts them uniquely requires investigation.

The frequency of fatigue and sleepiness make it likely that low effort choices are made regularly. In epidemiological surveys conducted in the United States, fatigue has been reported by 20-24% of respondents (39,40) and severe subjective daytime somnolence is experienced by 3-5% of the general population (8). It is possible that fatigued and sleepy individuals routinely make low effort choices of various kinds. For example, they may choose to eat at fast food restaurants instead of taking time and expending effort to prepare healthier meals at home. These types of choices, in combination with the physiological disadvantages inherent in sleep restriction (41,42), may worsen a variety of medical problems. Sleepiness and fatigue have also been responsible for driving accidents (43) and catastrophic events (44) commonly attributed to inattentiveness or carelessness.

It is unknown how much effort is reduced as a function of sleepiness and fatigue in individuals' day-to-day lives. The typical laboratory environment requires participants to respond to the demands of the situation, whereas outside of the laboratory, people are free to make choices as they please. The choice to engage in specific home and work activities instead of others may be a function of perceived energy and the effort necessary to complete specific activities. It would be worthwhile to assess the range of effort-requiring behaviors affected by perceived energy. The potential danger of reduced energy caused by sleep loss is that less effort may be applied in situations where maximal effort is expected or needed.

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