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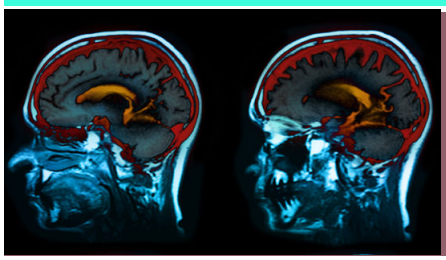

Mental Energy: Defining the Science

Highlights of the ILSI North America Technical Committee on Energy Workshop

Guest Editors

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The lack of "energy" to concentrate, to be productive at home or work, or to stay motivated to see a task through is a common complaint in today's hectic, non-stop society. Many consumers seek to "boost" their "energy" with the foods and beverages they choose to consume. But the science underlying the concept of energy is complex and poorly understood. How is energy defined? Do scientists, health professionals, and consumers talk about energy in the same way? Once defined, how is it measured? Foods and beverages certainly provide caloric energy to sustain life, but how do foods and food components contribute to an individual's sense of mental energy? What is the science that supports product claims to "enhance energy?"

The North American Branch of the International Life Sciences Institute (ILSI North America) is a public, non-profit scientific organization that advances the understanding and application of science related to the nutritional quality and safety of the food supply and to health issues related to consumer healthcare products.

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ILSI North America first formed a committee to explore these and other questions in 1998. The committee organized a workshop that resulted in the publication of a series of papers "Defining Energy for a New Millennium" (2000). Collectively, these papers pointed to a need for additional research, specifically to better understand how consumers perceive energy; to better define discrete components of mental energy and to describe the relationships among these components; and to assess the tools currently used to measure energy.

Immediately following the 2000 workshop, the ILSI North America Technical Committee on Energy began exploring consumer thoughts on energy by conducting a series of focus groups. This approach—novel to ILSI North America at the time—revealed interesting insights. The qualitative work suggested that mood—a feeling of happiness in particular—was associated with good energy levels. Conversely, a sense of unhappiness and anger was linked to low energy levels. The research also indicated that consumers continually experience "peaks and valleys" or energy highs and lows (Geiger, 2004).

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The workshop outcomes, the consumer research, and subsequent literature reviews revealed that (1) there was no consensus on the definition of mental energy or the related concept of mental fatigue; (2) biomedical scientists are interested in understanding and attenuating symptoms of fatigue in various patient groups, although they appear less interested in

optimizing feelings of energy in people without a medical condition; (3) a large number of scales have been developed to assess multiple dimensions of fatigue, often in a population with medical conditions such as cancer, multiple sclerosis, or chronic fatigue syndrome; (4) persistent symptoms of fatigue were common in the general population and among people with various medical conditions; and (5) little research into the neurobiological basis of mental energy or fatigue has been conducted.

Given these findings, the committee commissioned the development of a model to help elucidate the nature of "mental energy." Designed to establish a framework for better understanding the concept and determining how best to measure mental energy, the model initially defined mental energy as "the intensity of subjective feelings about one's capacity to accomplish tasks of daily life; these fluctuate from moment to moment." The preliminary model contained the core dimensions of mood, motivation, cognition, sleepiness, and quality of life (Figure 1).

The committee then commissioned independent reviews of the scientific literature on four of the five components of the model. Experts were asked to identify and evaluate the tools currently used to measure cognitive performance, mood, motivation, and quality of life, and to speculate on how to improve the measurement of these. Sleep was omitted from expert review because a gold standard for measuring sleep currently exists: polysomnography.

With these reviews in hand, the preliminary definition and model of mental energy was critiqued and revised. Mental energy was redefined to encompass "the ability to perform mental tasks, the intensity of feelings about energy/fatigue, and the motivation to accomplish mental and physical tasks." The model was also revised to include three core dimensions—cognition, the mood of energy, and motivation (Figure 2). Mental energy was recognized as an important feature of a broader concept of Quality of Life (QoL) but was no longer seen as core. Also, it was recognized that substantial evidence shows that mental energy may be influenced by a number of variables beyond the core three including genetics, health status, nutritional status, age, pain, and sleep to name a few.

The 8-9 November workshop "Mental Energy: Defining the Science" (see Appendix for a complete program) provided the

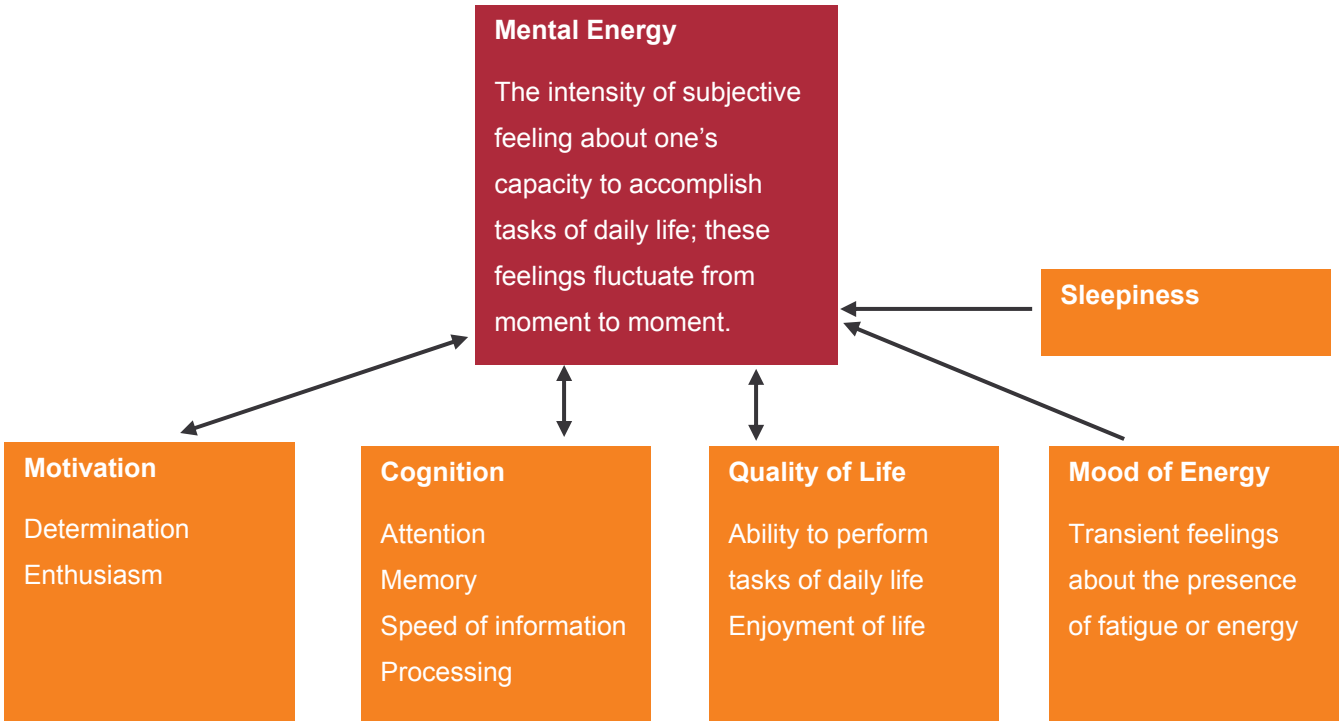

Figure 1. A preliminary definition and model of mental energy.

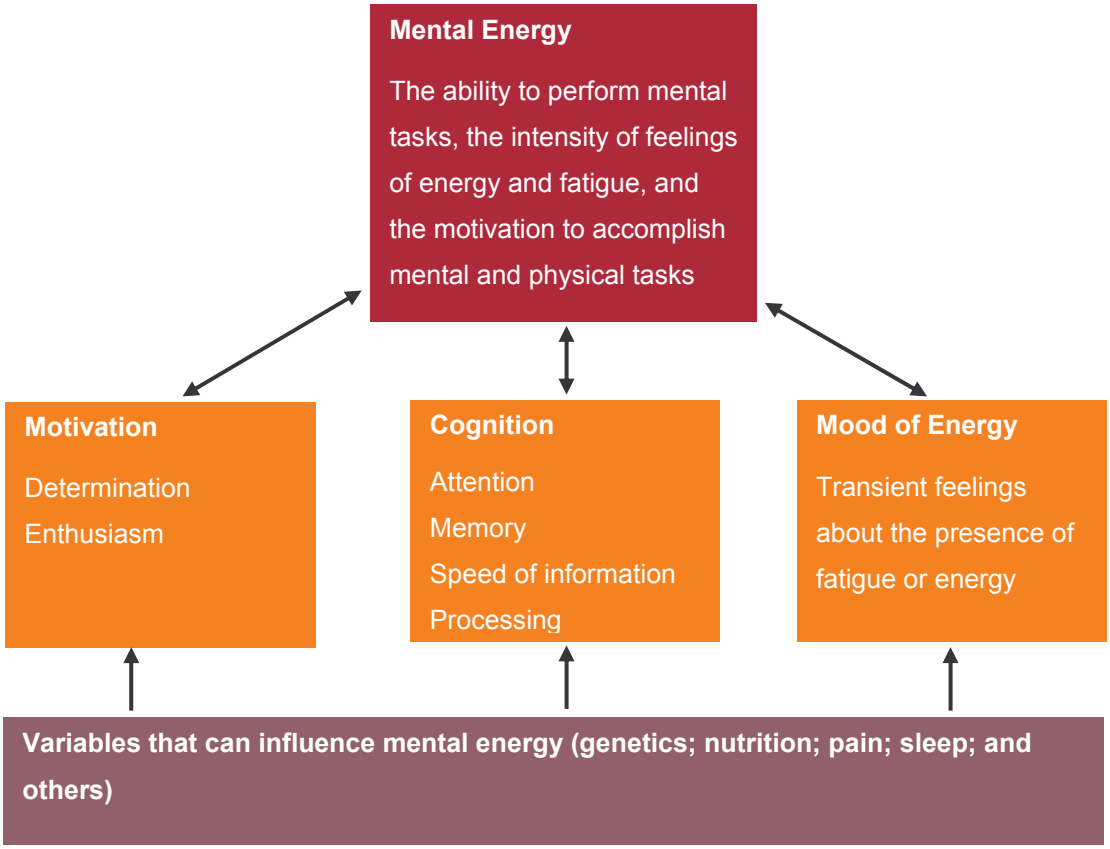

Figure 2. A revised definition and model of mental energy

forum to review the committee's cumulative work, identify knowledge gaps, and speculate on future research needs. Dane Cook, PhD, and J. Mark Davis, PhD, served as workshop moderators. Throughout the workshop, respondents were asked to comment on a given speaker's address thus providing context, more information, and/or an additional point of view which generated discussion.

Patrick O'Connor, PhD, University of Georgia, Athens and advisor to the ILSI North America Technical Committee on Energy, gave the first presentation providing a historical review of the committee's work and a description of how the energy model developed. Chris Bojrab, MD, then provided an overview of the neurophysiology of mental energy. Dr. O'Connor returned to the podium to review the first of the core dimensions of the mental energy model: the mood of mental energy. Harris Lieberman, PhD, discussed the model's second dimension, cognitive performance. Although subsequently deleted from the model, Richard Lucas, PhD, Michigan State University, highlighted his literature review of QoL. John Barbuto, Jr., PhD, University of Nebraska-Lincoln, finished discussion of the model's dimensions with a review of motivation.

On the second day of the workshop, Myles Faith, PhD, University of Pennsylvania, used weight management as an example of how mental energy, especially motivation, plays a role in maintaining health. The final series of speakers provided the US, Canadian, and European perspectives on product claims related to mental energy, and consumer perceptions of energy in general.

At the end of the workshop, participants (see Appendix for a complete list of participants) asked whether the mental energy model is necessary or suited for the purpose of nutrition-related claims. As articulated by Dr. O'Connor (2005), it was thought that the ability to improve mental energy, and to make claims thereon, will be based on compelling science, and that compelling science uses specific, valid measures of the important dimensions of mental energy. The greatest contribution to the science may be to focus on a rigorous evaluation of measures of mental functioning and, if needed, the development of an ideal measure of mental energy.

Neurophysiology of Mental Energy

Chris Bojrab, MD
Indiana Health Group

Fatigue is a symptom present in a myriad of disease states and a common complaint in healthy individuals. Advertisements promoting substances that promise to enhance energy, vigor, and performance are abundant and the public has increased access to a variety of medications, vitamin and herbal supplements, and foods that are alleged to increase energy.

Most prescription medications that have demonstrated some effect on treating fatigue and somnolence are not approved by the Federal Drug Administration (FDA) for use in treating these symptoms. Many have a significant abuse potential, cause untoward cardiovascular effects such as hypertension and tachycardia, and can cause a variety of side effects, including anxiety, tremor, irritability, insomnia, and anorexia. Furthermore, as the body acclimates to the energy-boosting effects, tolerance can develop.

Pharmacology of Fatigue and Wakefulness

The pharmacology of fatigue and wakefulness must be understood before one can comprehend how substances act to improve low energy states. The brain circuits involved in the regulation of sleep, wakefulness, energy, concentration, and alertness can be divided into "dopamine-mediated wakefulness" and "hypothalamic-mediated wakefulness." Medications that increase the availability of certain catecholamine neurotransmitters, such as dopamine and norepinephrine, have been helpful in increasing energy wakefulness, alertness, and attention. These medications have also been shown to be useful in the treatment of disorders such as depression, fatigue, attention deficit hyperactivity, and obesity.

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The mechanism of action in targeting fatigue, low motivation, concentration problems, and other cognitive impairments has been linked to activity of these medications in the prefrontal cortex of the brain.

Conversely, psychostimulant medications such as amphetamines and methylphenidates block the re-uptake of both dopamine and norepinephrine, and interfere with the storage of these chemicals within neurons. This dual mechanism of action on two types of neurotransmitters provides a potent effect on the synaptic concentration of these brain chemicals. However, whether and how neurotransmitters are directly involved in mental energy is not yet known.

The Sleep/Wake Switch

A better understanding of the anatomy and physiology of the primary sleep/wake switch in the brain has developed over the past decade. This switch is located in the hypothalamus and is comprised of three important areas: the suprachiasmatic nucleus (the primary regulation of circadian rhythm), the tuberomammillary nucleus (the "wake center" of the brain) and the ventrolateral preoptic area (the "sleep center" of the brain). These brain areas serve as the primary sleep/wake switch of the brain, separate from the pathways involved in dopamine-related wakefulness. Disruption in hypothalamic-mediated wakefulness has been implicated in the pathophysiology of narcolepsy.

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The discussion of sleep and sleepiness is important because of its impact on cognition, performance, and mood (Lieberman, 2001)—components of mental energy—and because sleepiness was identified as a significant influencer of mental energy in the original mental energy model (Figure 1). Sleep remained in the revised model as a significant influencer on mental energy, along with many other factors (Figure 2).

Moods of Mental Energy and Fatigue

Patrick O'Connor, PhD
University of Georgia, Athens

Moods are subjective transient feelings that can be described in broad terms, such as a person feeling generally pleasant or unpleasant. Moods can also be described more specifically as feelings of anxiety, anger, joy, depression, energy, and fatigue, which often last for hours, but can range in duration from minutes to weeks (O'Connor, 2004). Mood disorders involve intense feelings that are usually sustained for weeks to months. This article will focus on energy and fatigue conceptualized as moods.

Specific moods should be defined both conceptually and operationally. The mood of energy refers to feelings of having the capacity to complete mental or physical activities. The mood of fatigue refers to feelings of having a *reduced* capacity to complete mental or physical activities.

There is a large body of research that has examined moods of energy and fatigue using questionnaires that inquire about feelings of energy or fatigue. These include the Visual Analog Scale (VAS), the Activation-Deactivation Adjective Checklist (AD-ACL), the vigor and fatigue scales of the Profile of Mood States (POMS), and the Medical Outcomes Study Quality of Life Short Form 36 (SF-36). Scores from these questionnaires have been used to operationalize the definition of mental energy (O'Connor, 2004).

The mood of energy refers to feelings of having the capacity to complete mental or physical activities.

There is widespread acceptance of the validity of mood as a measure of mental energy. However, there is no consensus on the best method to conceptualize feelings of energy and fatigue. Some researchers view these moods as unidimensional (i.e., positive and negative descriptions of the same construct) (Ware and Sherbourne, 1992), while others conceptualize them as two separate constructs (McNair et al., 1971). For example, data from mood questionnaires have repeatedly identified feelings of energy (POMS vigor) and fatigue (POMS fatigue) as separate constructs (Norcross et al., 1984; Gibson, 1997). The apparent disctinction among these related concepts may be a function of a method artifact (e.g., differences in how people rate positive- versus negative-worded items). Further research is needed to resolve the issue of whether feelings of energy and fatigue have separate or similar neurobiological basis, and to determine which of the available measures of energy and fatigue moods is the most sensitive in measuring change.

Commentary on Moods of Mental Energy and Fatigue

Andrew Smith, PhD
Cardiff University

Although a consensus on the definition of mental energy has not been reached, consumers frequently perceive mental energy as a multidimensional concept that includes mood, cognition, motivation, sleepiness, and quality of life (QoL). As a result, O'Connor (2005) developed the mental energy model that includes the measurement of mood as a component of mental energy. It is unclear whether energy is the opposite of fatigue, or whether the two concepts, energy and fatigue, are correlated but not identical. Some researchers have conceptualized energy and fatigue as opposites of the same construct, while others view them as separate constructs.

Moods of mental energy may be accompanied by other mood states; they do not occur in a vacuum. For example, an individual may feel energetic and anxious in one context, and energetic and calm in another. The combined mood state is important, rather than a single dimension. However, if the model of mental energy includes cognition and motivation, these may interact with mood. The issue of the time course of mental energy requires further research, as it provides a possible link between short-term mood changes and more global perceptions of QoL.

Measurement of mental energy as a mood is not a major problem. The interplay between mood and the other components of the mental energy model requires further investigation. Whether the latent variable of mental energy is essential or whether claims might merely focus on the outcomes, which are currently thought of as consequences of changes in mental energy, needs to be determined.

The interplay between mood and the other components of the mental energy model is intriguing and requires further investigation.

Cognitive Performance

Harris Lieberman, PhD

It is likely that mental energy can be assessed by tests of cognitive performance, such as those used to assess vigilance and choice reaction time. However, little information is available on the use of these tests to assess mental energy per se, although many are used to evaluate both healthy individuals and individuals with reduced or increased levels of mental energy (Lieberman, 2001).

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Cognitive tests are accepted as established standards for the assessment of a diverse variety of human behaviors. However, there is no single test that assesses only one aspect of behavior. Cognitive tests provide reliable, quantitative information on a variety of abilities in healthy volunteers, and they can be used to diagnose and monitor individuals suffering from various mental and physical diseases. The functions assessed by cognitive tests include: sensation, perception, attention, vigilance, learning, memory, language, gross and fine motor performance, decision-making, and complex mental processes, such as face recognition.

Factors that alter mental energy provide clear guidance about the optimal cognitive tasks for measuring mental energy. These include drugs, food constituents and dietary supplements, sleep deprivation, and chronic disease states.

Drugs

Many drugs affect mood and performance. Drugs that are used clinically to affect mood and cognitive performance include hypnotics and sedatives such as benzodiazepines (e.g., valium and similar drugs), antihistamines and melatonin, and stimulants such as amphetamines. Hypnotics induce and maintain sleep and invariably reduce alertness and mental energy. Stimulants increase alertness.

Drugs that Affect Mental Energy

Benzodiazepines impair many aspects of cognitive performance, including memory, and have substantial effects on related mood. They slow reaction time and impair attention, vigilance, and fine motor coordination. Benzodiazepines also reduce the level of alertness, as measured by the POMS and other self-report questionnaires (Curran, 1991).

The first-generation antihistamines, such as diphenhydramine, have sleep-inducing properties. They are not as potent as benzodiazepine; therefore, they provide insight into the cognitive tasks that are particularly sensitive to increased fatigue and reduced mental energy. Antihistamines also have an effect on mood state, which is consistent with their effects on performance—inducing sleepiness and reducing self-reported alertness (Mansfield, 2003).

Melatonin is another compound that has hypnotic-sedative properties. In the United States, melatonin is regulated as a dietary supplement under the Dietary Supplements Health and Education Act of 1994. It resembles a drug in that it affects mood and cognitive performance similar to that of other hypnotics. Melatonin does not, however, affect memory, even at high doses. Currently, it appears to be an ideal compound for investigating the unique effects of hypnotics on cognitive performance (Lieberman, 2001).

Drugs that Enhance Cognitive Performance

Amphetamines and similar drugs such as modafinil are examples of performance-enhancing drugs or stimulants. They affect a wide range of behaviors and enhance many types of cognitive performance and related mood states, such as vigor and fatigue, which are associated with mental energy. Administration of these drugs to sleep-deprived individuals improved reaction times, vigilance, attention, learning, and memory (Newhouse et al., 1989; Magill et al., 2003). Vigilance tests are the most sensitive for detecting the effects of stimulants.

Food Constituents and Dietary Supplements

In general, the effects of food constituents and dietary supplements on cognitive function are not as robust as those of drugs. A possible exception to this is caffeine, which is a food constituent and a drug (Lieberman, 2001). Caffeine, ephedra, and tryptophan are examples of food constituents and dietary supplements that affect mental energy, fatigue, and cognitive performance.

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The most comprehensive research on the behavioral effects of a food constituent has been conducted with caffeine. It is the best example of a food constituent that alters mental energy in healthy, adequately fed individuals. Caffeine affects mood and performance similar to that of stimulant drugs, and numerous studies have shown that low and moderate doses of caffeine enhanced vigilance (both auditory and visual), improved choice reaction time, increased the level of self-rated alertness, and decreased the level of fatigue (Lieberman, 2001). Other aspects of cognitive performance and mood such as memory, fine motor function, and complex information processing are not affected by caffeine in rested individuals. However, in sleep-deprived individuals, the effects of caffeine generalize to many other cognitive parameters. These observed changes in performance and mood are consistent with increased mental energy.

Many behavioral tests have been used to detect the effects of low and moderate doses of caffeine on cognitive performance. These include the Wilkinson Auditory Vigilance test, the Choice and Simple Reaction Time test, and the Word List Learning test. In addition, questionnaires such as the POMS, the Multiple Affect Adjective Checklist, and the Caffeine Analog Scale are also used to detect the adverse effects of caffeine on cognition (Lieberman, 2001).

Sleep Deprivation

Sleep deprivation alters human mood and performance. Studies have shown that cognitive performance is impaired after a single night without sleep or when sleep is interrupted (Lieberman, 2001). Moreover, as sleep deprivation increases, cognitive performance declines and mood states such as fatigue and sleepiness increase. Sleep deprivation also impairs most types of cognitive function and affects mood states. For instance, it reduces vigor and increases the level of fatigue. Severe sleep deprivation adversely affects all mood states and cognitive performance (Dinges et al., 1997).

Many cognitive tests have been used to assess the effects of sleep deprivation on cognitive performance and mood. These include the Psychomotor Vigilance Test (PVT), serial addition and subtraction, the Wilkinson 4-choice reaction time, the 10-choice reaction time, and a complex synthetic work task (Synwork). The PVT is especially sensitive to the effects of sleep loss as are other vigilance tests (Dinges et al., 1997).

Chronic Disease States

A loss of mental and physical energy that is associated with quality of life issues occurs in some chronic disease states such as multiple sclerosis, cardiac disease, cancer, Parkinson's disease, systemic lupus erythematosus and depression. One disease, chronic fatigue syndrome, is characterized as a loss of energy necessary to conduct the activities of daily living. A number of cognitive tests and mood questionnaires detect the adverse effect of these diseases on an individual's cognitive state, including tests of vigilance, attention, reaction time, memory, and conceptual planning (Hart et al., 1998; Krupp and Elkins, 2000; Lawrie et al., 2000). However, there does not appear to be a cognitive test or type of test that is particularly sensitive to detection of the effects of these diseases on fatigue and loss of energy. In some disease states, physical and mental fatigue are independent symptoms which should be assessed and treated separately (Lieberman, 2001).

Mental energy can be assessed by the use of mood questionnaires and tests of cognitive performance. When these tests are used to evaluate the effects of drugs, food constituents and dietary supplements, sleep deprivation, and disease states on mood and performance, consistent changes are observed in mood states.

Commentary on Cognitive Performance

Phillip D. Tomporowski, PhD
University of Georgia, Athens

The psychological construct of mental energy has not been sufficiently defined. However, the review of cognitive methods available for assessing mental energy outlined above constitutes an important contribution towards operationalizing the construct of mental energy.

Four challenges confronting researchers interested in conceptualizing and systematically studying mental energy are: (1) to recognize that mental energy can be viewed as an individual's mood state and as a person's functional capability and willingness to engage in physical and mental work; (2) to develop valid methods to measure cognitive function in both the laboratory and real world conditions; (3) to determine how mental energy is affected by both environmental influences and

individual-difference factors such as diet, drugs, sleep, and chronic disease; and (4) to seek convergent evidence obtained from studies that emphasize behavioral as well as neuropsychological data.

An additional challenge is for researchers to analyze time-dependent changes in an individual's state of mental energy (e.g., prior to, during, and after a task).

Quality of Life

Richard E. Lucas, PhD
Michigan State University

Quality of life (QoL) is a broad, multi-dimensional construct that reflects an overall evaluation of the conditions in an individual's life. Models of QoL are developed using various domains that contribute to the construct. The definition of QoL, issues that may arise when measuring QoL, and psychometric characteristics of a subset of specific QoL measures will be reviewed in this article.

Definition of QoL

The definition of QoL is a much larger issue than the measurement of QoL. There is no widely agreed upon definition of the term QoL (Gladis et al., 1999). Researchers agree that QoL measures should have three common features: (1) multidimensionality (i.e., they should include characteristics from six broad domains such as physical health, mental health, everyday functioning, social functioning, cognitive functioning, and global assessments of overall health and well-being); (2) they should capture positive and negative aspects of life; and (3) they should be based on an individual's subjective judgments (WHOQOL Group, 1995; Trine, 1999). Beyond these commonalities, there is limited agreement about the definition of QoL.

Researchers interested in measuring QoL must first create an operational definition of the construct (Gill and Feinstein, 1994). A number of decisions must be made before operationalizing QoL which include: (1) identifying the domains that should be used in the model (e.g., medical outcomes related to QoL versus conditions that make one's life more or less difficult); (2) determining the extent to which one's measure of QoL captures subjective evaluations or objective conditions of life; and (3) determining whether QoL itself reflects a global construct or whether it emerges as a construct that results from the summation of multiple conditions (Beckie and Hayduk, 1997). These decisions affect the measurement model that underlies QoL scales and the interpretation of these measures.

Measurement of QoL

There is no gold standard criterion against which QoL measures can be judged. This is partly because of the ambiguities involved in defining the construct and because of its subjective nature. The methods used to collect QoL data include self-reports (e.g., questionnaire and experience sampling techniques); informant-reports (e.g., known informant and trained observer); objective measures of health and functioning (e.g., physiological and laboratory tests); and objective measures of subjective phenomena (e.g., facial, physiological and cognitive measures). This article will discuss QoL data from self-reports.

QoL measures can be subjected to rigorous empirical tests of reliability and validity. Many of these measures have a strong psychometric record because of their use in important medical outcome studies. Three specific measures that capture a broad range of QoL concepts are the Medical Outcomes Study Short Form (SF-36), the World Health Organization Quality of Life (WHOQOL)-100, and the Satisfaction with Life Scale (SWLS).

Medical Outcomes Study Short Form (SF-36)

The SF-36 is a 36-item, self report QoL questionnaire that takes about 5 to 10 minutes to complete. It is the most widely used and frequently studied QoL scale that captures eight specific domains of mental and physical health (Ware & Sherbourne, 1992). The component and domain scores show strong reliability. Various studies show that the scales are valid, sensitive to group differences, and responsive to change. The scale has been adapted for use in many different languages and cultures with encouraging results (Ware & Gandek, 1998).

World Health Organization Quality of Life (WHOQOL)-100

A more general, comprehensive QoL measure is the WHOQOL-100, a 100-item measure that takes about 20 minutes to complete. It was developed to capture health-related and non-health-related dimensions that could be used in many cultures. The WHOQOL-100 consists of 24 specific facets selected to represent six broad domains (i.e., physical, psychological, level of independence, social relationships, environment, and spirituality/religion/personal beliefs) (WHOQOL Group, 1995; WHOQOL Group, 1998). There is also a general well-being facet that captures health- and non-health-related QoL domains. The reliability of the facet, domain, and total scale scores is good.

Satisfaction with Life Scale (SWLS)

The SWLS is a five-item measure that takes about 2 minutes to complete. It was developed to assess an individual's broad sense of global satisfaction with life as a whole (Diener et al., 1985). The SWLS allows respondents to select the domains in their life that are most important to them and to weigh these domains in any manner. The SWLS does not assess symptoms, levels of functioning, or satisfaction with specific domains. It is very reliable, and its homogeneous, single-factor structure has been replicated in diverse populations. The SWLS has been shown to be sensitive to varying levels of psychological and physical functioning, and it appears to be responsive to changes in life events and medical conditions over time. Very few studies have examined the association between the SWLS and specific medical conditions.

Quality of Life and Energy

Models of QoL incorporate some aspect of energy or vitality. The inclusion of energy in these broad models is guided by the notion that feeling energetic is pleasant, and that energy allows people to accomplish many different tasks in their lives.

Most QoL theorists would view energy as one facet of QoL rather than viewing QoL as a facet of energy.

QoL may be related to energy differently than the other components in the comprehensive model. Mood, cognition, and motivation seem to be defining characteristics or essential components of the global construct of energy. The links between energy and QoL are not clearly defined. Most QoL theorists would view energy as one facet of QoL rather than viewing it as a facet of energy. Future research is needed in this area to help clarify the nature of the association between energy and QoL.

Commentary on Measurement of QoL

Ivan Barofsky, PhD

The Quality of Life Institute

Cross-cultural studies of QoL are important since the meaning of energy may be different between cultures. How the phrase "mental energy" is used in different languages and cultures should be the starting point, especially since different patterns of usage will be required for communication.

The terms "mental energy" and "QoL" are similar in that both can be viewed as extremes of an information continuum. Therefore, physical and mental status can be considered more concrete forms of the more abstract term QoL.

Information is organized around a common goal or objective (cross-classification of information). Diverse terms and objects may be collected together around a common theme. This organization is important because a complete definition of mental energy or QoL may never be defined, but only an approximate definition (operational) will be provided. In addition, usefulness of forming categories by cross-classification helps one understand how human induction, explanation, and problem-solving occurs.

The questions to be addressed are: to what extent do the various terms that people use when referring to mental energy fit into specific categories, and what type of categories are they? This information should help focus the research into the nature of mental energy.

Motivation

John E. Barbuto, Jr., PhD

University of Nebraska-Lincoln

Motivation can be defined as the psychological processes that give behavior purpose and direction; a predisposition to behave in a purposive manner to achieve specific, unmet needs; an internal drive to satisfy an unsatisfied need; and the will to achieve. Because motivated behaviors have an *energetic* or activational component, motivation is seen as a core domain of the mental energy model (Figure 1).

Research in the field of motivation has examined adult motivation, as well as motivation in other contexts such as youth, special needs and social disorders. A wealth of studies on human motivation and its measures have been conducted. The context to which motivation is studied or applied is salient to the choice of measures.

Because motivated behaviors have an *energetic* or activational component, motivation is seen as a core domain of the mental energy model.

Adult motivation can be classified into four broad categories which require different theory and measurement choices. These include content theories, process theories, decision-making (or choice) theories, and sustained-effort theories.

Content Theories

Content theories aim to identify the cause or source of motivation, whether there is an underlying need or value. The content theories in motivation research have asked the question, "What motivates others?" The best model of content theories includes four constructs: hierarchy of needs (self-actualization, esteem needs, love/belonging needs, safety and security needs, and physiological needs) (Maslow, 1954); trichotomy of needs (need for power, need for affiliation, and need for achievement) (McClelland, 1961); the erg theory (need for existence, need for relatedness, and need for growth) (Alderfer, 1969); and the meta-theory (intrinsic process motivation, instrumental motivation, self-concept external motivation, self-concept internal motivation, and goal internalization motivation) (Leonard et al., 1999).

The Motivation Sources Inventory scale was developed to measure an integrative taxonomy of motivation (Barbuto and Scholl, 1998). The sources include intrinsic processes, instrumental, external self-concept, internal self-concept and goal internalization. The predictive validity of the scale is evident from correlations with a variety of behaviors.

Energy, vigor, or persistence of work output in stimulus-seeking behavior is generally seen as a fundamental aspect of motivation.

Process theories

Process theories of motivation describe the motivation process and provide prescriptive interventions to induce higher levels of motivation and effort. The goal-setting theory and the control theory are examples of process theories.

Goal-setting Theory

The goal-setting theory has its roots in the theory of intentional behavior (Ryan, 1970). It appears to be a valid theory, which posits that goals and intentions are responsible for human behavior (Locke et al., 1968). The theory maintains that the difficulty and specificity of the goals increases motivation, while incentives provide little increase in behavior.

Control Theory

The control theory was proposed more than 50 years ago, but has since taken on a theoretical role (Klein, 1989). It is a model of human behavior with applications in a variety of human contexts and problem areas, including motivation, self-management, and affective and behavioral reactions (Carver, 1979).

Cognitive decision-making (or choice) theories

Decision-making or choice theories present the cognitive process behind motivation. They are characterized as cognitive process models or as attempts to cognitively map the decision to exert effort. The Valence-Instrumentality-Expectancy (VIE) Theory and the Equity Theory are examples of decision-making theories.

Valence-Instrumentality-Expectancy (VIE) Theory

The model for the VIE theory was initially developed to measure effort, performance, outcome, and valences (Vroom, 1964). Since then Porter-Lawler (1968) expanded on the model to include equity of rewards, abilities/traits and role perceptions. Ilgen, et al. (1981) represents the most empirically sound measure of the VIE theory, which featured multiple efforts, performance and outcome measures of expectancy and instrumentality. The VIE theory appears to be a valid model.

Equity Theory

The Equity theory posits that people like to be treated fairly in their exchanges and develop norms concerning what is fair and what is unfair treatment (Adams, 1965). People will also compare themselves to others. If inequity is perceived, people will be motivated to do something about it. The Equity theory has been supported by research and it has evolved today into theories of procedural justice.

VIE versus Equity Theories

Some primary distinctions between the VIE and Equity theories are that VIE theories are more general, they include equity considerations, they are more useful in a variety of contexts for studying motivation, and they are recommended for cognitive-process objectives for studying motivation.

Sustained-effort theories

Sustained-effort theories of motivation are those that operationalize motivation as exertion of effort. Typically, the source or process of motivation is less important in this definition of motivation. Instead, researchers and practitioners from the

sustained-effort perspective are interested in measuring the intensity or endurance of effort. The most common sustained-effort theory is described in intrinsic motivation research and other general works that use motivation and effort synonymously. Choice of optimal theory and measure depends on the objectives and goals of the research project.

Motivation needs to be examined and measured within its objective or context, which precludes the optimal choice of measures. Researchers examining human motivation are advised to make their objectives clear so that judgment calls made with respect to theory and measurement selection are logical.

Commentary on Motivation

John D. Salamone, PhD

University of Connecticut

As noted above, researchers and theorists have emphasized that motivated behaviors have an energetic or activational component. Energy, vigor, or persistence of work output in stimulus-seeking behavior is generally seen as a fundamental aspect of motivation. There are several motivational stimuli available in the environment and multiple ways of obtaining them. As a result, organisms are constantly engaged in effort-related decisions based upon cost/benefit analyses.

Several studies have shown that dopamine (DA) in the nucleus accumbens is involved in activational aspects of motivation (Salamone, 1988; Salamone et al., 1991; 1997; 2003; Salamone and Correa, 2002). Depletion of DA in nucleus accumbens decreases several behavioral markers of activation, including spontaneous, stimulant-induced, and food-induced motor activity. Nucleus accumbens DA is a critical component of brain circuitry, mediating effort-related decision-making and the tendency to work for significant stimuli. This area of research could have implications for understanding the brain circuitry involved in mental energy and the exertion of effort in the workplace.

Researchers examining human motivation are advised to make their objectives clear so that judgment calls made with respect to theory and measurement selection are logical.

Importance of Mental Energy in Weight Management

Myles Faith, PhD

University of Pennsylvania

Mental energy may be a critical component of successful weight control and obesity treatment. However, few studies have examined the role of mental energy in weight control. Moreover, few measurements of “mental energy for weight loss,” “motivation for weight loss,” or “readiness to change” have been developed. What is known is that individuals who lose and maintain weight loss over time appear more vigilant in their efforts.

Mental energy may be a critical component of successful weight control and obesity treatment.

Depression and Obesity

Numerous studies have shown that obesity is associated with medical complications, but much less is known about the relationship between obesity and depression. There does not appear to be a single or simple association between depression and obesity (Faith et al., 2003). Epidemiological studies have found that increased body weight was associated with increased symptoms of depression in women, but reduced symptoms in men (Faith et al., 2002; Stunkard et al., 2004). Depression is especially common among binge eating adults who seek treatment, and these individuals may lack the mental energy necessary to maintain weight loss. More research is needed to determine the relationship between depression and the onset of obesity (e.g., is it linked to decreased mental energy?) and the role of depression in achieving weight loss.

Quality of Life and Obesity

Obese individuals are more likely to have impaired QoL than non-obese individuals, especially in the area of physical health (Heo et al., 2003; Hulens et al., 2002). Those with more severe impairments in health-related QoL experience greater improvements during weight loss than obese patients with less severe impairments in baseline health-related QoL (Engel et al., 2003). The role of health-related QoL and its changes during weight loss and regain are important for the concept of mental energy in obese individuals.

Assessing Stages of Change

The stages of change model has had limited success in predicting weight loss outcomes. Studies have shown that "readiness for change," which is part of the stages of change model, fails to predict weight loss in obese adults (Jeffery et al., 1999). These results may reflect limitations in theoretical models or measurement, or other methodological issues.

The Institute of Medicine recommends "use of the Diet Readiness Test (DRT) or a comparable test to help point out potential problems with motivation" (IOM, 1995). The DRT has six subscales: goals and attitudes; hunger and eating cues; control over eating; binge eating and purging; emotional eating and exercise patterns; and attitudes (Brownell, 1990). In one study with obese women receiving weight loss treatment, the DRT scores did not predict weight loss treatment outcomes (e.g., weight loss, binge eating improvements, exercise improvement, nor sound psychometric properties) (Pendleton et al., 1998). In another study with 410 obese women, the bingeing and eating cues scale of the DRT was negatively associated with program attendance. None of the remaining scales correlated with weight loss. The authors concluded that the DRT does not appear to be a strong predictor of weight loss or treatment adherence (Fontaine et al., 1997).

Other instruments evaluate readiness to change for behaviors related to weight control. One is the "Eating Styles Questionnaire" which classifies readiness to change dietary fat intake (Hargreaves et al., 1999) and the other is the "Weight Loss Behavior-Stage of Change Scale" which evaluates readiness to change for specific behaviors (e.g., portion sizes, dietary fat, fruit and vegetable intake, usual physical activity and exercise (Sutton et al., 2004).

Manufacturers of dietary supplements and conventional foods are responsible for ensuring the accuracy and truthfulness of S/F claims.

Weight Loss Expectations and Perceptions

The motivational aspects of weight control are related to the individual's expectations for success. Unfortunately, many obese individuals have unrealistic expectations about the amount of weight loss they will achieve using existing behavioral weight control strategies or pharmacotherapy (Foster et al., 2001; Wadden et al., 2003). This disconnect can present motivational obstacles for obese patients. Therefore, some researchers have developed a cognitive-behavioral therapy approach for obesity that focuses on fostering more realistic weight loss goals in order to sustain motivation for weight loss.

Expert panels and governmental guidelines recommend that obese adults set reasonable goals for weight reduction of about 10% of baseline weight (NHLBI, 1998). Foster et al. (1997) assessed patients' goals, expectations, and evaluations of various weight goals. Weight goals averaged a 32% reduction in body weight—three times greater than the expert recommendations. The authors concluded that clinicians may want to help certain patients accept more realistic weight loss goals.

Motivational Interviewing

Motivational interviewing (MI) was designed as a brief, non-confrontational approach to help someone make changes in his or her behavior. The goals of MI are: to enhance self-efficacy and personal control for behavior change; to increase motivation by illuminating gaps between personal goals and current behaviors using an interactive, emphatic listening style; to actively encourage discussion of both positive and negative aspects of change; and to regard assistance as a normal part of the process and an opportunity to enhance motivation and spark behavior change (Miller and Rollnick, 2002).

Further research is needed to develop valid research tools for quantifying motivation for change, and to identify the specific intervention strategies that will enhance motivation within obese individuals who are ready for change.

FDA Update on Scientific Evidence to Support Health Claims

Paula R. Trumbo, PhD
Food and Drug Administration

Since the enactment of the Nutrition Labeling and Education Act (NLEA) in 1990, a number of health claims have been authorized by the United States' Food and Drug Administration (FDA). Health claims are authorized for labeling of foods where there is significant scientific agreement among qualified experts on the evidence for a causal relationship between a substance (i.e., food or food component) and a disease or health-related condition for the general United States population or subpopulation. A disease is defined as "damage to an organ, structure, or system of the body such that it does not function properly (e.g., coronary heart disease [CHD] or a state of health

leading to dysfunctioning, e.g., hypertension)." A health-related condition is defined as "a condition that is equivalent to the disease, as to be indistinguishable from the disease (e.g., hypertension) or a validated modifiable risk factor for disease (e.g., low density lipoprotein [LDL] cholesterol)." Examples of diseases and validated modifiable risk factors are: CHD and total/LDL cholesterol; cancer and colorectal polyps; diabetes and blood glucose levels; osteoporosis and bone mineral density; and dementia and mild cognitive impairment.

A number of factors determine the appropriate amount and type of substantiation required for claims.

An evidence-based ranking system is used by the FDA to evaluate the level of scientific evidence for a petitioned qualified health claim. The agency evaluates the scientific studies to determine which ones are useful to review in evaluating the substance/disease relationship. The studies are classified based on study design as Type 1 (intervention studies [gold standard]); Type 2 (prospective cohort); Type 3 (case-control); or Type 4 (cross-sectional [least reliable]).

The studies are also rated independently for methodological quality (e.g., study population characteristics, intervention design, data collection, quality of the statistical analysis). The FDA then rates the strength of the total body of evidence that it determines is useful for its review. It then determines whether there is credible evidence to support the substance/disease relationship and, if so, determines the ranking that reflects the level of comfort (i.e., high, moderate/good; low, or extremely low) among qualified specialists that such a relationship is scientifically valid.

Structure/Function Claims

The Dietary Supplements Health and Education Act of 1994 established special regulatory procedures for structure/function (S/F) claims for dietary supplement labels. In contrast to health claims and qualified health claims, S/F claims describe the role of a nutrient or dietary ingredient intended to affect normal structure or function in humans (e.g., calcium builds strong bones). In addition, S/F claims may characterize the means by which a nutrient or dietary ingredient acts to maintain such structure or function (e.g., nutrient X maintains mental energy) or they may describe general well-being from consumption of a nutrient or dietary ingredient.

The manufacturers of dietary supplements and conventional foods are responsible for ensuring the accuracy and truthfulness of S/F claims, since these products do not undergo a pre-review of the scientific evidence by the FDA. Dietary supplements that make a S/F claim must state in a "disclaimer" that the FDA has not evaluated the claim. Disclaimers are not required for conventional foods.

Federal Trade Commission Perspective

Heather Hippsley, JD
United States Federal Trade Commission

The United States Federal Trade Commission (FTC) and the FDA share the responsibility of regulating dietary supplements. The responsibility of the FDA has been described above. The primary responsibility of the FTC is in the realm of advertising: print and broadcast ads; infomercials; catalogs and other direct marketing materials; and marketing on the Internet. The FTC believes more information is beneficial to the public, only if it is truthful. Therefore, advertising for any product, including dietary supplements, must be truthful, must not be misleading, and must be substantiated.

The FTC Enforcement Policy Statement on Food Advertising describes the principles underlying the FTC's regulation of health claims in food advertising. These policies are applied to dietary supplements. There are instances in which the FTC will permit a carefully qualified health claim in advertising, even if it has not been authorized for labeling by the FDA. This situation is rare and requires both strong scientific support and careful presentation.

An advertisement can be considered deceptive if it contains a misrepresentation, or if it omits information that is likely to mislead reasonable consumers to their detriment. Therefore, the "net impression" conveyed to consumers by all elements of the advertisement must be identified and evaluated. Advertisers are responsible for the truthfulness and accuracy of the entire message conveyed by the advertisement. Examples of recent cases where FTC intervened were discussed and additional information can be found on their website www.fda.gov.

A number of factors determine the appropriate amount and type of substantiation required for claims, including the type of product, the type of claim, the benefits of a truthful claim and the cost/feasibility of developing substantiation for the claim, the consequences of a false claim, and the amount of substantiation experts in the field believe is reasonable. Claims about the

safety or efficacy of dietary supplements should be supported with "competent and reliable scientific evidence."

Under the Dietary Supplement Health and Education Act, all statements of nutritional support for dietary supplements must be accompanied by the disclosure that "the statement has not been evaluated by the FDA and that the product is not intended to diagnose, treat, cure, or prevent any disease." This statement can prevent the consumer from being misled about the extent to which a product has been tested for efficacy or safety by the FDA.

Canadian Perspective

Nora Lee, MS

Health Canada

The Canadian Food and Drugs Act (CFDA) defines a drug as "any substance or mixture of substances manufactured, sold or represented for use in the diagnosis, treatment, mitigation or prevention of a disease, disorder, or abnormal physical state, or the symptoms thereof." The definition does not make reference to mental state although this did not prevent the development of drugs to treat mental illness. This definition also includes products that are manufactured, sold, or represented for use in "restoring, correcting or modifying organic functions in man or animal." There is no exemption for foods comparable to the one in the US Food, Drug and Cosmetic Act (FDCA) which includes as drugs, "articles (other than food) intended to affect the structure of any function of the body of man." This is an important difference between the United States and Canadian legislative frameworks. Another difference is that "dietary supplements" (as defined by the United States) are in the category known as Natural Health Products in Canada. Because these are a subset of drugs in Canada, they can carry therapeutic claims as well as structure/function claims. However, adequate evidence must be presented before a product can be licensed for sale.

Structure/function claims for Natural Health Products as defined in guidance documents, "describe the effect of a medicinal ingredient on a structure or physiological function in the human body, or a medicinal ingredient's support of an anatomical, physiological, or mental function." A section in the CFDA Regulations permits statements or claims "to the effect that the food's energy value or a nutrient contained in the food is generally recognized as an aid in maintaining the functions of the body necessary to the maintenance of good health and normal growth and development." This type of claim is referred to in guidance documents as a "biological role claim." Because of the many potential interpretation nuances involved, it is difficult to comment on whether some of the types of claims of effects of foods or food energy on mental energy would fall within the parameters of a biological role claim or a S/F claim. In any event, to be considered a biological role claim, the subject of the claim would have to be a food's energy or a nutrient required in the diet that is in the food (not the food, itself) and the role would have to be well-established as a true, usual, and necessary function of that nutrient. To permit structure/function claims for foods, new regulations would be required to exempt products carrying those claims from the application of the drug regulations.

European Perspective

Sonia Samartin, PhD

ILSI Europe

There is a lack of consensus among European countries with respect to nutrition, nutrient function claims and health claims. A draft proposal of a Regulation of the European Parliament and of the Council on "Nutrition and Health Claims made on foods" states that "the following health claims shall not be allowed: claims, which make reference to psychological and behavioral functions."

Comments from the working party of Foodstuffs from the Council Secretariat include that the following health claims shall be prohibited, except under certain conditions and when explicitly provided for in the authorization: "(1) claims which make reference to general, no-specific benefits of the nutrient or food for overall good health and well-being, and (2) claims which make reference to psychological and behavioral function."

Consumers interpret the word "energy" broadly, and they did not associate energy with calories.

Communications and Consumer Perspective

Susan Borra, RD

International Food Information Council

Consumers interpret the term energy, in the context of health, in different ways. A review of the media coverage of the term "mental energy" in 2004 revealed numerous print and broadcast coverage of the term; however, very few were related to nutrition.

The relationship between energy expenditure and food intake can be expressed as "energy balance." The concept of

balancing energy intake with energy output is the foundation of weight management communications. The Dietary Guidance Alliance conducted qualitative research in 2004 on consumers' perceptions of and receptivity to the concept of "energy balance" (IFIC, 2004). The primary objective of the study was to explore how consumers think about food input and energy output, and the balance between the two.

In addition, the study examined whether consumers understood the concept of "energy balance" as it relates to food and physical activity. Consumers were asked how they make food choices, how they manage their health and weight, and whether they ever feel the need to burn off the foods they eat. They were also asked to define energy balance and its components. The consumers provided feedback regarding how they would like energy balance messages communicated to them. The researchers were able to determine that consumers interpret the word "energy" broadly, and they did not associate energy with calories. Therefore, at the present time it was concluded that consumers will not grasp the meaning of "energy" within the context of "energy balance." Moreover, other achievable, understandable, and realistic messages should be explored to find other terms or means to convey the concepts of energy and energy balance to consumers.

Summary and Conclusions

Having the mental energy to concentrate, to be productive, or to stay motivated to see a task through to completion helps individuals achieve a happy, satisfying life. Over the course of two days, workshop participants discussed how mental energy impacts cognitive performance, mood, and motivation—domains that make up a model for mental energy.

During the workshop some questions were answered:

- Mental energy is an important component of QoL;
- Mental energy can be defined operationally;
- Most operational definitions of mental energy can be categorized under one of three rubrics: cognitive performance, mood or motivational processes;
- Operational definitions of cognitive aspects of mental energy can be objective while valid mood measures of mental energy are always subjective.

One question was left unresolved:

- Does one aspect of mental energy—cognition, mood, or motivation—play a more important role in health, overall well being, or QoL than another?

Still other key ideas remained partially addressed:

- It was recognized the knowledge of the neurobiological basis of mental energy is at an embryonic stage;
- More research and discussion is needed to understand how to approach and best measure the motivation domain of mental energy.

As consumers increasingly look to foods and beverages to boost their energy levels and more and more product claims are being made promising this, the need for valid methods for measuring cognitive, mood, and motivational aspects of mental energy that may respond to diet or nutrient manipulations is critical. Ultimately, the workshop has helped move researchers closer to understanding what more is needed to develop and implement these methods.

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Mental Energy: Defining the Science

A Workshop of the ILSI North America Technical Committee on Energy

Monday, 8 November 2004
Washington, DC

Welcome and Introductions
Dr. Frances H. Seligson, representing The Hershey Company

Workshop Goals
Dr. Mark Davis, University of South Carolina

Part I: Mental Energy

What is Mental Energy?
Dr. Patrick O'Connor, University of Georgia

Neurophysiology of Mental Energy
Dr. Chris Bojrab, Indiana Health Group

Part II: Methodology for Measuring Mental Energy

Mood of Mental Energy
Dr. Patrick O'Connor
Expert Reactor—Dr. Andy Smith, Cardiff University

Cognition
Dr. Harris Lieberman
Expert Reactor—Dr. Phil Tomporowski, University of Georgia

Quality of Life
Dr. Richard Lucas, Michigan State University
Expert Reactor—Dr. Ivan Barofsky, The International Quality of Life Institute

Motivation
Dr. Jay Barbuto, University of Nebraska
Expert Reactor—Dr. John Salamone, University of Connecticut

Tuesday, 9 November 2004
8:30 a.m. to 12:00 noon

Part III: Importance of Mental Energy and Application of Paradigm and Methods to Diets, Foods, and Dietary Constituents

Importance of Mental Energy in Weight Management
Dr. Myles Faith, University of Pennsylvania

FDA Update on Scientific Evidence to Support Health Claims
Dr. Paula Trumbo, CFSAN

Panel Discussion and Gap Analysis of Application Needs
Lead by Dr. Dane Cook

FTC Perspective
Ms. Heather Hippsley, FTC, Assistant Director, Division of Advertising Practices

Canadian Perspective
Ms. Nora Lee, Acting Chief, Nutrition Evaluation Division, Health Canada

European Perspective
Dr. Sonia Samartìn, ILSI Europe

Communications Perspective
Ms. Sue Borra, International Food Information Council

Workshop Concluding Comments and Wrap Up
Dr. Mark Davis

Attendees
Speakers and Respondents
Dr. Jay Barbuto, University of Nebraska
Dr. Ivan Barofsky, The International Quality of Life Institute
Dr. Chris Bojrab, Indiana Health Group
Ms. Sue Borra, International Food Information Council
Dr. Dane Cook, UMDMJ
Dr. Mark Davis, University of South Carolina
Dr. Myles Faith, University of Pennsylvania
Ms. Heather Hippsley, US Federal Trade Commission
Dr. Harris Lieberman
Dr. Richard Lucas, Michigan State University
Dr. Patrick O'Connor, University of Georgia
Ms. Nora Lee, Health Canada

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