# Expert Meeting on Healthy Habits: Habit Formation and Habit Change

**The National Academies of Sciences, Engineering, and Medicine**
**Division of Behavioral and Social Sciences and Education**
**Board on Behavioral, Cognitive, and Sensory Sciences**

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# Table of Contents

# Meeting Summary

## Introduction

On June 16, 2020, the National Academies of Sciences, Engineering, and Medicine's Division of Behavioral and Social Sciences and Education's Board on Behavioral, Cognitive, and Sensory Sciences (BBCSS) convened an expert meeting to elucidate the mechanisms of habit formation and habit change as they relate to adoption of healthy behaviors.

This seminar reinforced the mission of the National Institute on Aging's (NIA) Division of Behavioral and Social Research (BSR), which supports social, behavioral, and economic research on the processes of aging at the individual and societal levels. BSR seeks to elucidate the pathways by which social, psychological, economic, and behavioral factors affect health; identify the causal mechanisms that account for observed associations; and target these mechanisms in order to modify individual behaviors and social contexts to promote health and prevent disease. As part of this mission, BSR targets mechanisms of behavior change to positively influence the experience of midlife and older age.

BSR's work is oriented toward use-inspired basic research and mechanisms-focused intervention science drawn from the National Institutes of Health (NIH) Stage Model and the Science of Behavior Change (SOBC) Common Fund Program. The SOBC is a trans-NIH program dedicated to redesigning behavior change interventions by implementing a mechanisms-focused, experimental medicine approach.

This expert meeting addressed the mechanisms that influence initiation, long-term maintenance, and persistence of behavior change. It aimed to fill two primary needs in the field: (1) clarifying the roles of affect, reinforcement learning and motivation, memory, goal-directed behavior, and context in shaping behavior change; and (2) specifying conditions within which each mechanism prevails to inform the design of future behavior change interventions.

Throughout the meeting, the following priorities, gaps, and needs were identified:

- Researchers need psychological models (quantitative vs. qualitative; prescriptive vs. descriptive) that explain the mechanisms not just for initiation but, more importantly, for maintenance of healthy habits; these models may need to reconsider conceptualization and definition of habit to better align with research advances in the cognitive, affective, social, and motivation sciences; measurement implications; applications to a spectrum of behaviors (e.g., simple to complex); and how these considerations may inform intervention development efforts.
- Researchers must continue to understand individual behavior choices, but the United States also needs policy-level changes to restructure the built environment and remove sources of friction that impose unequal access to healthy habits.
- The field needs to develop interventions that are effective across racial/ethnic groups and non-U.S. populations.

# Presentations

*Moderator: Susan Fiske, BBCSS*

**A Motivation Neuroscience Perspective on Habit and Behavior Change**
*Elliot Berkman*

Effective behavior change requires a will (i.e., motivational factors) and a way (i.e., cognitive factors). The "way" is the set of prerequisite skills, knowledge, and capacities for performing a target behavior. Three cognitive factors are targets for potential interventions: inhibitory control (i.e., ability to inhibit impulses and responses to stimuli), cognitive reappraisal (i.e., ability to reframe stimuli or situations to change their meaning), and planfulness (i.e., how carefully individuals consider their goals). However, although all three factors are strong predictors of behavior change, they have proven difficult to change. Therefore, Berkman advocates for concentrating research on changing motivational factors, or the "will."

### Measuring Motivation
Motivation is notoriously difficult to study but can be inferred from the choices people make and their  neurophysiology. The process of turning complex motivations into choices can be quantitatively modeled and appears to relate to brain networks centered around the ventromedial prefrontal cortex (vmPFC). Thus, choices that are tightly linked with activation in this region can be attributed to motivation (as opposed to an alternative behavior-driving system such as habit). To illustrate how the vmPFC accounts for specific choices, Berkman explained that, when faced with a choice, individuals apply a subjective value to each potential outcome. These values are influenced by inputs and attributes, including those that are tangible (e.g., money, effort, time, information), social (e.g., acceptance, status, norms), and identity-based (e.g., consistency, verification, autonomy). The vmPFC integrates these heterogeneous inputs, and researchers can apply a cumulative subjective value model (e.g., using drift-diffusion modeling) to track the accumulation of value over time and predict a final choice. The parameters of the cumulative subjective value model (including accumulation rate and decision threshold) can account for different decisions.

### Motivation Interventions
To identify areas where motivation interventions may be most effective, Berkman conducted a study of middle-aged overweight patients. Patients were asked to place a subjective value on foods (i.e., healthy or unhealthy) by bidding on them while in a brain scanner so that researchers could observe brain activation throughout the brain. This exercise provided a cross-sectional estimate of value. Across trials, vmPFC activation exhibited the highest predictive power of whether a person would place a higher or lower subjective value on a given food.

Another study by Berkman sought to change motivation by encouraging self-identification as a healthy individual. When embedded into an individual's identity, a value (such as health) can become a source of motivation for decision making. To modify individuals' self-images, Berkman asked some of the study participants to self-author messages that connected healthy eating to their core values; these messages were subsequently sent as periodic reminders via

text message. Other participants received generic health messages. The former placed higher value on healthy foods over time, and these values and sense of identity were correlated with activity in the vmPFC. These results point to the importance of self-motivation in behavior change.

These studies help address an important research gap. While most theoretical models of motivation offer purely descriptive accounts of its workings, these studies begin to adapt those models into prescriptive guidance on how to *change* and increase motivation.

## Discussion

### *Future Studies*
Researchers applying behavioral economic or contingency management interventional approaches have shown that economic rewards are effective tools for eliciting a target behavior (e.g., healthy eating) and treating disorders where behavior has a central role (e.g., substance use disorders). However, economic value has typically been used as an outcome to track behavior change, not a target or mechanism to *elicit* behavior change. Further, It is  not a scalable and long-term solution to generate behavior change.

### *Need for Better Tools*
Susan Michie's taxonomy of behavior change includes 93 behavior change techniques but lacks an ontology describing the interrelationships between those techniques and the mechanisms for behavior change, such as motivation or identity. Researchers need to better understand which mechanisms to modify and how to design effective behavior change interventions.

For example, motivation to continue an action may diminish, but still persists, after removal of an external incentive. The process for understanding why motivation persists is not well documented. The field lacks valid, objective, and accessible valuation measures: vmPFC network connectivity is a promising objective measure of valuation but its use is limited by access to magnetic resonance imaging (MRI) and expertise in complex neuroimaging methodologies. Alternatives include value-based self-report or performance measures. The field needs additional techniques for measuring valuation to better understand motivation.

Also needed are alternative behavior change tools and strategies for sustained motivation. Most techniques have focused on external incentives, despite the presence of other means to motivate individuals. In the taxonomy of values, factors leading to decisions include cost, identity, and social factors (norms and influence). Aside from cost, these factors are not only free, but also self-sustaining, because individuals monitor and regulate their own actions based on their sense of identity, which is strongly influenced by social factors.

**Transdisciplinary Approaches to the Initiation and Maintenance of Complex Health Behavior**
*Angela Bryan*

Complex health behaviors influence the factors—weight status, physical fitness, strength, mobility—that drive health, independence, and quality of life among adults, particularly among older adults. Bryan and her team have focused on exercise behavior, defined as activity requiring physical effort and purposely engaged in to sustain or improve health and fitness. The key to encouraging initiation of a new behavior is creating motivation to perform that behavior. To understand how individuals initiate exercise behaviors, researchers apply a variety of health behavior theories, including Theory of Planned Behavior and Self-Determination Theory.

### Initiation
Multiple factors influence an individual's likelihood to initiate an exercise routine. Individuals have different acute physiological responses to exercise (influenced by motivation and genetic factors), which in turn play a large role in determining their subjective experience of exercise (i.e., pain, exertion) and its influence on affect (i.e., an individual's experience of feeling, emotion, or mood). If affective response to exercise is positive, then the individual will experience stronger motivational factors such as increased positive attitudes toward exercise, confidence in their ability to exercise (self-efficacy), and intentions to exercise, all of which are translated to a higher chance of repeating the behavior. This process is dynamic, creating a feedback loop between positive affect, increased motivation, and behavior continuation.

Exercise offers multiple benefits to older adults, including delayed neurocognitive decline. Neurocognition has been linked to health and quality of life for older adults. Bryan's Fitness, Older Adults, and Resting State Connectivity Enhancement (FORCE) study found that regular exercise improves neurocognitive function in older adults. The study also showed increased connectivity in the brain between important nodes in the frontoparietal and default mode network of the brain after the 16-week trial. While these results are encouraging in the short-term, some benefits will emerge only after exercise has occurred on a long-term basis.

### Maintenance
The Maintain IT model delineates a conceptualization of factors that differ in influence and are important in the transition from the initiation to the maintenance of behavior. The model posits that complex health behaviors never fully reach automation. Initiation of a complex health behavior involves a heavy reliance on executive function. As the behavior continues over time, it embeds itself into the individual's centered identity—whose creation is influenced by multiple factors, including personal values, group-based identity, and psychological well-being—making the behavior easier to perform. This relative ease results from the decreased reliance on executive function over time and the transition to a *relatively* more automatic enactment of behavior However, even when strongly embedded in an individual's identity, the behavior will never reach the level of automaticity required for a habit. For example, if an individual who eats healthfully visits relatives who eat fatty foods, they will have to apply renewed effort to continue the healthy eating behavior in the context of strong temptations.

This lack of automaticity is due to the inherent difficulty of performing complex health behaviors. The context, cues, and psychological states surrounding such behaviors change over time and may challenge the centered identity of an individual. For example, physical activity, a complex health behavior, has many requirements and is by nature difficult. It is not as easily established in an individual's automated processes, and therefore the adherence rate is ~25 percent in naturalistic, real-world settings. By comparison, seatbelt use is considered to be a habit: its requirements rarely change and it is by nature easy, leading to an adherence rate of 91 percent. Researchers need a better understanding of the complexities associated with behavior maintenance to design better health behavior interventions.

## Discussion

### *The Gap Between Models and Applications*
A gap exists between laboratory models of behavior change and actual behavior change. The problem is a lack of theoretical models of neurocognitive function to bridge the gap. The Maintain IT model begins to narrow this gap. However, researchers need to improve models' incorporation of complexity to determine when and how particular motivators need to be applied. Furthermore, figuring out how to introduce interventions, and identifying the appropriate way to get the right intervention to the right individual at the right time, is another critical missing piece in modeling the process of behavior change. Ecological momentary interventions (EMIs), which intervene at critical junctions for individuals who experience challenges, are a promising step forward, but researchers need to determine what form they should take, at what time they should be implemented, and what their content should be.

### *The Relation of Executive Function to Self-Identity*
Wood noted that many theories of identity involve active control of behavior to monitor how actions align with an individual's identity. The trade-off between executive (active) control and self-identity in the Maintain IT model seems to disagree with these existing theories and offers a novel approach. Bryan clarified that executive function is not *replaced* by identity in the maintenance stage of the model, but instead the balance between centered identity and executive function shifts to rely more on identity and less on executive functioning. However, adequate data are not yet available to support this model.

### *Examples of Affective Response Measurements*
One of Bryan's more successful methods to improve affective response to exercise consisted of a technological game played during physical activity. Interventions increasing either mindfulness or distraction during physical activity were also linked to positive affective response. The common affective response to the seemingly opposed phenomena of mindfulness and distraction raises an interesting scientific question about potential commonalities in these phenomena's underlying mechanisms. However, Bryan noted that when introducing low-active individuals to physical activity (which varied by intensity and duration) in an exercise training study, there was no evidence that simply completing repeated bouts of the activity had any impact on affective response. In other words, experience with exercise behavior does not—in the absence of any external intervention—lead to more positive

affective response. Based on the variety of affective responses observed, Bryan concluded that affective response to physical activity is an individual-level variable that is challenging to manipulate.

## Exercise and Physical Activity: The Transition to Post-Cognitivist Theoretical Models and Interventions
*Panteleimon Ekkekakis*

Research reveals that interventions to promote exercise typically have limited effectiveness. A meta-analysis by Carrie Patnode et al. (JAMA 2017) showed that interventions lead to a mean effect size of just 0.2. Moreover, affect sizes in this range may actually overestimate the effectiveness of interventions because they are negatively related to sample size and the length of follow-up, and are positively related to assessments of methodological quality. Research has also revealed no significant differences among interventions to promote physical activity that are based on different psychological theories.

### Current Approaches
The most common behavior change theories applied to exercise promotion are cognitive (e.g., Theory of Planned Behavior, Social-Cognitive Theory, Self-Determination Theory). Cognitive interventions tend to occur in an office setting where individuals learn the abstract importance of exercise, removed from the environment where they might actually engage in it. Moreover, cognitive theories assume rationality, that is, that individuals will seek relevant information, retain this information, and subject this information to rational evaluation in making decisions about their behavior.

However, studies show that even without cognitive interventions, individuals already understand that exercise and physical activity are important. In a population survey of U.S. adults, 97 percent of individuals considered physical inactivity a health risk factor; yet 97 percent also failed to complete the minimum recommended amount of physical activity. A survey of British adults generated similar results. These surveys illustrate that the assumption of rationality that underpins cognitive theories of behavior change may be problematic and cognitive theories may be insufficient to change most individuals' behavior.

### Creating a New Approach
Researchers increasingly recognize that exercise imposes unique affective challenges. A workout routine not only requires time and energy but also may impose an emotional cost, because exercise is not always associated with positive affect.

Negative affective response may be among the largest barriers to developing effective exercise interventions. The degree of negativity is determined by an individual's intensity threshold—shaped by a combination of metabolic markers, especially ventilatory threshold and respiratory compensation point. Distinct affective trends correspond with three segmented intensity levels. Most individuals exhibit a homogeneous positive affect at moderate levels of intensity; a zone of response variability emerges at heavy levels of intensity, when individuals' affective responses differs; and another zone of response homogeneity surfaces at severe levels of

intensity, when all individuals experience decreased positive and eventually negative affect. However, in overweight and obese individuals, *no level* of exercise elicits a positive affective response.

Affective response to typical activity interventions may not improve over time; indeed, some research has found that it may actually deteriorate from baseline levels, even with encouragement. Affective responses are correlated both cross-sectionally and longitudinally with physical behavior, both self-reported and device-assessed: those individuals with positive affective response are more likely to remain active, even though almost all individuals drop off in amount of exercise over time.

Based on these findings, Ekkekakis and colleagues developed the Affective-Reflective Theory (ART) of physical inactivity and exercise. This theory attempts to extend the cognitive approach to exercise through a dual-process model that concentrates on conflicts between negative affective responses and positive reflective (or cognitive) processes. Such a conflict may arise when continued negative experiences of exercise establish a negative affective valuation, usually in adolescence or early adulthood. This negative valuation automatically signals a negative affective response to future exercise experiences, regardless of cognitive beliefs about the value of exercise. Moreover, this default negative affective response may even influence reflective processes.

### *Current Challenges*
Researchers need to (1) identify robust methods of improving the affective experience of exercise and (2) establish the relationships between affective experience and affective valuation. To identify methods to improve affective response, researchers should identify ways to modify exercise intensity, physical environment, social environment, and cognitive processing pathways. In addition, identifying ways to *measure* affective experience is a challenge that requires attention, because self-report is not always reliable. To establish connections between affective experience and valuation, researchers need new and better measurement tools. Current methods (e.g., implicit association, reaction-time tasks) have not generated reliable results.

## Discussion

Bryan noted that physical activity guidelines produced by major organizations seem to deliver contradictory materials. For example, the American College of Sports recently launched a campaign equating sports to medicine. Given that most individuals have negative associations with medicine, Bryan questioned whether major organizations are applying affective theory accurately. Ekkekakis noted that guidelines from major organizations are not developed by consistent teams of individuals and are therefore subject to inconsistent messages. To combat this problem, Ekkekakis suggests creating a "prime directive" to drive exercise guidelines—that no exercise guideline should conflict with the "prime directive" of encouraging individuals to return to exercise the next day. In other words, guidelines should never be extreme enough to cause a negative affective response that would discourage individuals from continuing to exercise.

**Health Habits**
*Wendy Wood*

In intervention science, researchers have successfully created short-term changes but struggle to develop lasting interventions. This struggle emerges even in well-designed habit change intervention studies, including of smoking cessation and weight loss. In general, habits form as individuals experience reliable rewards for particular behaviors in specific contexts, leading to the creation of mental short-cuts that favor those behaviors. To create a lasting habit, however, a behavior (such as a commute home from work) must be repeated until individuals develop context-response associations in memory. Such a habit does not require a *fixed* cue; rather, slight deviations in the setting become part of the broader context cues. Once a habit forms, individuals need only perceive the associated context cues for their response to be activated in memory. Thus, for individuals with habits, perceiving the performance context automatically triggers thoughts of the behavior(e.g., the gym activates thoughts of exercising), and people often act on the response in mind.

### Creating a Habit
Wood's observational research has shown that, in everyday life, people persist in doing an activity when they have formed habits. Research further shows that people who report high self-control are not displaying high motivation or successful inhibition, but rather strong habit formation. For these individuals, habits streamline the decision-making process so they meet goals on a more consistent basis.

To test the mechanics of habit formation, Wood studied individuals who played an online sushi-making children's game either 2 or 10 times. Each full game required a 16-step sequence of responses. As predicted, those individuals who had practiced the game 10 times (versus twice) were able to repeat it more accurately when tested at the end of the study. In addition, on a separate habit strength measure, more practice enabled them to more quickly choose the next step in the sushi-making sequence when primed with the prior step. These faster reactions reflect stronger cognitive associations and habit formation.

The more practiced individuals also reported increased ease of action, fluency of action, perceived automaticity. Most importantly, the study revealed the cognitive mechanics behind habit repetition. That is, practice enabled successful repetition of the behavior only to the extent that it increased strength of context-response associations (rapidly choosing the correct next step)Therefore, Wood concluded that strength of cognitive associations is the causal mechanism by which habits persist. Fluency, ease, perceived automaticity, and intentions can be part of the experience but are not driving forces.

### Future Directions
Future research should focus on defining the conditions under which people repeat desired behaviors so they can become habits automatically activated by environmental cues. Wood and her team have identified two processes to achieve these conditions: reducing friction in the environment (i.e., the ease/difficulty of performing an action) and increasing the enjoyability (i.e., the pride, positive affect, or goal congruence of an action).

Although the initial decision to perform a behavior (e.g., exercise) may require consulting personal identity or making a conscious decision, it is also influenced by environmental friction. For example, individuals who live within 3.6 miles of a paid fitness center went 5 times a month, while individuals who lived 5.1 miles from a paid fitness center went only 1 time a month. Friction, in the form of distance, was associated with less performance of a behavior.

However, friction can be used to decrease the appeal of alternative options in order to increase a targeted behavior. For example, in an office building, researchers introduced friction by slowing elevators by 16 seconds. As a result, elevator use decreased by 33 percent as individuals in the office building began to use the stairs. This is a noteworthy result because signs to take the stair, appealing to the need to save energy or increase health, had little impact on elevator use. In addition, even after the elevator returned to normal functioning, many individuals continued to use the stairs presumably because it had become habitual through practice. Thus, friction is also reflected in the time required to perform an action.

Enjoyment acts as an opposite force to friction, increasing the pleasure of performing a behavior, so that people repeat it more often, in turn increasing the likelihood of a behavior becoming a habit. For example, if individuals reported their New Year's resolution as being useful, life-changing, or important, they were less likely to continue the behavior than if they reported it as rewarding, fun, and enjoyable. These tools should be applied to long-term behavior research to increase habit formation for desirable health behavior change.

## Discussion

### Creating Broader Habits
Habits are commonly viewed as discrete, automated actions; however, Berkman asked whether it was possible to create more broad habits such as "eating more healthy food." Wood explained that stimulus generalization may make this possible to some degree. For example, individuals use stimulus generalization to interact with a refrigerator in broadly similar ways regardless of the location (at home versus at work). Furthermore, habits underlie more of our actions than we realize. Wood is conducting research to illustrate that even creativity problems benefit from work habits, as individuals learn steps to structure creative work in broadly the same manner. She noted that many highly productive writers report habits to write in the same places and times most days. In this way, habits are the infrastructure of much of what we do.

### Friction and Enjoyment as Tools to Maintain Habits
Building habits toward behaviors that lack reward and are viewed as "punishments" (i.e., exercise) will rely on adding friction to alternatives to make the decisions easier—increasing enjoyment of the target behavior when possible and increasing repetition of the targeted behaviors so that exposure creates the opportunity for liking.

Enjoyment and friction tools will direct individuals to repeat targeted behaviors and ultimately form a habit of those targeted behaviors. Habit formation is a basic learning system that associates responses and rewards. When forming a habit, repetition itself in a stable context may be more important than the reward. Wood explained that healthy habit formation is only

possible when the context we live in is changed to better promote repetition of healthy behaviors over less healthy ones.

## Moderated Discussion
*Moderators: Lis Nielsen and Luke Stoeckel, NIA BSR*

Because the themes raised during the presentations identified areas of disagreement, Nielsen and Stoeckel encouraged meeting attendees to engage in "adversarial collaboration" to identify points of difference and to unpack the themes at the basis of the disagreements. Stoeckel reminded the meeting attendees that the goal of the meeting was to identify gaps and opportunities to inform the development of intervention approaches to optimize sustained health behaviors over the life course.

### Increasing Healthy Behaviors across Populations
Michele Gelfand asked each presenter about the generalizability of their models in terms of diversity and inclusion of non-Western perspectives. Bryan noted that her studies consisted of predominantly White samples, particularly the older studies. She added that her latest trial on affective response included a more racially/ethnically and economically diverse population, but the generalizability of the findings is not clear.

Berkman seconded the lack of diversity in his studies, with predominantly White samples with some Latinx individuals. His samples included some socioeconomic status (SES) diversity. However, the premise for the developed interventions is grounded in Self-Determination Theory and other theories that have been well studied in diverse populations and outside of the United States. His studies rely on self-generated stimuli, which to some extent also offsets cultural bias because they are based on the individual's values and are not generated by the experimenter.

Gelfand agreed, adding that redesigning context as Wood suggested may more naturally occur in other cultures. The root of the challenge to initiating and maintaining behavior change may be embedded in individualistic cultures. However, researchers overall have not studied these other cultures to determine whether this concept is true. A pre-publication paper from Stanford reviewed the number of studies in the psychology field that focus on race and found that, especially in cognitive psychology, few studies examined race.

Building on this discussion, Nielsen asked the group to consider whether the ability to change context in order to facilitate a habit is equitably distributed in our society. The interventions discussed by Wood involve creating a context in which individuals can choose to engage in a desired habit. However, individuals with lower socioeconomic (SES) status, especially those in less-resourced communities, may have greater levels of friction that complicate such choices.

Wood noted that all levels of government must play a role in making the built environment more conducive to health behaviors such as exercise. An individual's built environment and SES are strongly correlated with body mass index (BMI) and other health outcomes. Therefore, without community planning and infrastructure for healthier lifestyles, population-level

behavior change is difficult. Infrastructure change requires policy solutions, and the United States may wish to model its built infrastructure on those of countries that have successfully implemented health-conscious, engineered environments. For example, when the COVID-19 pandemic struck France, the government closed streets to automobile traffic to encourage biking as an alternative to mass transit.

In pursuit of cross-cultural studies of exercise, researchers found that no country has been able to increase physical activity at the population level, but significant differences in physical activity levels exist across countries. For example, the Eurobarometer study asked whether people perceive exercise as fun. In Southern Europe, 11 percent of people report exercise as fun, but in Northern Europe, especially the Netherlands and Finland, 68 percent of people report exercise as fun. The correlation between the responses and participation at the national level is substantial. Therefore, the greatest issue with exercise in the United States may be national portrayal (e.g., high intensity; no pain, no gain). Researchers should redefine and reshape the portrayal of exercise to encourage greater population-level uptake.

However, even if the United States adjusts both the built environment and portrayal of health behaviors, encouraging motivation and self-efficacy will remain critical components of healthy lifestyle changes. Research suggests that motivation may override an imperfect built environment. Therefore, finding motivation interventions that work in all populations will continue to be a critical research effort and will need to involve approaches at the levels of the individual and environment as well as situational, sociocultural, and other considerations that may influence health behaviors.

## Group Identity: Benefits and Challenges
During the past decade or so, group-style interventions have become more popular. Such interventions are examples of social networks that build social influence (norms and persuasions) and create conformity that helps motivate individual members of the group to engage in the target behaviors. Such social networks play heavily into a long history of social norm interventions. In the Maintain IT model presented by Bryan, group identity is in fact a main aspect of self-identity, and thus group belonging can foster identity-driven behavioral change

Yet, social identity can also be a source of friction in behavior change. In some social circles, group identity may discourage health behavior changes. For example, in the South, the consumption of unhealthy foods is ingrained in the familial and cultural setting. Individuals not eating those foods threaten this Southern identity.

## Affective versus Reflective Responses to Exercise
Affect is the measure of the immediate internalized response to a behavior assessed via single-item rating scales while the behavior is ongoing. This immediacy distinguishes affect from a reflective evaluation; in fact, values placed on exercise during reflective assessments do not correlate strongly with how individuals feel while exercising. This lack of correlation stems from post-exercise cognitive processing, which for some individuals exhibits an inverse relationship:

the worse they feel during the exercise routine, the better they feel afterwards about the exercise behavior (i.e., no pain, no gain).

Based on current data, during-exercise affective response correlates with the continuation of exercise behavior. While attitudinal measures and reflective evaluations may correlate, most individuals assign positive evaluations to exercise during reflective measures regardless of affective experience. A ceiling effect or a reduced range phenomenon for retrospective affective reporting may account for this.

## Achieving the Prime Directive by Redefining Rewards

Ekkekakis' idea of a prime directive (the experience of exercise today should not prevent a person from exercising again tomorrow) aligns with Wood's goal of repeating a desired behavior. However, Wood noted that while individuals repeat rewarding behaviors, behavior change research has not identified a reward strong enough to transition an initiated behavior into a behavior that is reliably maintained. Every presenter agreed that motivating individuals to maintain a behavior change is more challenging than motivating them to initiate behavior change. However, despite this fact, researchers still spend a great deal of time studying methods of initiation. The field should shift its focus to methods of maintenance. Wood added that studies of behavior maintenance must look beyond executive function to consider the role of built environments and social surroundings and to people's health responses to these.

Future work in this area should more creatively and extensively explore a revised definition of reward. Researchers may explore social properties, such as agency and autonomy, as inherently rewarding, but they should also consider how to match rewards to different individuals, especially across cultures. They may also investigate the appropriate time to introduce a reward to achieve the maximum desired effect; extrinsic rewards may become less necessary over time as individuals become accustomed to what was previously viewed as an unpleasant experience.

### *Substances as Rewards*

Geisler explained that to initiate his own running habit, he rewarded himself with high-quality coffee when he completed a run. Noting that this reward is a drug (caffeine), Geisler wondered whether researchers could apply addiction science to establish and maintain health behaviors, such as using caffeine to amplify the positive feeling post-workout. Wood explained that such an external reward may be challenging for most individuals because linking it to the completion of the target behavior relies on high self-control (e.g., most habitual coffee drinkers will consume coffee independently of their exercise behavior). Instead, rewards that people realize through performing an action are more likely to build healthy habits for most people.

### *Creating a Self-Reward System*

Studies have generated a great deal of data on external rewards (e.g., monetary rewards) to initiate behavior change. However, external rewards are unsustainable, and when removed, motivation to continue the behavior may decline. Researchers should focus on interventions that incorporate target behaviors into the self-identity of individuals, in order to enhance the behaviors' personal value, or into the environment in which they live, in order to enhance the

behaviors' broader value in meeting life goals (e.g., walking to stores, eating healthfully with friends).

### *Positive and Negative Reinforcement*
Researchers know that individuals in the United States spend more time on their phones and watching television than ever before. In most time-allocation research, time budgets are consistent with the amount of satisfaction or enjoyment associated with a given behavior (i.e., the more enjoyment an individual experiences from an activity, the more time they will devote to it in line with principles of positive reinforcement). However, individuals tend to report only modest satisfaction with time spent with phones/television (they assign that time a 2 out of 10 on a satisfaction scale). The key to behavioral change may be to identify an activity that rates higher on satisfaction and then offer that activity as an alternative to initiate the behavioral change.

Geisler asked, however, whether reported levels of satisfaction can be accepted at face value. Many individuals may report that spending time with the television or other media formats is unrewarding simply to align with societal expectations. Yet, those same individuals may view that time as stress relieving and be unwilling to reallocate it to another activity. The stress relief may itself be a reward, and therefore an alternative reward must outweigh that benefit.

Nielsen noted that some instances may call for reducing a negative state rather than providing a positive reward. Bryan responded that the Maintain IT model characterizes discrepancies between current actions and individuals' identities as a negative state that individuals are motivated to avoid. In this approach, researchers could illustrate to individuals how physical inactivity directly contradicts their sense of a valued identity (e.g., identity as a mother). By illustrating the discrepancy, researchers might motivate individuals to initiate physical activity routines. Cognitive effort is another cost that individuals will pay to avoid, and thus reducing this cost (as in environmental frictions) might constitute an effective behavioral intervention.

## Thresholds of Habit Formation

### *Repetition*
Phillippa Lally concluded in a 2009 publication that it takes at least 66 days for a simple health habit (e.g., taking a walk after dinner, eating fruit with lunch) to become automated. However, some health behaviors that are more complicated (e.g., exercise) take much longer to become even semi-automated. This pattern is in line with animal models of habit formation, which can require hundreds of repeated actions. If an individual performs the behavior only once a day or less, the time to meet the high number of repetitions is extended.

In American culture, instant gratification and impatience may account for failure to arrive at a certain threshold of repetition. For example, many individuals report quitting diets because they do not see results quickly enough. Perception of time varies between individuals, which may act as a barrier to behavioral changes. Researchers have developed behavior change models that account for temporal discounting. These models have shown that reward value declines hyperbolically with delay.

Jonathan King suggested that a key to repetition may be manipulation of a status quo. Actions that require equivalent or less effort than individuals currently expend are easier to initiate than those requiring more effort. However, the deliberate introduction of friction can manipulate this balance. For example, King explained that he bikes to work daily because he removed all other options (sold his car) and because Washington, DC traffic provides its own form of friction that is unpleasant to deal with.

Berkman, however, asked whether it is useful to distinguish between a repeated action and a habit. By increasing friction for all activities other than a target behavior, an individual may come to perform that behavior daily, but only through canalization. This forced repetition does not necessarily match the reinforced, automatized nature of a habit undertaken with the expectation of a reward, even if performance of the behavior is a "win" in behavior change science. However, even apparently canalized behaviors may be associated with nontraditional rewards: for example, by riding a bike, an individual gets to work.

*Complexity*
Phelps asked whether the field should reconsider the definition of a habit. The literature defines habit as a simple automated action (e.g., pressing a specific button in an elevator). The nature of some of the complex, effortful behaviors described during this workshop seem to contradict this definition. Wood noted that some behavior change requires a higher level of effort during initiation than during maintenance. For example, a regular cyclist with a maintained routine and pace may find it difficult to adjust their pace to match a new partner, forcing them to use more effort to change their effort than to maintain their regular pace.

Stoeckel asked whether researchers consider complexity in assessments of behavior change. Phelps noted the difference in approaches between model-based and model-free reinforcement learning approaches. The model-based approach involves a complex path through which individuals receive a reward, whereas the model-free approach involves a more habitual learning response. In this way, actions requiring more complex approaches may need to be considered separately from simpler, traditionally defined habits.

**Future Directions**
Presenters identified the following next steps to enhance the field's research on habit formation:

- Identify approaches to reinforce behaviors that acknowledge individuals and their cultures
- Identify the timing for rewarding behaviors, potentially through EMIs or adaptive machine learning interfaces
- Identify the techniques by which individuals form new identities or associations with behaviors
- Identify strategies to make behaviors self-reinforcing and therefore enduring
- Expand the theoretical framework of exercise motivation to incorporate the role of affective experiences as well as cognitive appraisals, and interactions between the two

- Improve implicit and performance-based measures relevant to habit (e.g., affective response, valuation)
- Expand research that explains how environmental friction interacts within individual psychology to drive behavior change

**Final Thoughts**
*Moderator: Susan Fiske, BBCSS*

Fiske suggested the meeting's major take-home message is the importance of a simple mechanism: repetition, which is the key to behavior change. There are many approaches to fostering repetition and thus change, such as applying rewards and leveraging social identity. The moderators of behavior change include stage of change (initiation versus maintenance), complexity of the target behavior, affective response, context (e.g., SES, built environment), and friction. The specific role of friction in helping and hindering behavioral change is a research area that deserves more attention. Other research gaps are (1) the lack of precise, objective measurement of reinforcers and rewards and (2) the discrepancy between explicit reflective and implicit affective responses to behaviors and the de facto decisions to repeat them. The important themes and needs outlined in the introduction should be used as guidelines for researchers targeting any health-related behavior change.

# Appendix 1. Meeting Agenda

**Healthy Habits: Habit Formation and Habit Change**

*June 16, 2020*

*Virtual Event*

**SEMINAR AGENDA**

1:00          *Welcome and Brief Introductions*
               Susan Fiske, Chair, BBCSS

1:10          *Introductory Remarks from the National Institute on Aging*
               Lis Nielsen, NIA Division of Behavioral and Social Research

1:20          *Setting the Stage for the Seminar*
               Luke Stoeckel, NIA Division of Behavioral and Social Research

1:30          *Preliminary Presentations: Participants will share evidence and hypotheses using
               examples from their own work to address how they envision affect, motivation, and
               habit might or might not influence decision-making and behavior change.*

- Angela Bryan (15 min)
       Comments from other 3 panelists (10 min)
- Elliott Berkman (15 min)
       Comments from other 3 panelists (10 min)
- Panteleimon Ekkekakis (15 min)
       Comments from other 3 panelists (10 min)
- Wendy Wood (15 min)
       Comments from other 3 panelists (10 min)

*Moderator*: Susan Fiske

3:10          **BREAK**

3:30          *Moderated Discussion*

               Invited experts and BBCSS members will share thoughts on the questions below,
               considering the research gaps and opportunities that could inform the development of
               prevention and intervention approaches to optimize health behaviors over the
               lifecourse.

- In what contexts are affect, motivation, and habit important, especially as they
  relate to decision-making and behavior change?
- What is the evidence that habit formation by context change is easily
  implementable by individuals independent of affect and motivation? How might
  habit formation and change be impacted by broader sociocultural, contextual,
  and environmental factors?

- What steps should be taken to better integrate the sciences of affect, motivation, and habit to optimize innovation and advance fundamental decision-making and behavior change science?
- What happens when, as Michael Otto says, you fall off the wagon and have to re-engage (i.e., how can an integrated science of affect, motivation, and habit help us address the challenge of *sustained* behavior change)?

*Moderators:* Lis Nielsen, Luke Stoeckel

*4:45*          *Final Thoughts: Priorities for moving forward*
                  *Moderator:* Susan Fiske

*5:00*          **Adjourn Meeting**

# Appendix 2. List of Participants

**Presenters**
Elliot Berkman, University of Oregon
Angela Bryan, Arizona State University
Panteleimon Ekkekakis, University of Illinois in Champaign-Urbana
Wendy Wood, University of Southern California

**Division of Behavioral and Social Research, National Institute on Aging**
Lisbeth Nielsen, Division Director
Audie Atienza, Program Officer
Frank Bandiera, Health Scientist Administrator
Prisca N. Fall, Health Specialist
Elena Fazio, Health Scientist Administrator
Melissa Gerald, Program Director
Amelia Karraker, Health Scientist Administrator
Chandra Keller, Social Science Analyst
Jonathan King, Program Director
Laura Major, Health Specialist
Lisa Onken, Program Director
Georgeanne Patmios, Program Official
Dana Plude, Deputy Director
Janine Simmons, Chief, Individual Behavioral Processes Branch
Luke Stoeckel, Program Director
Rebecca Lazeration, Rose Li and Associates, Inc. (Contractor)

**Committee on National Statistics, National Academies**
Alexandra Beatty, Senior Program Officer
Molly Checksfield, Program Officer
Jacqueline Cole, Senior Program Assistant
Monica Feit, Deputy Executive Director
Julie Schuck, Program Officer
Adrienne Sith Butler, Associate Board Director
Barbara Wanchisen, Director
Tina Winters, Associate Program Officer

**Board on Behavioral, Cognitive, and Sensory Sciences, National Academies**
John Baugh
Susan T. Fiske, Chair
Wilson Geisler
Michele Gelfand
Nancy G. Kanwisher
William Maurer
Terrie E. Moffit

Mary Ellen O'Connell
Steven E. Petersen
Elizabeth A. Phelps
Timothy J. Strauman

**Attendees**
Holly Hapke, University of California, Irvine