
Meeting Summary

Introduction

The NIH SOBC Common Fund program seeks to promote basic research on the initiation and maintenance of behavior change and the application of such research to interventions. This effort is intended to integrate research across disciplines and to lead to an improved understanding of the underlying principles. The Third Annual Meeting of Investigators offered a unique opportunity to bring together grantees from SOBC and OppNet who work on self-regulation to discuss present and future research directions. Grantees presented results from a wide range of disciplines, including psychology, neurology, genetics, psychiatry, and social science. The goal of this meeting was to foster discussion on ways to include basic research in clinical research and to identify gaps and opportunities in the field of behavior change.

Investigators presented their research in a series of 10-minute talks, followed by panel question-and-answer periods. Three 1-hour discussion sessions provided additional time to elaborate on the topics of self-regulation, methodology, and use-inspired basic research.

Welcoming Remarks

SOBC Working Group Co-chairs, Dr. Patricia Grady (Director, National Institute of Nursing Research [NINR]), Dr. Richard Hodes (Director, National Institute on Aging [NIA]), and Dr. Richard Suzman (Director, Division of Behavioral and Social Research, NIA) welcomed the participants to the Third Annual Meeting of Investigators. Dr. Grady emphasized SOBC's mission to integrate various scientific disciplines in the study of behavior change.

Dr. Hodes thanked everyone for their participation and noted the importance of basic science research as a foundation for building intervention mechanisms. Understanding of the mechanisms of behavior change will facilitate the translation of basic research findings into effective clinical interventions.

Dr. Suzman noted that behavior change is more important than ever from a public health standpoint. Recent research demonstrates that the United States exceeds other developmental countries in morbidity and mortality, and the discrepancy is primarily due to preventable behaviors and social determinants of health.¹ Behavior change research is relevant for public policy. For example, the United Kingdom has a Behavioral Insights Team in the Cabinet Office that is tasked with designing inexpensive, community-level interventions. A recent meeting co-sponsored by the NIA, the White House Office of Science and Technology Policy, the White House Council of Economic Advisers, and the Association for Psychological Science convened various experts in psychology and behavioral economics to examine gaps and opportunities for behavior change research in the United States that can be used to inform policymaking. Dr. Suzman concluded by expressing optimism that researchers would continue to develop more effective interventions for behavior change.

¹ National Research Council. (2013). *U.S. Health in International Perspective: Shorter Lives, Poorer Health*. Washington, DC: The National Academies Press.

Self-Regulation Investigator Presentations

Regulating Temporal Discounting, Unexpectedly

Elizabeth A. Phelps, PhD, Silver Professor of Psychology and Neural Science, New York University

Dr. Phelps challenged the idea that emotion and decision-making are competing processes. Instead, emotion plays a modulatory role in cognitive processes such as value computation. In this sense, changing emotions may result in an altered choice. Dr. Phelps described the ways emotion can impact the decision-making process and presented evidence for a model of emotional regulation of choice.

Several components of the decision-making process can be influenced by emotion: loss aversion (the tendency to strongly prefer avoiding losses to acquiring gains), risk sensitivity (the ability to tolerate an environment with large variability), and temporal discounting (the tendency to discount rewards as they become distant in time). There are two gaps regarding the role of emotion in the decision-making process: characterizing how and when emotion is incorporated into the value computation and considering whether researchers can influence choices by changing emotions.

The specific aims of Dr. Phelps' research focus on the interplay between emotion and the three components of the decision-making process. For each of the specific aims, Dr. Phelps is investigating the behavioral outcomes and their underlying neural representations:

- **Specific Aim 1:** Investigate the link between variability in loss aversion, risk sensitivity, and temporal discounting on physiological arousal response to choice options or outcomes
- **Specific Aim 2:** Examine the impact of altering arousal on these decision variables
- **Specific Aim 3:** Explore the impact of stress on the decision variables and the effectiveness of the techniques used to alter arousal

Pupil dilation is an excellent correlate of physiological arousal. It reflects the activation of the sympathetic nervous system and is measured faster than skin conductance. Also, pupils dilate in response to both positive and negative stimuli. Dr. Phelps and colleagues measured emotional response via pupil dilation to varying conditions of immediate versus delayed rewards. For example, researchers measured pupil dilation as participants were given the choice between accepting \$10 today or \$20 in 30 days.

An individual's temporal discounting curve is hyperbolic: the percentage lost decreases rapidly at first and then plateaus. A high discount rate results in a steep hyperbolic curve. Interestingly, Dr. Phelps discovered that greater pupil dilation correlated with more acceptance of the delayed reward. Initially, this result seemed counterintuitive, because patience apparently results in an increase in sympathetic activation.

In order to further investigate this phenomenon, Dr. Phelps designed five experiments to systematically test how variability in either the immediate or delayed reward changed the decision outcome. Pupil dilations were measured as study participants assessed each choice combination.

- **Experiment 1: Vary the delayed reward with three immediate rewards**
In experiment 1 ($n=30$), three levels of immediate reward (\$10, \$20, and \$30) were combined with 20 different delayed rewards, varying in delay (7 days-180 days) and magnitude (\$11-\$90).

In this trial, the larger the delayed reward relative to the immediate reward, the higher the pupil diameter response. In other words, as the delayed reward became more financially attractive, the sympathetic response increased. In fact, pupil dilation predicted the choice of the delayed reward.

- **Experiment 2: Keep the immediate reward constant and vary the delayed reward**
In experiment 2 ($n=39$), one level of immediate reward (\$30) was combined with 20 different delayed rewards, varying in delay (7 days-180 days) and magnitude (\$33-\$90). The results from experiment 2 were identical to the results from experiment 1. As the delayed reward increased, arousal as measured by pupil dilation increased as well.
- **Experiment 3: Vary the immediate reward with three delayed rewards**
In experiment 3 ($n=33$), three levels of delayed reward (\$45 in 30 days, \$60 in 30 days, and \$90 in 30 days) were combined with 20 different immediate rewards. The pupil diameter and the amount of the immediate reward were positively correlated. As the immediate reward became more appealing, sympathetic activation increased.
- **Experiment 4: Vary both immediate and delayed rewards**
In experiment 4 ($n=30$), two levels of delayed reward (\$45 in 30 days, \$60 in 30 days) were combined with 15 different immediate rewards. Conversely, investigators combined two levels of immediate reward (\$10, \$20) with 15 different delayed rewards. The results of this experiment were intriguing. As the delayed rewards varied, the subjective values of delayed rewards were more likely to vary as well. A similar pattern was seen for immediate rewards and their subjective values.

The correlation between pupil dilation and discount rate depended on whether the individual was a high or low discounter. For high discounters, pupil dilation correlated with the value of the immediate reward, and for low discounters, pupil dilation correlated with the value of the delayed reward. This unexpected result implies that individuals have an internal discounting baseline average, which can be manipulated by varying the delayed or immediate reward.

- **Experiment 5: Subject each individual to the following conditions: vary delayed reward more than immediate, vary immediate reward more than delay, vary immediate and delayed rewards equally.**
Experiment 5 replicated experiments 1, 3, and 4 but was conducted with the same individuals rather than across groups. Results were similar to the previous experiments. Findings suggest that a high discounter remained a high discounter across various conditions. In other words, an individual's fundamental discounting nature is not altered, but rather pushed in one direction or another.

Dr. Phelps concluded that an individual's discount rate changes with context. When delayed rewards are varied more than immediate ones, an individual becomes more impulsive. Conversely, when immediate rewards are varied more than delayed ones, an individual becomes more patient. In these experiments, pupil dilation indicates a better-than-average choice, which is related to contextual shifts in the discount rate. Dr. Phelps is currently examining the effects of pharmacologically blocking arousal on loss aversion and discount rate.

Future research efforts will focus on other ways to manipulate the discount rate, including cognitive regulation or task manipulations. It will be interesting to examine the impact of non-specific stress on discount rate, loss aversion, and risk sensitivity. These experiments will also help determine the mechanisms of how stress impacts decision-making. Dr. Phelps will also examine the brain systems involved in the regulation of decision-making processes by functional magnetic resonance imaging (fMRI). By understanding the basic components of decision-making, researchers can develop interventions that account for emotion in the decision-making process.

Self-Regulation Failure: Identifying and Modifying a Risk Phenotype

Timothy J. Strauman, PhD, Professor, Department of Psychology and Neuroscience, Duke University

Dr. Strauman defined self-regulation as the neural and psychological processes that underlie the pursuit of personal goals. Many behavioral disorders involve self-regulation failure, including depression, anxiety, and addiction. Dr. Strauman proposed a model of a risk phenotype for self-regulation failure and described the experiments used to test this model as well as microinterventions targeting the risk mechanisms underlying the phenotype. By understanding the phenotype of individuals at risk for self-regulation disorders, it will be possible to design effective interventions before any disorder becomes apparent.

The self-regulation risk phenotype model has three components:

1. **Individual differences in goal pursuit:** Individuals with a strong tendency toward promotion (“making good things happen”) manifest robust motivational and affective responses to promotion relevant success/failure feedback. This response includes adaptive levels of sadness/frustration in the face of failure. Promotion goal activation is associated with a characteristic pattern of left prefrontal cortex (PFC) activation, which is correlated with individual differences in the strength of one’s tendency toward promotion goals.
2. **Variability in prefrontal dopamine:** The catechol-*O*-methyltransferase (COMT) Val₁₅₈Met polymorphism is a commonly occurring source of dopamine-mediated variability in goal-relevant information processing in prefrontal regions. COMT Met carriers show greater task focus but less flexibility than individuals with two Val alleles. This difference could be adaptive or dysfunctional depending on the kind of goal pursuit feedback that the individual experiences.
3. **The hypothesized role of failure feedback:** Alone, neither the COMT genotype nor a strong promotion tendency is a main risk factor. The combination of the two factors could even convey benefits under conditions of success. However, the combination does create a risk for dysfunction in goal pursuit when unexpected, cumulative, or catastrophic failure feedback appears. Under these conditions, high levels of frustration, dysphoric affect, and difficulty disengaging from failed goal pursuit create a risk for dysregulation.

The self-regulation risk phenotype model predicts that failure feedback in a susceptible individual would result in a downward spiral of frustration, dysphoric affect, and loss of motivation. Dr. Strauman described his efforts to find evidence for the self-regulation risk phenotype. He also presented data on cognitive interventions to help at-risk individuals deal more effectively with failure feedback.

Using fMRI and Genotyping to Identify Individuals Who Match the Risk Phenotype

PFC activation was measured in college ($n=75$) and high school students ($n=75$) using fMRI during a rapid word-priming paradigm. Students responded to continuously presented words involving promotion goals (greater left orbital prefrontal cortex [OPFC] activation) or prevention goals (greater right OPFC activation). Activation at the left PFC/OPFC correlated with promotion and self-reported strength of promotion orientation, and a significant three-way interaction was observed in which left PFC/OPFC activation was greatest for individuals with the Met/Met genotype. In conclusion, the fMRI study was successful in identifying individuals whose responses to personal goal priming matched the proposed risk genotype.

Using a Goal-Switching Task to Detect Phenotype-Related Vulnerability

Dr. Strauman described how COMT Met/Met participants performed in a task that revealed an individual's level of perseverance as well as inflexibility. This task required participants to switch their response pattern in several ways that can reveal vulnerability. Study participants were primed with a promotion goal failure event, a prevention goal failure event, or a neutral event. Those with two copies of the COMT Met allele exhibited the highest levels of perseverance and inflexibility, but only when primed with a promotion failure experience. This result confirms that the combination of the COMT Met allele genotype plus the self-regulation behavioral phenotype results in maladaptive behavior under promotion failure conditions. Cumulatively, these data provide support for the self-regulation risk phenotype model as well as a starting point for intervention strategies.

Using Cognitive Microinterventions to Prevent Maladaptive Goal Pursuit

The self-regulation risk phenotype model suggests possible novel intervention strategies for the at-risk individual. One strategy involves reducing the promotion engagement strength in response to prolonged failure feedback. This strategy would help the at-risk individual to disengage from a failing task. Another strategy involves disrupting the promotion "fit" in response to prolonged failure feedback.

People often ruminate over failures by engaging in counterfactuals (e.g., what should I have done differently?). Dr. Strauman demonstrated experimentally that using specifically targeted counterfactuals could reduce stress in response to goal pursuit failure and that different types of counterfactual "microinterventions" could be targeted toward promotion versus prevention failure.

In summary, Dr. Strauman presented evidence supporting the existence of a self-regulation risk phenotype. Individuals who match the phenotype thrive under conditions of success but struggle under conditions of failure. Cognitive interventions could, at least temporarily, interrupt the cycle of perseverance and inflexibility that follows promotion failure feedback. The mechanisms of risk phenotypes are critical to designing effective intervention strategies. Future research efforts include determining the association between the risk phenotype and psychopathology, as well as developing screening protocols and intervention methods.

Information Throughput in Risky Decision-Making Underlying Self-Regulation

John Hinson, PhD, Professor of Psychology, Department of Psychology, Washington State University

Dr. Hinson described how behavioral self-regulation is often based on decision-making processes that involve risk and ambiguity. According to Dr. Hinson, the key to understanding suboptimal risky decision-

making is how and why an information-weighting problem occurs.² Improper information processing can lead to decision-making errors in two ways: as a gating problem (i.e., insufficient throughput or availability of information for decisions) or as a weighting problem (i.e., available information does not properly contribute to decisions).

Decision-making can be further complicated by sleep loss. Sleep loss has adverse effects on real-world actions (e.g., driving while sleep-deprived).³ However, there are individual differences in resilience to sleep loss, and sleep loss does not inevitably lead to bad outcomes.⁴ Whether sleep loss has an impact on decision-making also depends on the task involved.⁵

Dr. Hinson reviewed the key research focus areas involving information needed for good decision-making: examine risky decision-making with correct and incorrect choices; employ extrinsic challenges to cold or hot cognition; assess information utilized in the decision process; and examine these processes within the greater challenge of sleep loss.

Experiments for the key focus areas have the following core elements:

- **Risky Decision-Making Task (RDMT):** a description-based variant of framing tasks
- **Framed Gambling Task (FGT)⁶:** an experienced-based hybrid of RDMT and Iowa Gambling Task
- **Assessment of Information:** embedded memory probes and questions
- **Sleep Deprivation:** in experiments involving sleep loss, participants experienced one night of sleep deprivation under controlled laboratory conditions.⁷

With no sleep loss, RDMTs and FGTs show distinct patterns of choice errors. Specifically, the potency of emotional challenges changes over time. However, there are no differences in knowledge of choice options. Also, emotional challenges have no effect on information accuracy. Therefore, the pattern of choice errors reflects a weighting problem. This means that adequate information is available but is improperly used.

With sleep deprivation, however, RDMTs and FGTs show no distinct patterns of choice errors for challenges under sleep deprivation. All emotional challenges impair performance similarly. In this case, knowledge accuracy is impaired; emotional challenges have significant effects on information accuracy. Therefore, the pattern of choice errors with sleep deprivation reflects a gating problem, where adequate information is not available.

² Hinson, J. M., Whitney, P., Holben, H. & Wirick, A. K. Affective biasing of choices in gambling task decision making. *Cogn. Affect. Behav. Neurosci.* **6**, 190–200 (2006).

³ Rosekind, M. R. Underestimating the societal costs of impaired alertness: safety, health and productivity risks. *Sleep Med.* **6 Suppl 1**, S21–25 (2005).

⁴ Van Dongen, H. P. A., Maislin, G., Mullington, J. M. & Dinges, D. F. The cumulative cost of additional wakefulness: dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep* **26**, 117–126 (2003).

⁵ Whitney, P. & Hinson, J. M. Measurement of cognition in studies of sleep deprivation. *Prog. Brain Res.* **185**, 37–48 (2010).

⁶ Hinson, J. M., Jameson, T. L. & Whitney, P. Somatic markers, working memory, and decision making. *Cogn. Affect. Behav. Neurosci.* **2**, 341–353 (2002).

⁷ Tucker, A. M., Whitney, P., Belenky, G., Hinson, J. M. & Van Dongen, H. P. A. Effects of sleep deprivation on dissociated components of executive functioning. *Sleep* **33**, 47–57 (2010).

Further research from Dr. Hinson points to *feedback blunting* as a specific mechanism for sleep loss–induced decision problems. This mechanism is defined as a blunted emotional reaction to choice feedback during sleep loss. Feedback blunting is illustrated in a reversal go/no-go task where decision-making must be responsive to dynamic changes in outcomes. Dr. Hinson further demonstrated that reduced emotional reactions to outcome feedback result in poor task performance.

In conclusion, Dr. Hinson has identified a model for self-regulatory decision-making that can inform interventions for better choice processes. Interventions should focus on eliminating biases in the weighting of available information. Simply having good information does not ensure a correct outcome, especially after sleep loss. Interventions to improve self-regulatory decision-making should carefully note the specific challenge involved.

Sleep loss introduces a significant gating problem in decision-making that is not apparent in well-rested individuals. Dr. Hinson’s research suggests a novel mechanism for the impact of sleep loss on performance. Feedback blunting in sleep loss reduces the impact of choice outcome feedback and thus provides a special target for proactive intervention. By understanding the basic psychological processes involved in decision-making, especially under challenges like sleep deprivation, effective interventions can be designed to improve the decision-making process.

Self-Regulation Failure

Todd F. Heatherton, PhD, Lincoln Filene Professor in Human Relations, Department of Psychological and Brain Sciences, Dartmouth College

Dr. Heatherton described the Balance Model of self-regulation failure.⁸ There are several contexts in which self-regulation fails, and all are associated with increased subcortical activity and decreased frontal control. A common mechanism may be involved in self-regulation failure, regardless of the threat (e.g., negative mood, alcohol consumption). These various threats to self-regulation overwhelm PFC control and break down the prefrontal-subcortical circuit, resulting in self-regulatory failure.

The Balance Model predicts that individuals whose balance is tipped in favor of subcortical areas, either because of strong impulses or prefrontal function impairment, are exposed to a tempting food cue, they are more likely to give in to temptation and overeat. Dr. Heatherton described the results of a cohort ($n=31$ females) exposed to a food cue during fMRI. Investigators texted images of appetizing food seven times a day for 1 week and analyzed food consumption. Results of the study confirm that subcortical activity in the nucleus accumbens (NAcc) was predictive of overeating and that prefrontal activity in the inferior frontal gyrus (IFG) was predictive of less overeating. These results confirm the model in which PFC control is necessary to restrain the activity of subcortical regions of the brain during threats to self-regulation.

Self-regulation reflects individual differences in the capacity to control behavior.⁹ A second study tested individual differences in self-regulation capacity. Investigators gave study participants a milkshake and analyzed brain activation patterns by fMRI. Investigators then measured the study participants’ consumption of ice cream. Individuals with strong ventrolateral prefrontal cortex-anterior olfactory

⁸ Heatherton, T. F. & Wagner, D. D. Cognitive neuroscience of self-regulation failure. *Trends Cogn. Sci.* **15**, 132–139 (2011).

⁹ Demos, K. E., Heatherton, T. F. & Kelley, W. M. Individual differences in nucleus accumbens activity to food and sexual images predict weight gain and sexual behavior. *J. Neurosci. Off. J. Soc. Neurosci.* **32**, 5549–5552 (2012).

nucleus (vIPFC-AON) connectivity and weak vIPFC-frontal control connectivity consumed more ice cream. These results suggest a mechanism to account for the individual differences in self-regulation capacity.¹⁰ Distinct activation patterns may prove predictive for individuals with low self-regulation abilities. These individuals can then be targeted for specific interventions.

Self-regulation stores can be depleted in a variety of ways (e.g., consumption of high-calorie food, emotional upset). This depletion results in the activation of subcortical regions and overwhelms impulse control by the prefrontal regions.¹¹ In Dr. Heatherton's Self-Regulation Strength Model, self-regulation is likened to a muscle that can be weakened or strengthened. In fact, self-regulation depletion leads to heightened cue reactivity to food images for dieters and heightened amygdala activity to negative images. These effects are associated with reductions in functional coupling between frontal control and subcortical regions.

Future research efforts will focus on interventions that seek to strengthen the self-regulatory muscle. Specific interventions will attempt to increase the self-regulatory capacity for use in times of temptation. These interventions will have relevance for situations in which self-regulation is challenged.

Question and Answer

Moderator: Lisbeth Nielsen, PhD, Chief, Individual Behaviors and Processes Branch, Division of Behavioral and Social Research, National Institute on Aging

Participants discussed the possible advantages of being a low or high discounter, noted that individuals have an internal discounting baseline, and agreed that no phenotype is inherently advantageous. Dr. Phelps' research demonstrated that discounting could be affected by changing choice options.

They also commented that examining discounting in the context of mental status would be valuable. For example, discounting may be affected in individuals with depression. These data could be informative in designing interventions for individuals with depression and/or anxiety.

Adolescent Self-Regulation and Behavior Change Investigator Presentations

Determinants of Adolescent Exercise Behavior; Towards Evidence-Based Intervention

Meike Bartels, PhD, Associate Professor in Behavior and Quantitative Genetics, Department of Biological Psychology, VU University, Amsterdam

Drs. James Hudziak (Principal Investigator), Meike Bartels, and Eco de Geus collaborate on this project, which focuses on the determinants of adolescent exercise behavior. The study involves an international partnership between the Netherlands Twin Register (NTR) and the Vermont Center for Children, Youth, and Families (VCCYF).

¹⁰ Demos, K. E., Kelley, W. M. & Heatherton, T. F. Dietary restraint violations influence reward responses in nucleus accumbens and amygdala. *J. Cogn. Neurosci.* **23**, 1952–1963 (2011).

¹¹ Wagner, D. D. & Heatherton, T. F. Self-regulatory depletion increases emotional reactivity in the amygdala. *Soc. Cogn. Affect. Neurosci.* **8**, 410–417 (2013).

The project is highly relevant to public health. Healthy lifestyle promotion strategies are becoming a cornerstone of medical health, and regular exercise is a key contributor to health. A sedentary lifestyle is one of the main causes of obesity and associated health outcomes. Studies on adolescents and adults suggest that genetic influences contribute to an individual's exercise behavior. This project seeks to understand the genetic architecture in children to inform effective interventions that encourage adolescents to exercise regularly.

Individual Differences in Voluntary Exercise Behavior

The first specific aim of the study was to determine the causes of individual differences in voluntary exercise behavior from childhood to young adulthood by a) quantifying the sex-specific contribution of heritable and shared/nonshared environmental factors to stability and change of adolescent exercise behavior in twins 7 to 18 years old; b) examining the causality in the association between voluntary exercise behavior and its established correlates, psychological well-being and exercise attitudes; and c) identifying pure environmental factors that influence exercise behavior using identical twins discordant for current exercise behavior at age 18 using interviews and actigraphs. Progress has been made on the first two sub-aims.

In adults, differences in voluntary exercise behavior are mainly genetic. This study used data from the NTR and found a large effect of shared environmental factors on voluntary exercise behavior in children and young adults, although the patterns differed somewhat by gender.¹² Heritability of exercise behavior seems to become more important at an earlier age for boys. The influence of shared environmental factors for children suggests that there are opportunities for intervention. Preliminary data suggest that voluntary exercise behavior at age 12 was significantly correlated with the same behavior at age 7 ($r=0.28$).

Psychological well-being and exercise attitudes are established correlates of voluntary exercise behavior. People generally feel better if they exercise, but the mechanisms at the population-based level are less clear. This part of the study found that although exercise behavior was associated with higher levels of subjective well-being, there was no evidence of a *causal* effect of voluntary exercise on well-being. This finding suggests there is genetic pleiotropy—the same genes that influence well-being could be influencing exercise.¹³ Findings using NTR data demonstrate that exercise attitudes and exercise behavior are heritable, attitudes and behavior are partly correlated through pleiotropic genetic effects, and the data are compatible with a causal effect of exercise attitudes on behavior.¹⁴

A community study of high school freshman in Vermont was also conducted to examine exercise motivation and psychological response. Students were surveyed about their daily exercise and offered monetary rewards for a 6-month daily exercise program. Individuals who reported needing more money to participate in the study exercised 0.71 days more than those who were not motivated by any reward option. Participants who exercised the most and the least were less satisfied than those that exercised a moderate amount.

¹² Huppertz, C. *et al.* Effect of shared environmental factors on exercise behavior from age 7 to 12 years. *Med. Sci. Sports Exerc.* **44**, 2025–2032 (2012).

¹³ Bartels, M., de Moor, M. H. M., van der Aa, N., Boomsma, D. I. & de Geus, E. J. C. Regular exercise, subjective wellbeing, and internalizing problems in adolescence: causality or genetic pleiotropy? *Front. Genet.* **3**, 4 (2012).

¹⁴ Huppertz, C., Bartels, M., Jansen, I. E., Boomsma, D. I., Willemsen, G., de Moor, M. H. M., & de Geus, E. J. C. A twin-sibling study on the relationship between exercise attitudes and exercise behavior. (forthcoming).

Two studies—one using data from the NTR and one using archival clinic study data from the VCCYF—explored the genetic and environmental contributions to attention problems, leisure time exercise behavior, and their association. The twin registry data did not show any correlation between attention problems and exercise behavior. In the clinical sample of 191 patients using the Vermont Health Behavior Questionnaire (VHBQ) and Child Behavior Checklist (CBCL), the average metabolic equivalent (MET) and withdrawn/depression scores significantly differed between exercise type groups (no exercise, individual only, team only, and individual and team); the average MET score and individual and team sport exercise participation were significantly negatively associated with withdrawn/depression scores; and the average MET score did not mediate the relationship between individual and team sport participation and withdrawn/depression scores. These findings need to be replicated in a population-based sample.

Individual Differences in Exercise Ability and Psychological Response to Exercise

The second aim of the study was to test the hypothesis that individual differences in exercise ability and the psychological response to exercise are the major factors underlying the heritability of adolescent exercise behavior by a) testing the association between exercise ability and current exercise behavior, and establishing a gene-exercise interaction (data on ability are currently being collected); b) establishing the heritability of acute psychological responses during and after a standardized exercise protocol in a subsample of twins; and c) testing the association between acute psychological response to exercise and exercise behavior, and establishing the contribution of genetic factors to this association.

Work on the heritability of acute physiological responses to exercise in a subsample of 500 twins will be completed in August 2013. The laboratory protocol includes measurements of height, weight, balance, hand grip strength, flexibility, vertical jumping, resting heart rate, blood pressure; lifestyle questionnaire; bicycle ergometer for 20 minutes; treadmill for 20 minutes; and an all out test. During and after the exercise tests, participants complete the activation/deactivation checklist, the feeling scale, and the rate of perceived exertion. Preliminary results showed that the pattern of response on the feeling scale to increased difficulty on the treadmill and bicycle was similar for exercisers and non-exercisers (i.e., mean feeling scale scores decreased with increased load) but the baseline of feeling scores for regular exercisers was consistently higher.

Summary

The research conducted thus far has demonstrated that environmental factors play an important role in child and adolescent exercise behavior. There is no evidence for causality between exercise and well-being or emotional problems; however, there is evidence of causality between exercise attitudes and exercise behavior. Energy expenditure and exercise type are associated with withdrawn/depression symptoms in a clinical child sample. Voluntary exercise and attention problems are unrelated in a population-based sample. External motivators, such as money, may be implicated in increasing exercise behavior in children. Exercisers and non-exercisers show a similar pattern of psychological response to increasing exercise load, but exercisers start at a higher baseline. Positive psychological responses to exercise may be maximized at moderate levels of physical activity. Exercise attitudes and psychological response to exercise should be taken into account when developing interventions.

Self-Regulation of Reward in Adolescence

Erika E. Forbes, PhD, Associate Professor of Psychiatry, University of Pittsburgh

Dr. Forbes is the recipient of an OppNet R21 on basic research in self-regulation. The goal of the grant is to develop a novel, ecologically valid, personally relevant peer social reward fMRI task for use with adolescents. Heightened reward-seeking behavior during adolescence contributes to risky behaviors with serious consequences (e.g., substance and alcohol addiction, sexually transmitted disease, teen pregnancy). Although many of adolescents' risky behaviors occur in peer social contexts, and peer relationships take on increased salience during adolescence, few studies of risky behavior or reward function in adolescents include assessment in social contexts.

The altered development of neural reward circuitry can contribute to reward-related problems that occur during adolescence, including affective problems, substance use, and risky sexual behavior. The typical fMRI tasks to assess neural circuitry in adolescents have been particularly focused on standardized rewards and do not include social rewards or account for the peer context of risky behavior. Monetary reward tasks are very effective in engaging the reward circuitry of interest. However, it is likely that relevant social relationship rewards are lacking in this paradigm, and it is possible that investigating the neural circuitry of social reward—particularly personally relevant social reward—will provide enhanced ability to understand the neural mechanisms of adolescents' reward-related problems. Dr. Forbes and colleagues have developed an ecologically valid fMRI paradigm to capture engaged reward circuitry for social rewards.

Protocol and Preliminary Findings

Participating teenagers and their same-sex best friends were videotaped having a conversation about the best experiences they have had together. The discussion was used to generate video stimulus materials for the fMRI task, so that the task is personalized for each participant. The team currently has scans for 43 participants ages 14 to 18 years old, with the goal of a total sample of 70. The stimuli used in the fMRI are videos (with audio) of the best friend showing positive or neutral affect and a stranger of the same sex as the best friend showing positive or neutral affect. The goals of the project are to develop the fMRI task, compare it to existing reward measures (from both fMRI and behavioral tasks), and examine whether neural response and functional connectivity to the task are associated with individual differences in reward-related characteristics and problems in adolescents. In all, the study seeks to examine how a better understanding of social rewards can enhance the overall understanding of reward circuitry and associated behaviors in adolescents.

Early findings, which are focused on the contrast between the friend showing positive affect and a stranger showing a positive affect, indicate that the task does engage neural reward circuitry. Furthermore, comparison with a standardized monetary reward task suggests that there is a much larger response to social than to monetary rewards. The social rewards task engaged regions critical to reward function: medial PFC and the striatum. The medial PFC is a region involved not only in reward processing but also, critically, in the default mode network and self and social processing. Greater medial PFC activation was associated with lower depressive (for dorsal mPFC) and higher mania symptoms (for ventral mPFC), as well as increased sensation seeking and likelihood of sexual activity. Although the current study population was a healthy sample, there is variability in reward-related behavior and problems, and the findings thus could contribute to the understanding of serious health problems.

Implications and Next Steps

This research describes neural mechanisms of individual differences in reward-related problems in adolescents by measuring response to social reward in a peer context. Findings could help to identify adolescents who are likely to engage in risky behaviors or develop reward-related problems, as well as identify targets for interventions such as neurocognitive training.

The assessments for this project will be completed in August 2013. Additional grants related to this work include two R01s on frontostriatal response to peer social reward and substance use initiation and progression in high-risk adolescents and on frontostriatal response to peer social reward and the development of affective psychopathology. The goals of these coordinated research efforts are to employ prospective, longitudinal designs to examine mutual influence of brain development, peer experiences, and affective/substance use problems.

Using Media to Explore Mechanisms of Behavior Change Among College Students

Megan A. Moreno, MD, MEd, MPH, Associate Professor of Pediatrics, University of Washington, Seattle Children's Research Institute

Alcohol and substance use are among the top causes of morbidity and mortality in college students. It remains challenging to identify college students at risk for alcohol and substance abuse and provide accessible interventions using traditional means. College students frequently reference and display alcohol and substance use on Facebook. This project explores the role of social media in identifying at-risk behavior and as a potential platform for interventions.

Predictive Value of Alcohol References on Facebook

The first specific aim of the study was to test the predictive value of references to alcohol, drugs, and tobacco displayed on Facebook profiles for identifying substance use intention, use, and misuse longitudinally. Study participants include college students from two universities—one in the Midwest and one in the Northwest. Data were collected from monthly reviews of Facebook pages and interviews (scheduled and those prompted by evidence of a behavior change). Facebook pages were assessed for evidence as a non-displayer, alcohol displayer, or intoxication or problem drinking displayer.

Upon arrival as freshmen, 20 percent of participants had references to alcohol on their Facebook profiles and the majority of these were relatively bland. Over the course of the first year of college, the proportion increased to 50 percent. Significant predictors of increased alcohol display on Facebook include university (participants at the Northwestern school were half as likely to display references compared to the Midwestern school), the number of Facebook friends, and total average monthly status updates. Spikes in reference on Facebook correlated with major school events involving alcohol (e.g., Halloween party and spring event at the Midwestern university). For one campus event, the investigators found a correlation between the number of drinks participants had on the day of the event and references made in the event-planning stage.

Dr. Moreno and colleagues constructed a Markov model to estimate transition probabilities between non-displayer, displayer, and intoxication and problem drinking displayer, and the patterns are predictable. There is a 5 percent chance in any given month during the first year of college that a non-displayer will become a displayer or that a displayer will become an intoxication or problem drinking displayer. It is less likely (1.5 percent) that a non-displayer will change to an intoxication or problem drinking displayer.

Pre-college-age alcohol drinkers who are likely to escalate to intoxication and problem drinking during the first year of college may represent a unique population for intervention messages. It is clear that the timing of increased numbers of displays are associated with alcohol-themed events, and universities may wish to explore providing targeted messages within Facebook linked to keywords during these time periods.

Exploring Facebook as an Intervention Tool

Another aim of this study was exploratory and sought to investigate methods by which Facebook can be used as an intervention tool among college students. Intervention possibilities include clicking on an advertisement within Facebook and “friending” a research team. Participants who scored in the at-risk range on the Alcohol Use Disorders Identification Test (AUDIT) were more likely to indicate they would click on a Facebook advertisement for participation in a research study, despite this being an unpopular option in the general sample. No difference was found in the likelihood of friending a researcher on Facebook. Next steps include exploring intervention possibilities of timed messages to college students triggered by displayed content and delivering web-based interventions via social media. The potential benefits include broad reach, targeted audience, and low cost.

The Development of Emotion Regulation: Mechanisms Impacting Health

Kevin Ochsner, PhD, Associate Professor of Psychology, Columbia University

Adolescents are prone to strong outbursts of negative emotions and may be drawn to risky behaviors and substances. Dr. Ochsner’s project aims to identify signatures of reactivity and regulation that predict vulnerability to these kinds of maladaptive health outcomes. Extant data suggest that adolescents are either more affectively reactive, lack the ability to effectively regulate because prefrontal control systems are not yet mature, or some combination of both. This “reactivity versus regulation” hypothesis is even evidenced in pop culture—an Allstate Insurance advertisement asks why most 16-year-olds drive like they are missing a part of their brain. The answer: because they are.

The first sub-study testing these hypotheses uses a cross-sectional lag design. Behavior and brain measures are taken at the first time point between the ages of 6 and 18. Behavior measures include delay of gratification and physical/mental health. Brain measures include fMRI data collected during tasks assessing affective reactivity and the abilities that control these reactions using attentional control and reappraisal as well as structural MRI scans of gray and white matter. The measures are repeated after 2 years between the ages of 8 and 20. The investigators are currently finishing the analysis of data from the first wave of participants.

Preliminary Findings

The first finding, which has been replicated four times, supports the regulation arm of the reactivity versus regulation hypothesis.¹⁵ For negative/aversive responses, reactivity is constant across ages 10 to 22, but adolescents differ from adults in their ability to regulate emotions. Younger adolescents also have greater difficulty regulating responses to social versus nonsocial stimuli. Additional data suggest that adolescents might not typically activate brain regions associated with mental state attribution, but that reappraisal instructions¹⁶ can effectively increase such activation.¹⁶ The team is currently developing

¹⁵ Silvers, J. A. *et al.* Age-related differences in emotional reactivity, regulation, and rejection sensitivity in adolescence. *Emot. Wash. DC* **12**, 1235–1247 (2012).

¹⁶ McRae, K. *et al.* The development of emotion regulation: an fMRI study of cognitive reappraisal in children, adolescents and young adults. *Soc. Cogn. Affect. Neurosci.* **7**, 11–22 (2012).

hypotheses about how these systems are involved in regulation processes. Another early finding indicates that although reappraisal decreases amygdala response reliably for everyone, the effects are not as strong or as long-lasting for younger participants.

For positive/appetitive responses, reactivity (craving) decreases with age between 10 and 18 years. Regulation success remains constant across this age span, which suggests that all subjects can rethink the meaning of cues in order to diminish brain activation but that there are age-related changes in overall reactivity to appetitive cues. That said, data from Walter Mischel's delay of gratification task (i.e., the "marshmallow test") suggest that there may be important age-related individual differences in regulatory ability as well. It is known that children can increase delay time by using a reappraisal strategy (e.g., imagine that the treat is far away or that it is only a picture of a treat). Dr. Ochsner found that the children who were successful at delaying gratification showed greater ability to use reappraisal to reduce responses to food cues in the medial orbital frontal cortex, which is a key region related to reward.

Question and Answer

Moderator: Lois Tully, PhD, Program Officer, Section on Neuroscience, Genetics, and Symptom Management, National Institute of Nursing Research

Dr. Nielsen inquired about the implications of the best friend study design used in Dr. Forbes' study. The sample participants could be somehow different than potential participants who do not have a best friend or have multiple close friends. Additionally, consent is required from both parents, which makes it more difficult to recruit. Dr. Forbes and colleagues have not assessed the relationship quality or evidence of asymmetry in the relationship.

Dr. Nielsen noted that Dr. Bartels' finding of no causal relationship between exercise behavior and subjective well-being was surprising. Exercise behavior was measured by self-report of activity, frequency, and intensity. Subjective well-being was ascertained from measures of life satisfaction, subjective happiness, and quality of life. The investigators are currently assessing objective fitness levels and have yet to correlate these data with subjective well-being measures.

Dr. Grady inquired about the veracity of Facebook posts from the participants in Dr. Moreno's study and about how the team assessed whether the young adults were posting fake entries to show off or were referencing actual behavior. Dr. Moreno noted that in 96 percent of the times participants displayed new alcohol use behavior on Facebook, the corresponding behavior was confirmed with data collected from the impromptu interview. The findings for substance abuse are less clear, because participants appear to joke about drugs on Facebook more frequently than they do about alcohol.

Maternal and Early Childhood Self-Regulation Investigator Presentations

Self-Regulation as a Biological Mechanism for Excess Weight Gain in Toddlers: Year 2 Progress

Alison L. Miller, PhD, Assistant Research Professor, School of Public Health, University of Michigan, Ann Arbor

Julie C. Lumeng, MD, Associate Professor, University of Michigan Medical School, Ann Arbor

Self-regulatory capacities are evident from a very young age. Drs. Miller and Lumeng hypothesized that decreased self-regulation in overweight toddlers correlates with behavioral and physiological markers. In addition, the intimate bond between a parent and child suggests a powerful role for parental self-regulation in the development of a child's self-regulation capacity.

Dr. Miller described the ABC-Toddler Study, which is designed to test several possible correlates of decreased self-regulation in overweight toddlers. Data collection includes measures on the following:

1. **Self-Regulation**
 - physiology (diurnal cortisol levels and salivary Alpha-Amylase [sAA] levels)
 - observed behavioral responses (response to no-touch food and no-touch toy)
2. **Parenting**
 - mother-child interactions at free play
 - parent cortisol and sAA levels
3. **Child Eating Behavior and Body Mass Index (BMI)**
 - kilocalories consumed
 - behavioral response (delight, latency to eat)

Researchers evaluated the toddler cohort at three consecutive ages: 21 months ($n=132$), 27 months ($n=115$), and 33 months ($n=77$). The toddlers were from low-income families (less than 185 percent of poverty level) and represented several ethnicities (53 percent White, 22 percent Black, 24 percent biracial, and 14 percent Hispanic/Latino). Approximately 30 percent of the children were overweight or obese as defined by the Centers for Disease Control and Prevention (CDC).

Initial Results of Physiological Analyses

Cortisol levels are typically high in the morning and decrease throughout the day.¹⁷ The opposite is true for sAA: levels are low in the morning and increase during the day.¹⁸ Levels of cortisol and sAA are associated with weight status at 21 months of age. Cortisol levels are consistently lower in overweight and obese 21-month-olds ($n=63$) as compared to children of normal weight. Conversely, sAA levels are consistently higher in obese 21-month-olds ($n=63$) when compared to children of normal weight.

¹⁷ Nater, U. M. *et al.* Performance on a declarative memory task is better in high than low cortisol responders to psychosocial stress. *Psychoneuroendocrinology* **32**, 758–763 (2007).

¹⁸ Nater, U. M., Rohleder, N., Schlotz, W., Ehlert, U. & Kirschbaum, C. Determinants of the diurnal course of salivary alpha-amylase. *Psychoneuroendocrinology* **32**, 392–401 (2007).

Initial Results of Parenting Analyses

Dr. Miller presented evidence that the mother's emotions predict not only the child's current weight status, but also the child's future weight gain. In observing mother-child interactions during free play, mothers who were less positive in free play had children (21 months, $n=103$) who were more obese. In addition, the mother's positive affect was related to the child's weight status increase from 21 to 27 months ($n=66$). These findings suggest that maternal behavior is associated with child weight status.

Self-Regulation Implications Based on Initial Results

Dr. Miller emphasized that children who are physiologically dysregulated display more behavior problems and tend to be overweight. Results demonstrated that parenting was associated with both behavior problems and weight gain in children, and may be a target for self-regulation interventions. By working with parents early to improve a child's self-regulation skills, researchers may be able to reduce child obesity risk. The goal is to give parents tools to help children self-regulate, bearing in mind that the child's physiology and behavior may make it challenging.

These results have implications beyond obesity. With early intervention, improvement of other health and social outcomes related to self-regulation may be possible. In addition, this research points to the importance of early interventions for parents and children in the development of a robust capacity to self-regulate.

The Influence of Mother's Self-Regulation on the Family and on Young Children

David J. Bridgett, PhD, Assistant Professor, Department of Psychology, Northern Illinois University

Self-regulation has a central role in behavior and life-long functioning. By focusing on early childhood for self-regulation interventions, a lifetime of negative outcomes may be avoided. A key intervention point for children's behavior is parental self-regulation. The critical first step is to understand how parental behavior, regulation, and affect contribute to a child's behavior. Dr. Bridgett examined several contextual parameters, including parenting behavior, home environment, inter-parental relationships, and parent mental health, how these contextual influences may be affected by parental self-regulation, and how they affected a child's behavior.

Investigators recruited mother-infant dyads (targeted enrollment of 100 dyads) at two sites (Northern Illinois University and Yale University). Researchers evaluated mother-child interactions at multiple time points (4, 6, and 8 months postpartum). So far, 85 families have been recruited from Northern Illinois University and have a range of backgrounds (21.3 percent below the poverty line, 10.7 percent teen mothers, 70.2 percent Caucasian, and 58.3 percent of infants are girls). Researchers assessed mothers on their self-regulation capacities in a number of contexts and correlated the results with infant behavior.

Context 1: Experimental Setting

Mothers interacted with a simulated distressed infant, while investigators measured the mothers' behavior. Results of this study determined that mothers with higher self-regulatory capacity are more effective at reducing their own stress levels. Also, mothers who demonstrate more control have better soothing behavior toward the distressed infant. Results with a simulated infant mirrored those found with their own children during interactions that occurred in the laboratory at the 8-month follow-up.

Context 2: Follow-up at 8 Months

Investigators assessed maternal affect and involvement in a free play session with no toys. Results from this study suggest that mothers with higher self-control display fewer negative parenting practices.

Context 3: Home Chaos and Interpersonal Adjustment

Investigators concluded that mothers who self-regulate better have less chaotic homes and better family relationships, both of which indirectly improve infant affect.

Overall, Dr. Bridgett determined that higher maternal self-regulation directly and indirectly results in improved infant affect and behavior. Maternal self-regulation could also be implicated directly in child health. To address this question, Dr. Bridgett designed a pilot study to evaluate the effect of maternal self-regulation on toddler BMI. Initial results indicate that mothers with better emotional regulation display better monitoring of food intake and thus have toddlers with lower BMI scores.

In conclusion, Dr. Bridgett implicated family and maternal functioning in the development of a child's self-regulatory capacity. This model suggests multiple possible intervention points, including improving the self-regulation of the parent and child, and changing key aspects of the home environment to be more conducive to self-regulatory development. Given the costs associated with self-regulatory failure, interventions early in childhood have the potential to provide substantial public health benefits. Dr. Bridgett's future work will focus on preventive interventions for at-risk children and families, as well as determination of the mechanisms involved in self-regulation early in life.

Epigenetic Influence on Early Childhood Self-Regulation Capacities and Obesity

Bernard F. Fuemmeler, PhD, MPH, Associate Professor in Community and Family Medicine, Duke University

Dr. Fuemmeler noted that weight gain occurs early in development for many overweight children. He emphasized the importance of understanding the mechanisms associated with early weight gain. Dysfunction in self-regulation has been associated with childhood weight in the following instances:

- Attention deficit hyperactivity disorder (ADHD) symptoms have been associated with weight in adolescents and young adults.¹⁹
- Inhibitory control, attention, and ability to delay at age 4 have been associated with increased childhood BMI.²⁰
- Infant temperament has been linked to BMI at age 6.

Few studies, however, have examined these associations in early childhood (2 to 5 years old). Individuals with deficiencies in self-regulation display impulsive behavior, lack inhibitory control, have short attention spans, and lack emotional regulation. This phenotype is believed to be heritable, and evidence points to an additive effect of multiple genes.

¹⁹ Fuemmeler, B. F., Østbye, T., Yang, C., McClernon, F. J. & Kollins, S. H. Association between attention-deficit/hyperactivity disorder symptoms and obesity and hypertension in early adulthood: a population-based study. *Int. J. Obes.* 2005 **35**, 852–862 (2011).

²⁰ Seeyave, D. M. *et al.* Ability to delay gratification at age 4 years and risk of overweight at age 11 years. *Arch. Pediatr. Adolesc. Med.* **163**, 303–308 (2009).

On a genetic level, two prominent routes can alter gene function. DNA mutations alter protein amount, structure, or function, and epigenetic changes usually result in transcriptional up- or down-regulation.²¹ Examples of epigenetic modifications include DNA methylation, histone acetylation, and non-coding ribonucleic acids (RNAs). The phenotype of the agouti mouse is an excellent illustration of the impact of methylation on genetic expression. Agouti mice are prone to obesity, diabetes, and cancer; this phenotype is correlated with CpG methylation in a region upstream of the agouti gene.

DNA methylation is one of the most studied epigenetic mechanisms. Methylation in the promoter region of genes can vary between tissues and with age. This phenomenon creates challenges when studying the epigenetic effects on neurobehavioral phenotypes.

However, there is a set of imprinted genes that has a stable non-tissue-specific and heritable methylation pattern, making it uniquely suitable to the study of epigenetic effects on genetic expression. For imprinted genes, one parental allele is methylated while the other is not, providing a baseline from which to measure subsequent methylation. Many imprinted genes are expressed in the brain, potentially contributing to an individual's neurodevelopment and psychiatric health.

Study Design

In order to understand the role of DNA methylation in the expression of genes required for self-regulation, Dr. Fuemmeler designed a study including DNA methylation and self-regulatory analyses. Specifically, mothers from the Newborn Epigenetics Study (NEST) perinatal birth cohort completed an assessment of their child's behavioral self-regulation ($n=454$ mothers with children aged 3.3 years on average, 49 percent Caucasian, 44 percent African-American, 3 percent Hispanic; 58 percent female). Other data collected include child weight and height, dietary intake, and DNA methylation of nine imprinted genes.

Results

Results confirmed that children with more inhibitory control problems tend to be more overweight. In addition, children with decreased executive functioning tended to consume more calories from fat.

DNA methylation in the epsilon-sarcoglycan gene (SGCE) was found to be associated with self-regulation problems.²² Mutations in SGCE have been associated with myoclonus-dystonia syndrome (MDS), which also presents with psychiatric disorders.²³ This result represents the first link of DNA methylation to early childhood self-regulation behaviors.

DNA methylation is an intriguing possible biomarker to identify children at highest risk of self-regulation failure.²⁴ DNA methylation is also a potential intervention point: methylation has been shown to be reversible through nutrition and social-environmental interactions. In summary, understanding of the

²¹ Hoyo, C., Murphy, S. K. & Jirtle, R. L. Imprint regulatory elements as epigenetic biosensors of exposure in epidemiological studies. *J. Epidemiol. Community Health* **63**, 683–684 (2009).

²² Peall, K. J. *et al.* SGCE mutations cause psychiatric disorders: clinical and genetic characterization. *Brain J. Neurol.* **136**, 294–303 (2013).

²³ Van Tricht, M. J. *et al.* Cognition and psychopathology in myoclonus-dystonia. *J. Neurol. Neurosurg. Psychiatry* **83**, 814–820 (2012).

²⁴ Marsit, C. J. *et al.* Placenta-imprinted gene expression association of infant neurobehavior. *J. Pediatr.* **160**, 854–860.e2 (2012).

biological mechanisms of self-regulation failure has led to the identification of DNA methylation as a potential new intervention point.

Lunch Is in the Bag: Administrative Supplement

Courtney Byrd-Williams, PhD, Faculty Associate, University of Texas, Austin

The importance of nutrition in childhood physical and behavioral development is well known. Currently, about half of 3- to 5-year-olds regularly attend child-care centers where they typically consume two-thirds of their caloric intake. About 40 percent of the centers request that parents pack lunches. These lunches are less healthy than center lunches (i.e., do not meet recommended standards for fruits, vegetables, fiber, and sodium).²⁵

Lunch Is in the Bag is an intervention program designed to increase fruit, vegetable, and whole grain content in packed lunches. The intervention consists of parent handouts, classroom-based activities, activity posters to increase parent/child interaction, and training to familiarize teachers with the curriculum. The intervention has resulted in significant improvements in the amount of vegetables and whole grains found in packed lunches. To further determine whether the improved lunches were actually consumed by children, the investigators designed a randomized controlled trial (RCT) with 30 centers assigned to either *Lunch Is in the Bag* or a waitlist. After the 6-week intervention, parents and teachers reported on packed lunch contents and consumption.

Initial feedback from parents indicated that teacher support was critical to the success of the intervention. Parents reported a feeling of “being held accountable” by the teacher to provide a healthy lunch. Although not a specific intervention focus, parents determined teacher support to be an element crucial to success. Teachers also reported feeling more comfortable talking with children about nutrition after the intervention.

An additional study, funded by an SOBC administrative supplement, was designed to examine the effect of enhanced teacher training on improving packed lunches. This training focuses on increasing teachers’ knowledge of nutrition, including the importance of a balanced diet and appropriate serving sizes. Researchers also provided instruction on creating a healthy eating environment by encouraging children to attend to satiety cues.

Researchers randomly assigned 12 centers to one of four trial conditions: *Lunch Is in the Bag*, waitlist control group, *Lunch Is in the Bag* plus enhanced teacher training, or enhanced teacher training only. The aims of this ongoing study are to a) examine whether teachers who receive the enhanced teacher training will engage in significantly more behaviors to support healthy eating; b) determine whether the experimental manipulation of teacher support improves lunch contents; and c) examine whether the effects of the enhanced teacher training are independent of the effects of the *Lunch Is in the Bag*.

In conclusion, Dr. Byrd-Williams described the importance of understanding why an intervention is successful. The initial intervention suggested that teacher support was a critical component of the *Lunch Is in the Bag*’s success. Dr. Byrd-Williams’ factorial design will enable her to determine the critical

²⁵ Sweitzer, S. J., Briley, M. E. & Robert-Gray, C. Do sack lunches provided by parents meet the nutritional needs of young children who attend child care? *J. Am. Diet. Assoc.* **109**, 141–144 (2009).

component of the intervention. By simplifying the intervention and focusing on the efficacious components, *Lunch Is in the Bag* will become more effective and more easily disseminated to the public.

Question and Answer

Moderator: Melissa Riddle, PhD, Chief, Behavioral and Social Sciences Research Branch, Division of Extramural Research, National Institute of Dental and Craniofacial Research

The discussion centered on understanding how self-regulation develops in young children. Dr. Lumeng remarked that the appetitive drive appears very early. Children as young as 1 or 2 months old can be said to “love to eat.” However, self-regulation appears to develop much slower, perhaps around age 9. If this is the case, then parents must impose self-regulation on the child until their own self-regulatory capacity develops. As a result, targeting parental self-regulation is critical to preventing obesity of very young children.

Self-Regulation Discussion

Moderator: Lisbeth Nielsen, PhD, Chief, Individual Behaviors and Processes Branch, Division of Behavioral and Social Research, National Institute on Aging

Individual Predictors of Self-Regulation

Children with high self-regulation tend to become adults with high self-regulation. Dr. Nielsen inquired about what individual differences might account for these differences in self-regulatory capacity. There are reports in the literature that self-regulation capacity is 90 percent genetic. However, participants discussed other literature on families in poverty, where financial status at age 5 is predictive of self-regulatory behavior. Meeting participants agreed that individual differences are important but only when considered in a social context.

Further discussion centered on the best way to design interventions. Participants evaluated whether focusing on the individual or the environment is more important. Early intervention in both areas could change the trajectory of a child’s self-regulatory phenotype. Strategies will be necessary for adults as well.

Participants identified automaticity of self-regulation as a key target for interventions. Some individuals are able to induce change on their own, while others may need a nutritionist or trainer. The individual differences that determine whether self-regulation is automatic need to be determined. However, self-regulation cannot be so automatic that it cannot adapt to specific situations. Flexibility of self-regulation is, therefore, an additional target for interventions.

Environmental Predictors of Self-Regulation

Changing the value of a stimulus might result in positive behavior change. For example, by rewarding healthy food choices, the perceived value of healthy food increases. However, there is no way to fundamentally change the value of food. Food and other stimuli have innate reward systems in the brain. Instead, other rewards must take the place of food rewards. For example, a social reward (e.g., a gold star for a healthy lunch) can successfully replace the innate food reward (e.g., eating a cookie tastes good).

Although social rewards are considered acceptable for children, some aspects of social rewards are concerning for adolescents and adults. At these ages, it might be inappropriate to design an intervention

using social reactions to replace food behaviors. Social factors already have a large impact on adolescent behavior, and therefore manipulation of these factors should be done with care.

Participants noted that some behaviors are done strictly for social reward. Many teenagers comment that they do not like drinking but engage in the behavior anyway in order to be accepted by their peers. Changes in population attitudes are sometimes required to change behaviors with a social reward. For example, smoking in public has become socially unacceptable and smoking rates have dropped significantly. The smoking rate has further decreased as the prevalence of images of people smoking in popular media has declined.

Decreasing advertising could be a very effective way to lessen the social reward of negative behaviors. Food and toy advertising on television is related to negative child eating behaviors. A possible intervention would be to encourage the use of online video streaming services so children can watch age-appropriate television shows without being exposed to commercials for unhealthy food.

In conclusion, understanding why individual and environmental factors matter for some individuals but not others is crucial to understanding behavior change. In some cases, interventions will have to be specific not only for the behavior mechanism, but also for the individual.

Anxiety, Stress, and Depression Investigator Presentations

Idiographic Strategies to Evaluate Mechanisms of Action of Interventions for Emotional Disorders and Neuroticism

David H. Barlow, PhD, Professor of Psychology and Psychiatry, Founder and Director Emeritus, Center for Anxiety and Related Disorders, Boston University

Anxiety, mood, and related disorders, sometimes called “emotional disorders” are not distinct and unrelated entities; rather, they should be considered parts of a spectrum of “neurotic behaviors.” There is substantial phenotypic overlap and high comorbidity. The sub-threshold presentation of anxiety, mood, and related disorders (such as obsessive-compulsive disorder and social anxiety disorder) also supports the notion of emotional disorders as a spectrum of disorders with shared temperamental characteristics such as neuroticism. A spectrum analogy is further warranted by the necessity of not-otherwise-specified diagnoses, which are required when an individual’s behavior does not fall neatly into a particular category. Dr. Barlow described all emotional disorders as sharing an “experience of intense emotion and anxiety or distress about the intense emotion that provokes inappropriate appraisals and maladaptive avoidance behavior.”

The partitioning of this neurotic spectrum into discrete diagnoses has resulted in the development of narrowly conceived and discrete psychological treatment protocols. Dr. Barlow proposed that these interventions have significant commonalities and developed a transdiagnostic unified treatment protocol that spans all emotional disorders.²⁶

²⁶ Barlow, D. H., Farchione, T. J., Fairholme, C. P., Ellard, K. K., Boisseau, C. L., Allen, L. B., & Ehrenreich-May, J. *The unified protocol for transdiagnostic treatment of emotional disorders: Therapist guide*. New York: Oxford University Press. (2011).

Dr. Barlow's unified protocol focuses on an individual's reaction to the experience of emotion. The protocol is modular and is comprised of the following elements:

- **Module 1:** Motivation enhancement for treatment engagement
- **Module 2:** Psychoeducation and treatment rationale
- **Module 3:** Emotional awareness training
- **Module 4:** Cognitive appraisal and reappraisal
- **Module 5:** Emotion-driven behaviors and emotional avoidance
- **Module 6:** Interoceptive awareness and tolerance
- **Module 7:** Situational exposures
- **Module 8:** Relapse prevention

Dr. Barlow hypothesized that the unified protocol would reduce anxiety and distress triggered by intense emotional experiences. In order to test the protocol's effectiveness, he designed an equivalence RCT that assigned study participants ($n=240$) to the unified protocol, or a protocol designed for a specific disorder (obsessive-compulsive disorder, generalized anxiety disorder, panic disorder with agoraphobia, or social anxiety disorder) for 12 to 16 weeks of treatment compared to a waitlist control group. Researchers assessed mental health at post treatment as well as at 6 and 12 months post treatment.

Although this study design will test the effectiveness of the unified protocol, it is ineffective in determining the mechanisms of the protocol's success. Case study designs are uncontrolled observations of individuals that can test treatments but cannot determine causality. Dr. Barlow argued for the importance of also including single-case experiments, in which an individual is exposed to multiple treatments, thereby serving as his or her own control. Single-case experimental design allows for systematic manipulation of independent variables (treatment conditions).

Dr. Barlow's SOBC administrative supplement award will implement an alternating treatment single-case experimental design to test the mechanisms of treatment therapies. Twelve individuals with four different diagnoses—social anxiety disorder, obsessive-compulsive disorder, panic disorder with agoraphobia, and generalized anxiety disorder—were assigned to rapid alternation of mindfulness (experience emotion and let it go) versus avoidance (imagine something else). Initial results show functional relationships between therapeutic conditions and outcomes that will shed light on core mechanisms of action of the unified protocol.

In conclusion, Dr. Barlow noted that there is room for improvement in current treatments for emotional disorders. The number of protocols and their complexity are significant barriers to the dissemination of treatment. By simplifying treatment protocols into a single, effective, transdiagnostic unified protocol, treatment can be more effective and more easily disseminated.

Mechanisms Underlying Attentional Bias Training in Children at Risk for Depression

Ian H. Gotlib, PhD, David Starr Jordan Professor of Psychology, Stanford University

Children of depressed mothers are at increased risk for depression themselves. Depressed adults display an attentional bias toward negative stimuli, including attending selectively to sad rather than happy faces.²⁷ Never-disordered daughters of mothers with recurrent depression also exhibit negative

²⁷ Joormann, J. & Gotlib, I. H. Selective attention to emotional faces following recovery from depression. *J. Abnorm. Psychol.* **116**, 80–85 (2007).

attentional biases.²⁸ Conversely, daughters of mothers who have never had a depressive episode exhibit attentional biases to positive stimuli. These data indicate a possible causal role for attentional biases in major depressive disorder.²⁹ These biases may also be a potential intervention target in depression.

Studies of Attention Bias Training (ABT) have demonstrated beneficial effects in reducing symptoms of anxiety and depression. ABT involves “conditioning” participants to attend to happy or positive stimuli by placing dot probes under positive images. Participants learn to attend to happy images rather than to negative stimuli. Given the negative attentional bias exhibited by girls at familial risk for depression, Dr. Gotlib hypothesized that ABT may be able to delay or prevent the onset of depressive episodes in these girls.³⁰

With the SOBC administrative supplement funding, Dr. Gotlib and colleagues are extending this research by scanning a sample of high-risk girls who are randomly assigned to receive real or sham ABT both before and after the training. Investigators are using the neural data collected in this SOBC supplement to examine neural aspects of both short- and long-term effects of this intervention, including changes not only in cognitive biases and stress reactivity, but also in specific clinical constructs such as levels of depressive symptomatology and the onset of major depressive disorder. This study is the first to examine neural mechanisms underlying attentional training with a young sample at high risk for major depressive disorder.

Preliminary data from the parent grant indicate that ABT is effective in reducing bias toward negative faces. An emotional interference task that is designed to assess neural reactivity to emotional distractors is being used to examine the neural mechanisms underlying successful ABT. Girls are presented with a pair of houses and a pair of faces in each trial, with one pair arranged horizontally and the other vertically around a central fixation cross. They are instructed to fixate on the cross and attend to the horizontal or vertical axis for a given run (two runs total, counterbalanced order). For each trial, girls indicate, via button press, whether the two items in the target axis are the same or different. Prior findings in depressed adults showed heightened amygdala activation and decreased prefrontal activation during the “ignore negative” (but not during the “attend negative”) condition.³¹ Therefore, ABT-related differences were examined in the current study measuring prefrontal and amygdala activation during trials in which girls ignored sad faces.

Neural fMRI scans pre- and post-ABT demonstrated a decrease in amygdala activation and an increase in PFC activation following ABT. Suppression of the subcortical regions and activation of prefrontal regions are important in self-regulation and other emotional disorders. These results are the first to demonstrate a direct relation between ABT and changes in brain function in children at risk for psychopathology. The results also suggest a biological mechanism by which ABT operates to increase

²⁸ Joormann, J., Talbot, L. & Gotlib, I. H. Biased processing of emotional information in girls at risk for depression. *J. Abnorm. Psychol.* **116**, 135–143 (2007).

²⁹ Gotlib, I. H., Krasnoperova, E., Yue, D. N. & Joormann, J. Attentional biases for negative interpersonal stimuli in clinical depression. *J. Abnorm. Psychol.* **113**, 121–135 (2004).

³⁰ Amir, N., Bomyea, J. & Beard, C. The effect of single-session interpretation modification on attention bias in socially anxious individuals. *J. Anxiety Disord.* **24**, 178–182 (2010).

Wells, T. T., Beevers, C. G., Robison, A. E. & Ellis, A. J. Gaze behavior predicts memory bias for angry facial expressions in stable dysphoria. *Emot. Wash. DC* **10**, 894–902 (2010).

³¹ Fales, C. L., Barch, D. M., Rundle, M. M., Mintun, M. A., Snyder, A. Z., Cohen, J. D., et al. Altered emotional interference processing in affective and cognitive-control brain circuitry in major depression. *Biol. Psych.*, **63**, 377–384 (2008).

positive attentional bias. Future research will focus on longitudinal studies designed to assess whether ABT can delay or prevent depression in at-risk children.

Question and Answer

Moderator: Varda Shoham, PhD, Senior Advisor for Translational Research, Division of Adult Translational Research and Treatment Development, National Institute of Mental Health

The discussion centered on biological markers that correlate with pre-symptomatic depression. Dr. Gotlib noted that cortisol levels are higher in girls at risk for depression, and ABT is associated with reduced levels of cortisol. Additionally, lower levels of cortisol result in smaller hippocampus size. These two markers are potentially indicative of a pre-symptomatic depressive state.

Methodology Discussion

Moderator: Varda Shoham, PhD, Senior Advisor for Translational Research, Division of Adult Translational Research and Treatment Development, National Institute of Mental Health

Methodology in Behavioral Research

Dr. Shoham emphasized that all projects employed robust and effective methodologies to test hypotheses. There is a perception in other scientific fields, however, that behavioral research methodology is sub-standard. The challenge for the field is to continue to develop rigorous methodologies that are useful in large clinical settings or clinical trials.

Real-World Behavioral Measures

Participants agreed that making measures of behavior relevant to the real world is a key challenge. The least scalable measure of behavior is fMRI. However, a suitable proxy might be pupil dilation. It was also noted that questionnaires are too long and too specific. Development of a simplified questionnaire would be much more useful in a large service-oriented clinic. Dr. King noted that developing a collection of usable measures for constructs directly related to behavior change, such as PROMIS developed measures for patient-reported health outcomes, would be valuable to the field in creating common predictive profiles.

Rigorous methods are necessary to encourage acceptance and dissemination of effective interventions. There is a risk of implementing interventions that are not evidenced based, which further diminishes the perception of behavioral science by policy makers and the public. Participants noted the need for science to determine the best intervention points and procedures. Self-regulation models need to be tested at the genetic, brain, and behavioral levels.

Significant barriers to testing self-regulation models are money and time. Behavioral research is longitudinal by nature, and longitudinal study designs are costly to implement. Retention of child participants and their families over a long period of time is another barrier.

Animal Behavior Models

Participants discussed the value of animal models in understanding behavioral processes. There is some interest in translating animal models of behavior into human clinical work. It is perceived that there is funding available for animal models of behavior and their ability to inform human psychological conditions (e.g., mouse model of autism). There was, however, some concern, because mouse models, although informative and useful, cannot take the place of research on human behavioral interventions.

Positive Behaviors and Early Interventions

Encouraging positive behaviors is as important as discouraging negative behaviors. Promotion of positive behaviors results in prevention of negative ones. Participants expressed enthusiasm for studies of both positive and negative behaviors and agreed that early intervention is a key component to intervention success. Longitudinal studies are necessary to determine at what points in development interventions are most likely to succeed.

Wellness Behaviors and Adherence Investigator Presentations

Investigating Affective and Genomic Mediators of Sustained Behavior Change

Barbara L. Fredrickson, PhD, Kenan Distinguished Professor, University of North Carolina at Chapel Hill

During sickness, inflammation results in a suite of responses collectively known as “sickness behaviors,” which include reduced physical activity, decreased positive affect, and lack of interest in social interaction. Presumably, these effects are evolutionarily beneficial: sickness requires rest for healing to occur, and social isolation can prevent the spread of viruses. Dr. Fredrickson hypothesized that there may be a parallel set of “wellness behaviors” that are also evolutionarily beneficial, including physical activity, social engagement, learning new things, the pursuit of meaning, healthy eating, and caring for the body. Changes in inflammation and other biological systems may alter the frequency of these and other wellness behaviors by amplifying or dampening the positive emotion yield, rendering wellness behaviors more or less appealing depending on a person’s current biological state.

Dr. Fredrickson described the upward spiral theory of lifestyle change. This theory posits that wellness behaviors that produce positive emotions in turn create a non-conscious wanting to further engage in that wellness behavior (a dopaminergic response), coupled with broadened awareness and increments in several enduring biological resources that further amplify the positive emotion yield of that wellness behavior. The upward spiral model sheds light on how healthy lifestyle habits take root and are sustained over time.

Dr. Fredrickson’s project has three specific aims to understand how positive emotions create increasing and non-conscious motives for wellness behaviors.

- **Specific Aim 1:** Identify peripheral biological resources and genetic polymorphisms that moderate the link between wellness behaviors and their positive emotion yield
- **Specific Aim 2:** Identify the biological signaling pathways that mediate the proposed association between increases in positive emotions and changes in inflammation-related gene expression
- **Specific Aim 3:** Investigate the pathways through which increases in positive emotions influence changes in inflammation-related gene expression, sustained wellness behavior, and associated health outcomes

The brainstem vagus nerve is a key component in the parasympathetic branch of the autonomic nervous system. Resting respiratory sinus arrhythmia (RSA) and heart rate variability (HRV) are used as proxy measures for cardiac vagal tone and have been found to correlate with both cardiovascular and immune health. Consistent with the upward spiral theory, Dr. Fredrickson’s past work shows that one particular wellness behavior, engaging in a form of meditation called Loving-Kindness Meditation (LKM) both affects and is affected by cardiac vagal tone: participants with higher cardiac vagal tone show greater

identification of personal values within each life area, engagement in daily activities based on values, and an emphasis on structure and support to encourage success.³⁶

Dr. MacPherson's parent grant involves an RCT comparing the effectiveness of BAT versus standard treatment in adult smokers with depressive symptoms. The efficacy of BAT depends on its capacity to increase the activation of alternative behaviors that function to provide rewarding experiences while also decreasing smoking behavior; however, the potential mechanisms of "activation" of alternative non-smoking behaviors have not been directly tested. The SOBC administrative supplement supports studies using methodological tools of basic self-regulation to identify individualized activities with strong reward potential and train the participant to approach them automatically. Specifically, in the experimental condition, a joystick task procedure is being used to train the individual to approach images with positive meaning. Investigators then determine whether BAT leads to higher smoking cessation rates.

Preliminary results indicate that BAT was significantly more effective at decreasing the number of cigarettes smoked per day as compared to control. The advantage of BAT is that it takes into account the values and activities important to each individual. Future research will examine whether these values have core components. This treatment may also have applicability in the cessation of other negative behaviors.

Use-Oriented Basic Research: Testing Change Mechanisms in Project PREPARE

Cathleen Sheil, MA, LPC, Department of Behavioral Science, Senior Research Counseling Associate, University of Texas, MD Anderson Cancer Center

Overview

Ms. Sheil, a collaborator of Eileen Shinn (Principal Investigator), presented a model for determining the critical aspects of an intervention designed to improve swallowing following radiation for oropharyngeal cancer. She reviewed data showing that the intervention improves the ability to eat a normal diet following radiation. Based on patient responses to the intervention, the investigators designed a follow-up study, funded by an SOBC administrative supplement, to test which components were responsible for the success of the intervention.

Background

Oropharyngeal cancer is a diverse set of diseases primarily affecting men in their late 50s. Although highly curable (the 7-year survival rate is 87 percent), oropharyngeal cancer requires a challenging radiation treatment, resulting in fibrosis of the larynx and permanent difficulty swallowing. Swallowing exercises following radiation are extremely effective at preventing fibrosis. However, participants are not generally adherent to the exercises and 60 percent did not attempt even one.

Shinn and colleagues designed the Project PREPARE intervention to improve adherence to swallowing exercises. The intervention is based on self-regulation theory and involves weekly counseling sessions on identity, causes, personal control, timing, and consequences. A counselor reinforces all written material. The effectiveness of Project PREPARE, as evidenced by the ability to eat a normal diet 6 weeks post radiation, is being tested with an RCT. Study participants ($n=186$) are assigned to the PREPARE intervention or a control condition. Preliminary results indicate that the PREPARE intervention is

³⁶ Lejuez, C. W., Hopko, D. R., Acierno, R., Daughters, S. B. & Pagoto, S. L. Ten year revision of the brief behavioral activation treatment for depression: revised treatment manual. *Behav. Modif.* **35**, 111–161 (2011).

significantly more successful at encouraging participants to complete swallowing exercises: 40 percent of PREPARE participants were able to eat a normal diet 6 weeks post radiation compared to 27 percent of control participants.

Potential Mechanisms for Behavior Change

Participants' self-report of reasons for the success of the PREPARE intervention included accountability as a result of their bond with the counselor and the counselor's monitoring of how many exercises they completed. Based on these results, the SOBC administrative supplement is supporting the study of the role of accountability and monitoring in adherence to swallowing exercises using a three-group, one time point, correlational study. Investigators suspected that these two dynamics, accountability and monitoring, were fueling the behavior change, and therefore the supplemental study manipulates these factors to see whether behavior change could be achieved with high- versus low-touch accountability and high- versus low-touch monitoring. The three groups were high accountability/human monitoring, low accountability/technological monitoring, and low accountability/technological monitoring. A group with low accountability/human monitoring was deliberately not included because it does not have potential applicability in the real world. The supplemental study will have 100 participants; 22 have already completed the assessment.

Although preliminary results are not yet available, the trial design has many implications for future interventions. For example, if human monitoring is not necessary to intervention success, a simple sensor may be enough to ensure adherence. An academic collaboration between M. D. Anderson Cancer Center and the California Institute for Telecommunications and Information Technology (CAL IT 2) has developed an integrated network of research and medical databases with wearable sensors. The Cyberinfrastructure for Comparative Effectiveness Research (CYCORE) project, funded by an NIH GO grant, has tested sensors that remotely transmit adherence data to the participant and doctor. However, if human monitoring is required, then medical centers will need to add clinicians to increase adherence to interventions. Results of this trial will be relevant for other diseases that require adherence to treatment protocols for health maintenance or prevention of problems.

Question and Answer

Moderator: Jonathan W. King, PhD, SOBC Working Group Coordinator, Program Director, Division of Behavioral and Social Research, National Institute on Aging

Dr. Suzman noted that price and taxation are effective deterrents in alcohol consumption for beginning drinkers or those with little disposable income. He also asked Dr. Saffer if age and social networks could be integrated into his research. Dr. Saffer responded that children and young adults perceive through social networks that their peers drink a lot. However, if it is revealed to them how little their peers actually drink, consumption goes down.

Dr. Neilsen remarked that technical accountability is actually a hybrid of human and computer monitoring. Adherence to a protocol might be boosted because a doctor is checking the data. Dr. Shoham added that caregivers might be excellent monitors because they are already involved in patient care.

Dr. MacPherson elaborated on the methods used in her smoking cessation study. The intervention is intended to disrupt the automaticity of a negative behavior by replacing it with a new activity. She emphasized the importance of finding ways to incentivize alternative behaviors.

Use-Inspired Basic Research Discussion

Moderator: Lisa Onken, PhD, Chief, Behavioral and Integrative Treatment Branch, Division of Clinical Neuroscience and Behavioral Research, National Institute on Drug Abuse

Financial Incentive Paradox

The costs of an addictive habit and the use of money to encourage people to quit is somewhat of a paradox. It is ironic that individuals are not influenced by the financial cost of purchasing cigarettes or drugs, yet can be encouraged to quit with cash incentives. It is possible that pointing out the costs of a habit may augment treatment; however, this construct has yet to be rigorously tested.

Investigators concurred that rebates are far less effective than direct payments as reward for wellness behaviors. Lowering insurance payments to reward for improved health is ineffective because it is not a direct payment and therefore does not offer enough incentive to change behavior.

Dr. Halpern's data point to the effectiveness of rewards that require an individual to make a small deposit in promise for a larger future reward. However, acceptability of that incentive structure was low. Participants discussed ways to get people to accept a deposit structure. It is important to consider that the individuals who accepted this financial reward structure might have already been more motivated to quit smoking. Further research is necessary to understand the individual traits that make a person more or less likely to accept a deposit reward structure.

The Boundaries of Financial Incentives

The concept of using financial incentives to change behavior is intriguing. It is unclear how widely applicable financial rewards would be to changing behaviors in depression, mood disorders, or drug addiction to heroin or morphine.

Investigators discussed the conditions required to make financial rewards successful. Participants agreed that, in general, financial rewards only work when the behavior is under volitional control. Theoretically, emotional behaviors such as phobias would not be responsive to financial reward. Also, although depression is not under volitional control, depressive behaviors might be. Future research is necessary to determine the effect of financial rewards on other behaviors.

It is also unclear whether financial incentives alone would maintain wellness behaviors over time. Without coping and self-regulation skills, individuals may revert to unhealthy behaviors once the financial incentives end. A possible solution is "pay to engage," where money is offered as a reward to encourage individuals to enter a therapeutic program. Initial payment may be relevant for non-volitional disorders such as depression and anxiety as well. The financial payment may offset the emotional cost of finally facing the roots of depression and anxiety.

Ideal Mechanisms to Include Basic Behavioral Research into Clinical Studies

Participants agreed that interventions are not possible without understanding the basic mechanisms of the behavior and behavior change. The SOBC administrative supplements have allowed investigators to add basic research to existing clinical trials. However, recipients noted that the parent grants were not necessarily designed in the way they would have wanted to test these hypotheses.

Participants discussed ideal mechanisms for including basic behavioral research into clinical studies. Investigators noted that a Request for Applications (RFA) specifically requiring behavioral research in

conjunction with clinical trials would be the most effective vehicle. Including clear language in such an RFA indicating that a lack of basic behavioral research would render the application unresponsive.

Several meeting participants commented on the availability of funding opportunities for incorporating basic research into clinical trials, but acknowledged that they were spread across the Institutes and Centers at NIH. It was suggested that relevant funding opportunities could be listed on the SOBC website for easy access in one place, even if the opportunities were not funded by the SOBC.

Standard Measures and Tools for Behavioral Research

Participants noted that measures for behavior and self-regulation often lack uniformity and rigor. Basic constructs are needed to consistently measure behavior. These measures need to be scientifically valid and scalable for use in large clinical trials. Investigators and NIH staff engaged in a robust discussion about the possibility of standardized self-regulation measures, appropriate for particular populations (e.g., children versus adults) and available to embed in clinical trials to test mechanisms. Dr. Nielsen noted the importance of having measures from laboratory experiments link to real-world behaviors. The field lacks a toolbox of self-regulation phenotypes; development of such a resource will be a painstaking process, but potentially very useful for the field. As a corollary, Dr. Ochsner shared his experience talking with clinicians about developing valid psychometric tests in core domains of cognitive neuroscience that are tolerated by patients for clinical use. Dr. Shoham offered an approach taken by a group that sought to refine measures for schizophrenia research as a good example of the process. Some participants felt that there are too many self-regulation constructs and different variations and terms are used for similar constructs across disciplines. The development of standardized measures would require discerning the variations and creating a common language.

The NIH Toolbox for the Assessment of Neurological and Behavioral Function is a useful starting point for standardizing basic research protocols. The NIH Toolbox includes multidimensional measures to assess cognitive, sensory, motor, and emotional function in 3- to 85-year-olds. A toolbox of self-regulation phenotypes is currently lacking. However, there are circumstances that will inevitably require special considerations. For example, children will require more observational tools than adults. Any analyses used would need to be relevant to the study participants and appropriate for the developmental stage. PROMIS is another model of a collection of standardized measures.

Simplifying Behavioral Constructs

Simplifying measures of behavior would require reducing the number of self-regulation phenotypes. A common language of self-regulation would lead to a common set of measures. Adopting a common language of self-regulation behavior would be valuable but also difficult. Currently, it is in the interest of the researcher to present an innovative theory on a particular behavior. Members cited the genomic field as one that has adopted a common language and hence a common set of laboratory measures.

On behalf of the NIH, Dr. King thanked all attendees for their participation and input. He noted that significant progress had been made in identifying opportunities for the future of behavior change research and expressed enthusiasm for research progress to be presented at the Fourth Annual Meeting of Investigators in June of 2014.

Appendix B: List of Participants

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