

# Future directions of the National Institutes of Health Science of Behavior Change Program

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## Abstract

**Background:** The National Institutes of Health Science of Behavior Change Common Fund Program has accelerated the investigation of mechanisms of behavior change applicable to multiple health behaviors and outcomes and facilitated the use of the experimental medicine approach to behavior change research.

**Purpose:** This commentary provides a brief background of the program, plans for its next phase, and thoughts about how the experimental medicine approach to behavior change research can inform future directions in two areas of science—reproductive health and COVID-19 vaccine uptake.

**Conclusions:** The incorporation of a mechanisms-based approach into behavior intervention research offers new opportunities for improving health.

## Keywords

Science of behavior change; Experimental medicine approach; Mechanisms of behavior change; Reproductive health; COVID-19 vaccine uptake; NIH

## INTRODUCTION

The National Institutes of Health (NIH) Science of Behavior Change (SOBC) Common Fund Program was established to capitalize on emerging basic behavioral science research and existing evidence-based interventions to improve the initiation, personalization, and maintenance of healthful behaviors [1]. The goals for the SOBC Program are to: (a) unify the science of behavior change through a focus on mechanisms of behavior change and by strengthening links between basic and applied behavior change science; (b) strengthen behavioral intervention development by implementing the experimental medicine approach to behavior change research and developing tools and measures to facilitate such an approach; and (c) increase rigor, transparency, and dissemination of common terminology, methods, and measures to advance the field of behavior change research.

The experimental medicine approach to behavior change research

The experimental medicine approach to behavior change research seeks to understand the underlying

## Implications

**Practice:** Systematic mechanisms-focused behavior change research informs and enables the development and implementation of potent real-world behavioral interventions in clinical practice to optimize a variety of health outcomes.

**Policy:** Conducting systematic research to understand the mechanisms underlying behavior change across multiple health behaviors can inform effective public health policies.

**Research:** Systematic mechanisms-focused behavior change research should be employed in areas not yet explored by the NIH Science of Behavior Change Program, such as reproductive health and COVID-19 vaccine update.

## Lay summary

The National Institutes of Health Science of Behavior Change Common Fund Program has accelerated the investigation of mechanisms of behavior change applicable to multiple health behaviors and outcomes and facilitated the use of the experimental medicine approach to behavior change research. This commentary provides a brief background of the program, plans for its next phase, and thoughts about how the experimental medicine approach to behavior change research can inform future directions in two areas of science—reproductive health and COVID-19 vaccine uptake. The incorporation of a mechanisms-based approach into behavior intervention research offers new opportunities for improving health.

mechanisms that drive behavior change. The SOBC Program supports and facilitates behavior change research driven by hypotheses of specific malleable target mechanisms or processes, which, if engaged, can lead to changes in the desired health outcome (Fig. 1). A mechanisms-focused approach to behavior change research can help identify the essential components of behavioral interventions, which is crucial for translation, dissemination, and replication of behavior change interventions with fidelity. The

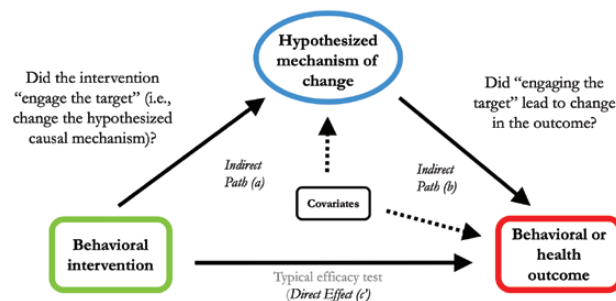


Fig 1| Experimental medicine approach to behavior change research.

steps in the experimental medicine approach include (a) identifying potential malleable targets; (b) leveraging existing or developing new experimental manipulations or interventions to engage the identified targets; (c) identifying or developing measures to permit verification of target engagement; and (d) examining the degree to which target engagement produces a change in the health behavior outcome of interest [2–6].

#### Leveraging SOBC insights to inform future research

SOBC-funded projects have used an experimental medicine approach to investigate a variety of mechanistic targets and health behaviors across the domains of self-regulation, interpersonal and social processes, and stress resilience and stress reactivity, with links to health outcomes relevant to multiple NIH Institutes and Centers. These health outcomes include, for example, cardiovascular health [7, 8], sleep health [9], stress and physical activity [10], opioid use disorder [11], obesity [12–14], prediabetes and diabetes management [15, 16], smoking cessation [17], and breast cancer survivorship among African American women [18]. Two areas of research not addressed by current SOBC-funded projects provide promising opportunities to apply a mechanisms-focused approach to behavior change research: reproductive health and COVID-19 vaccine uptake. We first describe how insights learned from SOBC-funded research can inform behavior change research and intervention development in the area of reproductive health. We then elucidate the experimental medicine approach steps as they could be applied to a new behavior change challenge—COVID-19 vaccine uptake.

#### PROMISING NEW DIRECTIONS

##### Reproductive health

The NIH mission includes support for research “in the processes of human growth and development” [19]. As for all living organisms, reproduction is a central activity in these domains. More than 25 years ago, delegates to the United Nations’ International Conference on Population and Development in Cairo declared that reproductive health is a

fundamental human right [20]. Beyond these deeply significant principles of biology and policy, reproductive health has nearly universal significance, as 99% of American women who have ever had sexual intercourse have used at least one contraceptive method, and more than half of all women of reproductive age are currently using some type of contraception [21]. Poor reproductive health outcomes can be as dire as any disease or condition. Even in the 21st century, infant mortality remains a critical issue in the United States, which has the highest rate among developed nations, and poor infant mortality rates have been linked to a lack of preconception and interpartum care [22].

Reproductive health covers a range of human activity from puberty through menopause and andropause. It includes both preventing and facilitating childbearing as well as the prevention of sexually transmitted infections. A particular challenge in this field is that many of these activities involve healthy people trying to stay healthy. Individuals whose behaviors might but are not yet creating a recognized health problem are likely to be in the precontemplation phase where they are unlikely to participate in preventive behavior change [23]. Additionally, there is often ambivalence about goals such as pregnancy, which leads to inaction or lack of adherence to recommendations for healthful behaviors in anticipation of becoming pregnant [24] or, conversely, medical regimen adherence or device used for avoiding pregnancy [25]. Nearly half of pregnancies to American women in 2011 were unintended [26].

One of the current challenges in contraceptive behavior is one of utilization, not access—effective technologies (e.g., drugs, devices) are available but methods require varying degrees of user adherence to a prescribed regimen. Contraceptive method effectiveness is directly correlated with the degree of user action required [27]. Nevertheless, reversibility is highly valued by users along with effectiveness; therefore, research that informs better adherence of user-dependent methods would advance public health. An extensive body of research on the use of individual theories of behavior change for interventions to improve contraceptive use, particularly studies using a

social cognition approach, developed through the 1990s and first decade of the 2000s (e.g., theory of reasoned action). Overall, findings have been inconsistent [28]. Several SOBC-funded projects focused on the imperfections of decision-making processes and may provide insights for new directions to sort through these inconsistencies.

#### *Stress resilience and stress reactivity*

Haushofer et al. proposed three targets that may be impacted by stress and consequently change adherence to preventive health practices: self-efficacy, executive control, and temporal discounting [29]. Self-efficacy is the belief that one can perform well enough in a specific situation to produce one's intended outcome [30]. It has been shown to be strongly related to medical regimen adherence and other health behaviors [31]. For the related area of sexually transmitted infection treatment, Esopo et al. cite a meta-analysis of 207 studies of HIV antiretroviral therapy adherence, which concluded that interventions to boost adherence should target psychological factors such as self-efficacy, as well as beliefs about the efficacy and safety of the medications [32]. Likewise, executive function is positively associated with HIV medication adherence [33].

Temporal discounting leads individuals to assign greater value to a reward nearer in time than one more distant. Thus, a user of a contraceptive method that requires them to pause in the middle of a sexual encounter to insert a device may choose instead to continue with the immediate reward of the encounter. Along similar lines, the behavioral economics principle of loss aversion—preference for avoiding losses over acquiring gains—may lead an individual to avoid interrupting the encounter if they fear that in response their partner may end it.

In an effort to target and measure changes in temporal discounting as a mechanism of behavior change, Haushofer and colleagues used an intervention analogous to a new approach in clinical care: reproductive life planning. The participants visualized the outcomes of different behavioral options and pretended to speak deeply and emotionally with their potential future selves. The team hypothesized that making the future more vivid would reduce temporal discounting and increase self-efficacy [34]. Similarly, in reproductive life planning, the provider encourages the patient—woman or man—to think about their life goals and reproductive goals within that larger context. Together, the provider and patient consider both short- and long-term desires and then discuss contraception options that best fit those goals and timing [35]. The consideration hereof time targets temporal discounting and the focus on planning facilitates self-efficacy.

#### *Interpersonal and social processes*

Another complexity in this area is that decisions are often either dyadic or made by one person with

impacts on another person who is not yet known to the first person. For example, behavior changes to improve preconception health such as smoking cessation can be taken at the individual level, although reinforcement from a partner is usually helpful. In contrast, preventing sexually transmitted infections is largely a dyadic process because sexual transmission occurs between partners. The partnership may last only as long as the act or may extend for years. This temporal dimension adds to the challenges.

The project led by Slep and Heyman focused on interpersonal processes—specifically, on coercion as a destructive force in family dynamics. Reproductive coercion in couple relationships is associated with poor adherence to healthful behavior patterns resulting in lower levels of condom use for prevention of both sexually transmitted infections and pregnancy and compromised decision-making across many aspects of family planning and reproductive health [36]. The SOBC project developed multimethod measures of coercion that can be obtained from the participant (self-report, biomarker) or a trained observer [37]. The latter type of measure could be an important tool for reproductive health clinicians such as family planning providers.

#### *Self-regulation*

Another aspect of reproductive health for which tools and findings from SOBC projects may prove useful is the developmental considerations for self-regulation investigated in a study of diabetes self-management in adolescents [38]. Self-regulation includes the capacity to control one's thoughts, emotions, and behavior to achieve a goal, which overlaps somewhat with self-efficacy, but the emotion regulation component is unique. Developing and enacting emotion regulation skills are particularly important during adolescence [39] so this population is particularly useful for testing such targets and measures. The role of perceptions of love in sexual experiences is well-documented in the academic and lay literatures, but, overall, the mechanistic processes linking emotion and fertility-related behaviors such as contraceptive use are understudied [40].

These different types of targets—stress resilience and stress reactivity, interpersonal and social processes, and self-regulation—must all be considered within contexts and across moderators. Such a discussion is beyond our scope here. Examples include the context of global health and population characteristics such as gender, race/ethnicity, and sexual orientation. For example, the Haushofer project provides measures that were developed outside the U.S. Information and data about those assays are publicly available through the Open Science Framework (<https://osf.io/pf2jh/>).

#### *COVID-19 vaccine uptake*

As of November 1, 2020, the Centers for Disease Control and Prevention (CDC) reports 9,105,230

confirmed cumulative cases of COVID-19 in the United States (2,751 cases per 100,000 up from 26 per 100,000 on March 26, 2020) and 229,932 COVID-19 deaths ([https://covid.cdc.gov/covid-data-tracker/#cases\\_casesinlast7days](https://covid.cdc.gov/covid-data-tracker/#cases_casesinlast7days)), which may undercount the true estimate of excess deaths in the United States due to the novel coronavirus and corresponding gaps in screening and care for other diseases and chronic conditions [41]. COVID-19 morbidity and mortality burden falls disproportionately on Black, Latinx, and Native American persons, widening existing health inequities in the United States [42]. The development and deployment of an effective vaccine is seen as one promising way to end the COVID-19 pandemic [43, 44]. As of September 2020, there are almost 200 vaccines in development, 24 of which are in various stages of clinical trials [45]. Despite the promise of vaccination, significant concern about the successful deployment of vaccination exists. Indeed, nationally representative studies suggest that 30–40% of the U.S. population are unwilling to, or unsure of whether, they will vaccinate [46, 47]. Although COVID-19 vaccination hesitancy may be a rational response, particularly among Black Americans who have reasonable medical mistrust as a result of structural inequities and history of abuses within the medical system and in medical research [48], reducing COVID-19 vaccine hesitancy and increasing vaccine uptake is critical for halting the pandemic and reducing inequities in COVID-19 complications and mortality [49, 50]. As such, reducing vaccine hesitancy is another example of how the approaches promoted in the SOBC Program (i.e., experimental medicine approach to behavior change research) can be leveraged to improve public health.

Many existing approaches to increase vaccination uptake involve developing interventions that target many constructs from health behavior theory (i.e., the “kitchen sink” approach) [51], which often result in diffuse and less efficient and effective interventions [52–54]. There is no strong evidence to support the effectiveness of any one approach for facilitating vaccine adherence, particularly among those who are vaccine hesitant [51, 55]. Indeed, existing interventions designed to reduce vaccine hesitancy by correcting misinformation, facilitating positive attitudes towards vaccination, appealing to emotions, or mandating vaccinations are often ineffective—and sometimes even backfire [56–60]. The potential for such interventions to backfire may be magnified by the increased polarization on beliefs about COVID-19 and the strength of anti-vaccination movements [61–63]. Moreover, even interventions that have been shown to be efficacious in increasing vaccination adherence in other domains are often costly, complex, and time-consuming [61, 64].

An experimental medicine approach can be leveraged to develop more potent, cost-effective,

and easy-to-disseminate interventions to increase vaccine uptake. This approach would (a) identify potential intervention targets (i.e., mechanisms of action) based on research on vaccine hesitancy and acceptance in other domains and existing research and theory on COVID-19 vaccine hesitancy and acceptance; (b) conduct formative research to engage the target through experimental manipulation or intervention to examine whether targeting these mechanisms in relevant samples produces reasonable changes in measures; (c) develop measures that would capture the change in the target; (d) examine the degree to which target engagement using methods developed in Step c in relevant samples produces changes in the health behavior outcome—vaccine acceptance and adherence—in randomized controlled trials. Identifying individual and contextual moderators of the effects of targeting key mechanisms on vaccine outcomes is also important. Critically, given the disproportionate COVID-19 burden for Black, Latinx, and Native American persons [42], such studies should ensure there is adequate power to examine whether mechanisms are malleable and lead to behavior change among these groups, and should also involve adequate power to examine heterogeneity and moderators of effects within these groups [65].

#### *Identify potential malleable targets (step a)*

Preliminary research and theory on COVID-19 suggest potential mechanisms that may influence vaccine hesitancy and acceptance: misunderstanding of the pandemic [62]; beliefs about post-infection immunity [66]; trust in institutions [67]; motivated reasoning and rationalizing risk behavior [61]; and other biases in risk perception and decision making [62, 68]. Research on vaccine hesitancy and acceptance in other domains (e.g., measles, mumps, rubella [MMR], human papillomavirus, influenza) identifies additional potential mechanisms, including the belief that vaccine can cause disease or other harms [69], ambivalence about risks and benefits [70], and belief in misinformation [71].

#### *Engage the targets (step b) and develop measures (step c)*

Once mechanisms are identified, the next step in the experimental medicine approach is to identify experimental manipulations or interventions that would produce a change in the mechanisms, as well as measures to capture such change, and to use these to examine whether mechanisms are malleable. For example, self-persuasion interventions can be used to target vaccine ambivalence [72]. Consideration of future consequences has been linked to H1N1 vaccine uptake [73], and may play an important role in COVID-19 vaccination behavior. Risk perception biases can be targeted with interventions that facilitate a gist, or intuitive, sense of risk [74–76], or with interventions that translate numeric risk into images



[76, 77]. Several approaches can be leveraged to reduce biases in decision making [68]. Inoculation strategies can counteract misinformation [64].

*Determine whether target engagement leads to health behavior change (step d)*

The final step is to examine whether producing changes in the malleable mechanisms identified as potentially underlying vaccination behavior actually lead to vaccination behavior change using randomized controlled trials. This step is comparable to traditional health behavior change research but has the advantage over such approaches because only malleable processes will be targeted, resulting in the potential for more potent interventions than the more traditional “kitchen sink” approach [52–54].

Within this last step, it is important not only to measure changes in the target mechanism, but also to identify potential moderators—for example, characteristics of individuals that would intensify or weaken the effect of a mechanism on the vaccination behavior outcome. Political ideology may be an important moderator, such that although bias can occur regardless of political ideology, the type of bias may cause any given intervention to be more or less effective [78]. People’s prior beliefs about the vaccine may be another moderator to consider, such that herd immunity may be more achievable with interventions targeting those who already have positive attitudes towards the vaccine, and interventions essentially close the intention-behavior gap among those individuals [51, 61]. Numeracy may also moderate the effects of mechanisms like disease risk, severity, and side effects perceptions on vaccination outcomes [79, 80]. Conspiracy beliefs may also modulate intervention effectiveness [81, 82]; for example, one recent study demonstrates individuals high in conspiracy beliefs may be more likely to change their health beliefs in response to misinformation inoculation, whereas individuals low in conspiracy beliefs may not [83]. Moderators related to the information landscape may also be relevant for consideration; for example, research suggests that anti-conspiracy intervention may be effective only prior to misinformation [84]. Identifying moderators is a critical step in developing targeted, “precision medicine” interventions [85].

Many of the hurdles to vaccine uptake, particularly in underserved communities, could require organizational behavior change at the institutional or community level [86, 87]. Systematic exploration of the most effective organizational interventions, such as by incentivizing collaboration and public-private partnerships to improve vaccine access and uptake, is equally important.

## CONCLUSION

The mechanisms-based experimental medicine approach to the development of therapeutic and preventive interventions has a long history in

academia and the commercial sector. Drug development relies on determining innovative ways to interrupt or accentuate pathways that control or prevent disease development, progression, and disability. Regulatory agencies review pre-clinical studies of the effect of proposed agents on disease pathways. Purely empiric drug studies are not common; outcomes of clinical studies frequently include determination of the effect of agents on biomarkers or intermediates in relevant disease pathways. In contrast, behavior change research intervention studies have not regularly focused on measuring the effect on known mechanisms underlying the targeted behavior along with the effect on the behavior itself.

The SOBC research community has developed an impressive collection of measures of underlying behavior mechanisms (<https://scienceofbehaviorchange.org/measures/>). Although additional work is needed to refine and validate these and other measures, the incorporation of a mechanisms-based approach supported by basic behavior research into behavior intervention research offers new opportunities to improve health. The NIH’s continued facilitation of a mechanisms-based approach to behavior change research, in part through its collective support of the renewal of the SOBC Research and Coordinating Center (2U24AG052175-06), and the application of the experimental medicine approach in future research to the development of novel behavioral interventions, such as described here for reproductive health and COVID-19 vaccine hesitancy, will inform strategies to improve the health of individuals and our communities.

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