The Impact of a “Well-Timed” Nudge on Individual Physical Activity and Health Outcomes Via Wearable Devices

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PPOL 768

Agenda

- Introduction
- Motivation and Conceptual Framework
- Outcomes, Data Sources, and Hypotheses
- Intervention
- Samples
- Randomization
- Estimation Methodology
- Conclusion

Introduction - Using Wearable Devices to Improve Physical Activity and Health Outcomes: A Randomized Control Trial

Investigating the Effectiveness of Digital Nudges:

- Obesity and sedentary lifestyles are becoming increasingly prevalent, leading to numerous health problems
- Self-monitoring with wearable devices has been shown to modify health behaviors, including physical activity
- Digital nudges have also been found to effectively influence human behavior
- This study aims to examine the effectiveness of a well-timed nudge on a wearable device to promote physical activity and improve health outcomes
- Little research has been conducted on how a nudge via a wearable device impacts physical activity and health outcomes, which is where our study fits in.

What is a “Nudge”?

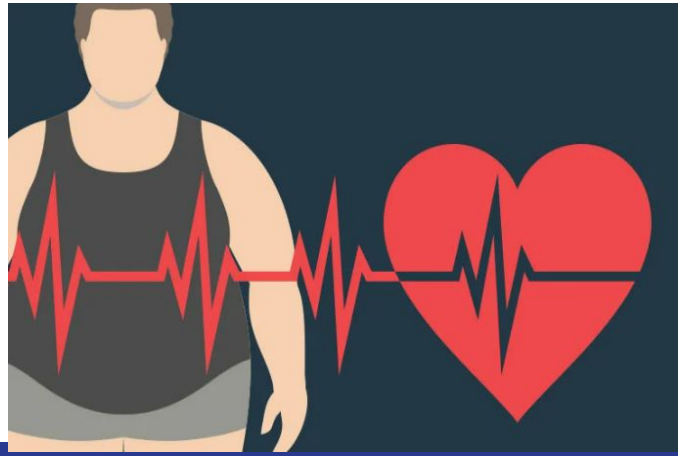
“A nudge… is any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives.”

- Cass Sunstein and Richard Thaler

Motivation - The Urgent Need to Increase Physical Activity Levels in America

- Obesity-related health issues such as diabetes and heart disease are prevalent in America and **negatively impact individuals, families, and society at large**
- Poor nutrition and low physical activity are contributing factors to these health issues
- **Over one third of American adults are obese and less than half meet weekly recommended levels of moderate- to vigorous-intensity physical activity**
- These issues carry financial burdens for agents such as employers and health insurance companies

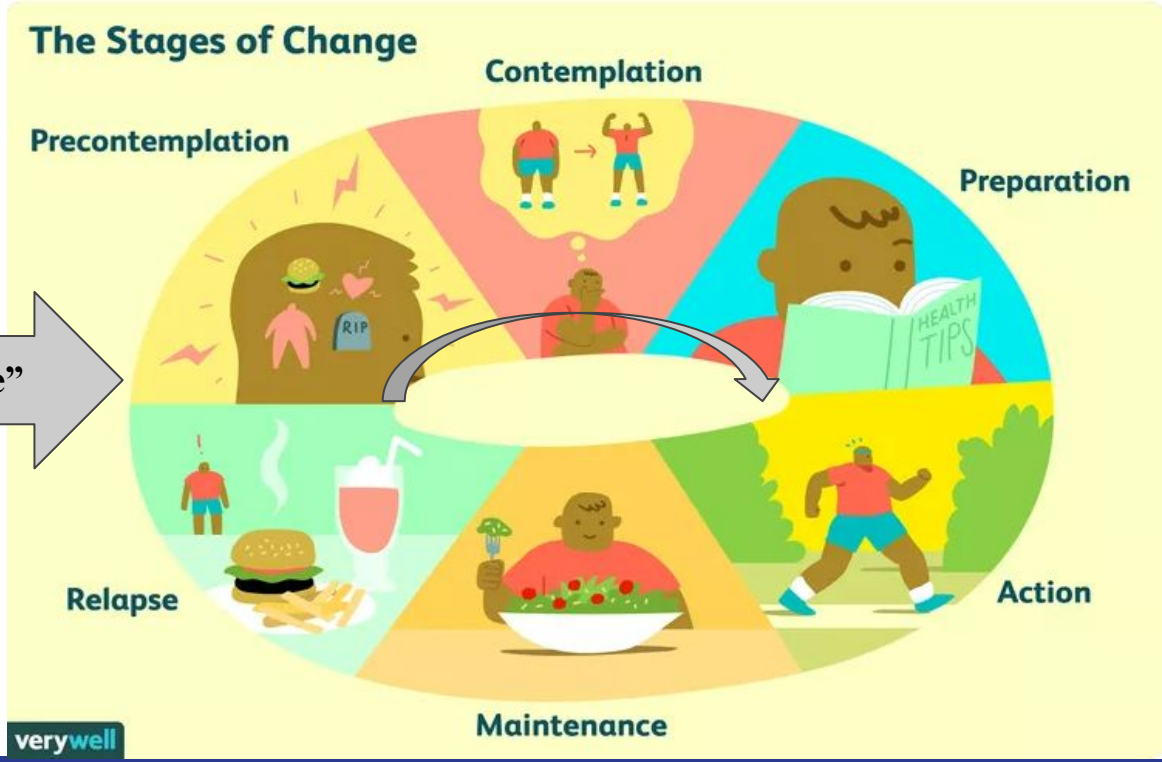
- Developing **low-cost interventions** to increase physical activity levels is a public health priority
- By increasing physical activity levels, we can combat obesity-related health issues and their negative impacts on individuals, families, and society at large
- This presentation will explore the **effectiveness of a low-cost intervention, using wearable devices and digital nudges, to increase physical activity levels.**



Conceptual Framework - Where the digital nudge fits into the Transtheoretical Model of Behavioral Change

Self-efficacy
Motivation
Outcome expectations

"Nudge"



Data Sources

- Wearables:
  - Passively record data such as heart rate and steps.
- Baseline/endline visits:
  - Vitals and medical characteristics are recorded.
- Survey:
  - Administered at three points throughout the study and measure factors such as eating, exercise, and sleeping habits.

Outcomes

1. Moderate to Vigorous Physical Activity (MVPA)
    a. Moderate: 64%-76% of one's maximum heart rate
    b. Vigorous: 77%-93% of one's maximum heart rate
    c. Recommended: 150 minutes a week
2. Resting heart rate
    a. Healthy range: 60-100 bpm
3. Steps
    a. Recommended benchmark: 10,000
4. BMI
    a. CDC healthy range: 18.5 - 24.9

Hypotheses

We hypothesize that compared to the control, the treatment group will have a:

a. Greater increase in the number of minutes spent engaging in MVPA per week compared to baseline.
b. Greater percentage of participants that migrated to the healthy heart rate range.
c. Greater increase in the number of daily steps compared to baseline.
d. Increased percentage of participant in the healthy BMI range compared to baseline.

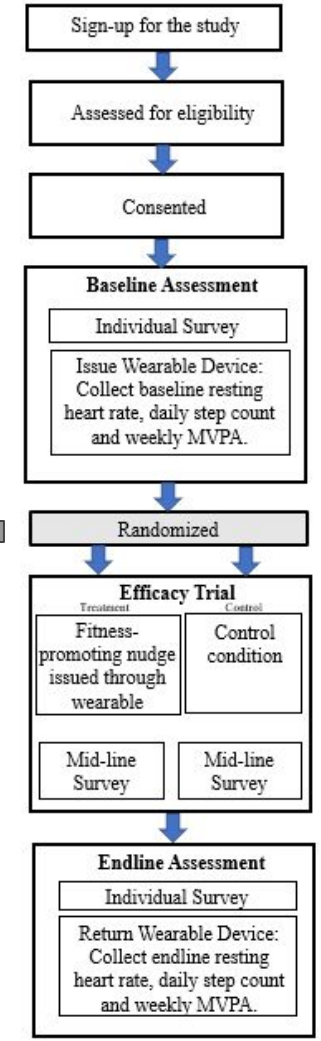
Sample

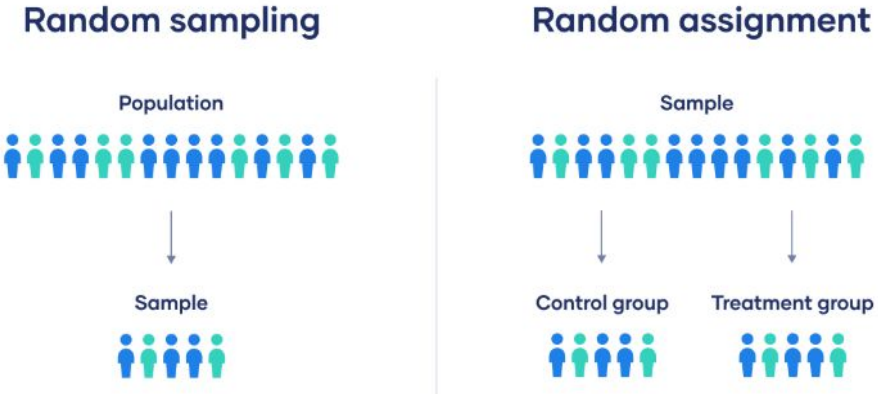
- The State University of New York (SUNY) and City University of New York (CUNY)
  - One rural, one suburban, and one urban campus in an effort to increase generalizability
- Compensation
- Sample size = 450

Stratified Sampling and Individual Level Randomization

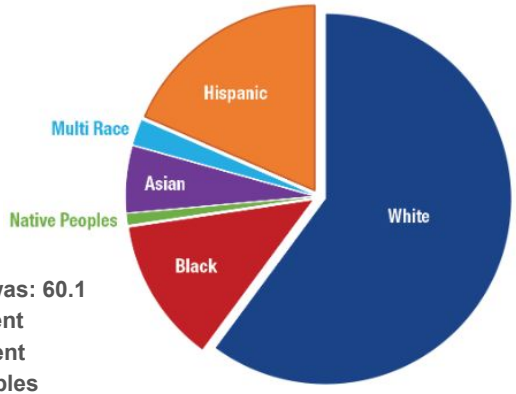
- ML nudge intervention will be randomized at the individual level
- 50% of the sample (around 225 individuals) will be assigned to pure control (no nudge)
- 50% of the sample (around 225 individuals) will receive the ML nudge
- n = 150 individuals per campus

Study Flow Chart:





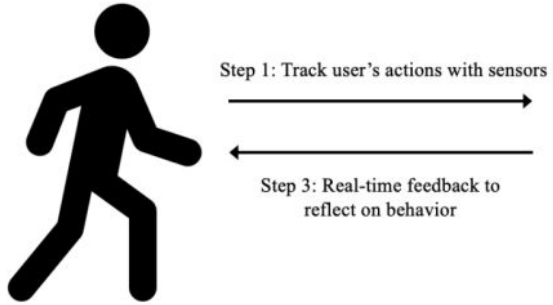
U.S. Census Bureau



*The latest Census Bureau estimates are that the population was: 60.1 percent non-Hispanic White; 18.5 percent Hispanic; 12.5 percent non-Hispanic Black; 5.8 percent non-Hispanic Asian; 2.2 percent non-Hispanic of two or more races; and .9 percent Native Peoples

Intervention

- Thompson sampling based algorithmic “nudge” protocol
- Participants will receive timed notifications encouraging them of their current daily activity level and encourage them to engage in exercise
- “Prompting Nudge”
- Nudge will never occur more than 4 times within a day



Thompson Sampling Model for Nudges

- Best use cases are multi-armed bandit problems - learning while influencing
- Commonly used algorithm for maximizing the opportunity of behavioral change while also allowing for some exploration
- Optimizes the nudge based on prior behavior but isn't "greedy" like decision tree models

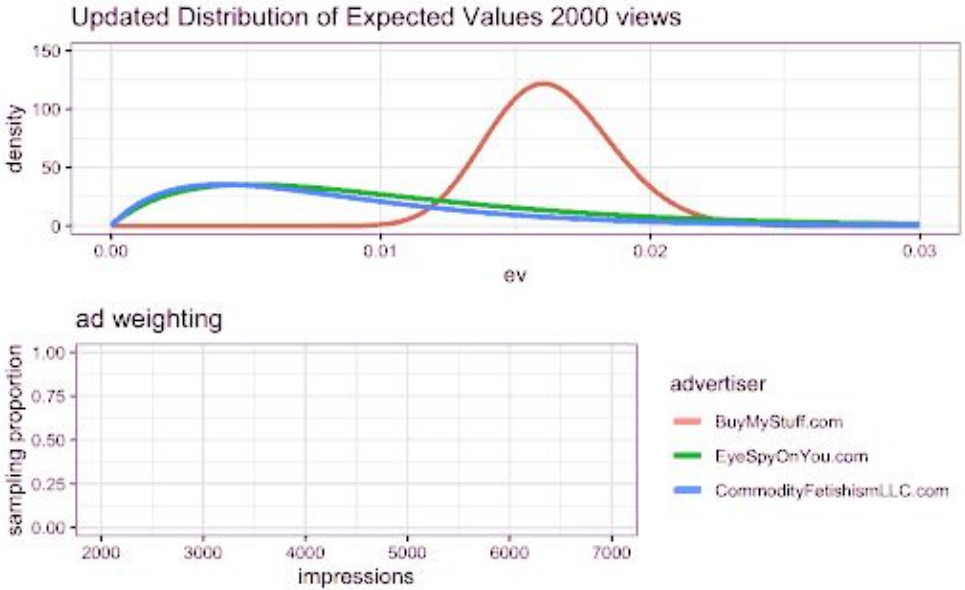
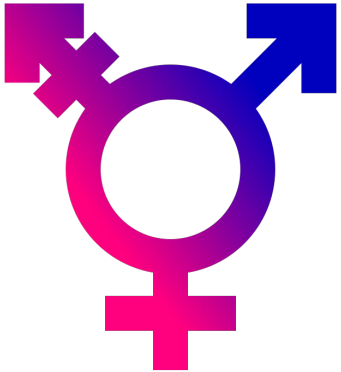


Image Source: Count Baysie (2020)

Controls & Treatment Effect Heterogeneity

- Controls:
  - Substance use
  - Prior health status
  - Gender
  - Race
  - Age
  - Prior use of wearable
- Treatment Heterogeneity
  - Weather
  - Relative free time
  - Gym/ fitness accessibility



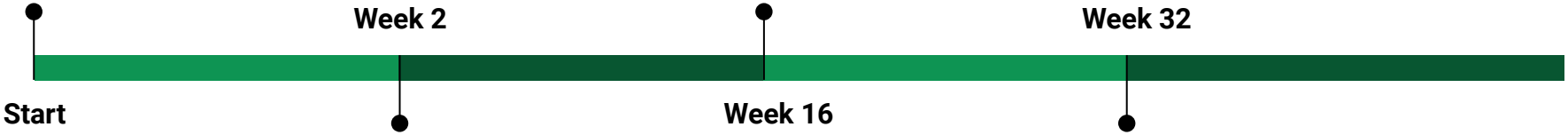
Timeline of Study

Intro and Survey

Eligible participants selected for the study will receive their wearables, receive a physical exam, have all required compliance documents submitted

Midpoint Evaluation

Midpoint surveys will be administered asking identical questions to the intro survey (free time, activity level estimates, etc.)



Intervention Start

After the wearable collects data on the activity of participants to inform initial treatment and identify discrepancies between the survey answers and activity levels, those in the test group will begin receiving nudges

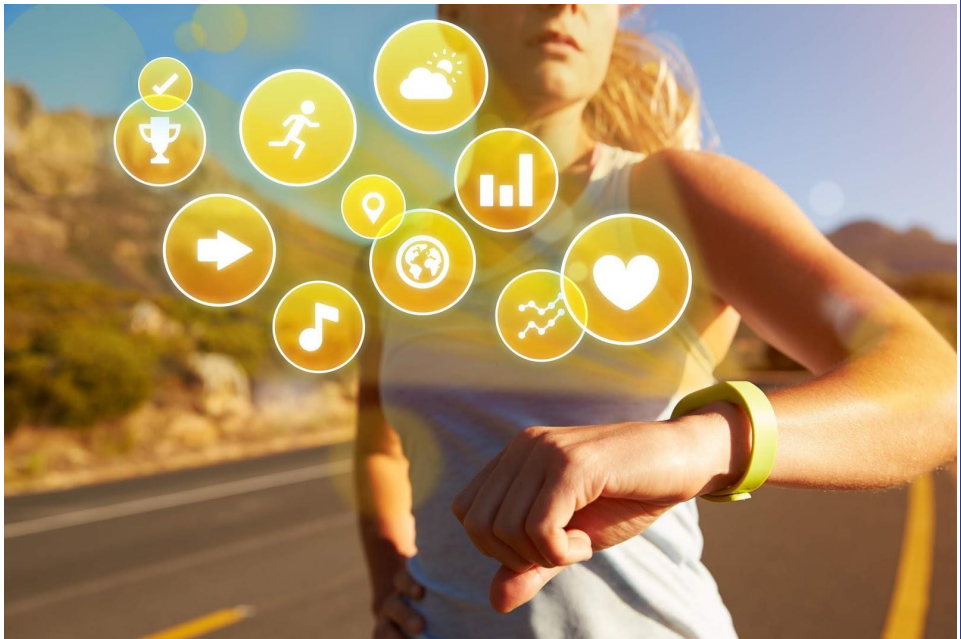
Conclusion

Exit surveys and a physical exam will be conducted, and compensation for compliant participants will be administered

Risks

- Minimal discomfort may come from the wearable
- Data & privacy risks
- Eating disorders (OCD)
- Body dysmorphia

Study Threats



- Attrition
  - Resale or damage of device
  - Competing device preferences
  - Non-standard use / non-compliance
- Self-selection bias

Conclusion

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Ben’s concept note feedback we need to address

Coming out of our discussions, this is a great improvement on the study design and I like it a lot. I think the measurement and estimation is very well built out and the heterogeneity approach is super interesting.

The biggest expansion you need to make is in **Intervention and Sampling.** If there are 64 campuses and you are recruiting 500 people, that is less than 10 per campus. If you have ONLY by-campus stratification, you have already basically run out of ability to stratify. (Also, where are all these people going for the site medical visits if there are just 10 participants at each site? You will need almost as many staff as participants...) Anyway -- I don't want you to worry enormously about this from a practicality perspective (ie, what happens if you have thousands of respondents who want what's basically a free $1000), but do take it seriously. What are the "key demographic characteristics"? What counts as "prior wearable experience"? Is "90% of waking hours" meaning, they can have it off for 10% of time, or they have to have it on 90% of time? How can you tell "waking hours"?

For **randomization,** you have three basic stages, which need to be a bit more explicit. First, you have overall inclusion in the study. **Let's just make it concrete. I**f you have, say, a thousand applicants at each campus, how many will you choose from each? Which ones? Exactly how many of each? Second, from there, how are you stratifying that into nudge/no-nudge? Is your 20% control really big enough (you will want to do power calculations depending on effect size, which I will introduce next week in class)? Third, if you want to use "Thompson Sampling ML" for targeting, I expect an explanation of what that means -- are you randomizing when people get nudges to some extent? Does this mean you are comparing within the nudge group on dimensions like frequency and alignment with existing habits?

Anyway -- this is really good and shows a super clear understanding of our discussion. **If you expand out the sampling and randomization elements -- effectively, building out an exact idea of your regression along the lines of the models I am discussing in my lectures for the class -- you will have a very successful project pitch. Great work!**