Wearable Devices and Smoking Cessation: What Have We Learned About Using Wearables in Behavior Change Research?

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The Methodology Center
advancing methods, improving health

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Much Promise for Health Behavior Change!

Obesity/Weight Management

(e.gHsu et al, 2014)

Eating disorders

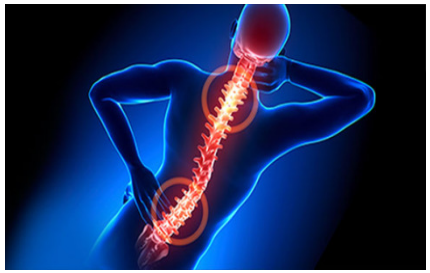
(e.g., Bauer et al. 2010)

Smoking cessation

(e.g., MD2K, 2017)

Physical activity

(e.g., Thomas & Bond, 2015)



Other chronic disorders

(e.g., Kristjánsdóttir et al., 2013)

Alcohol use disorders

(e.g., Gustafson et al., 2014)

Mental illnesses

(e.g., Ben-Zeev et al., 2013)

PI: S. Kumar

Most (93%) unaided smoking cessation attempts fail in 1st week

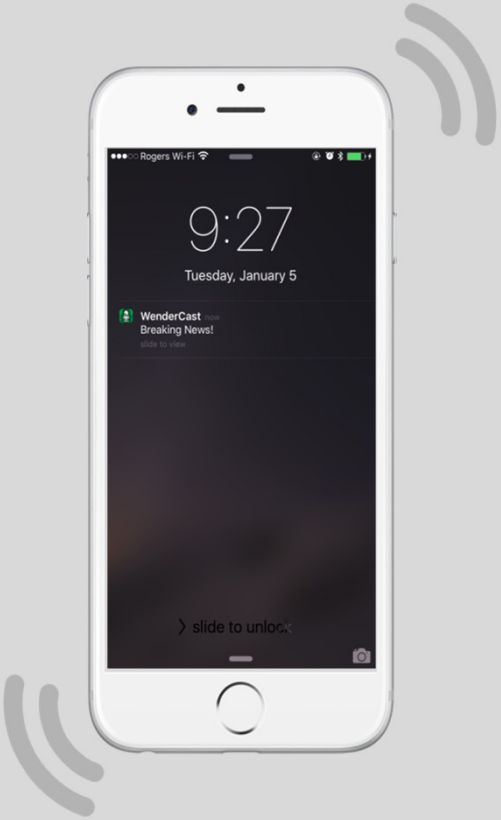
- 95% of **lapses** (slips, few puffs) followed by **relapses**
- Patients are encouraged to call when tempted to smoke. …but they rarely do

Stress predicts lapse/relapse=> increasing state of risk?

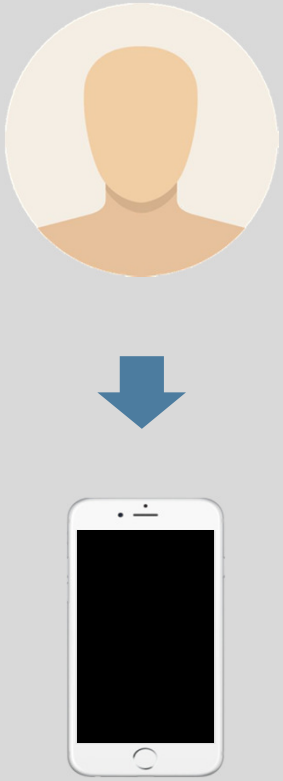
- Performing brief relaxation exercises can buffer/blunt real-life life stress
- ***But people fail to use them***
- Can we prevent smoking relapse by intervening on stress?
- Maybe we should provide reminders via a phone?

Mobile Intervention Types

PUSH



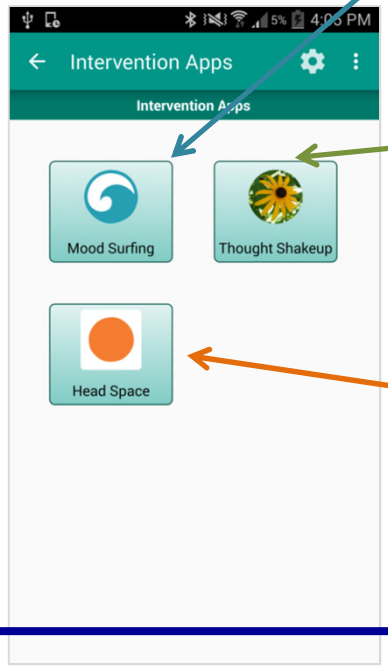
PULL



Intervention Push is a Reminder to Access Stress Management Apps:

Apps employ

- Evidence-based approaches to manage stress
- Take about 3-5 minutes for user to apply
- Feasible to implement in mobile setting
- Developed and refined based on input from experts and users



Mood Surfing:
- 3 exercises
- Grounded in ACT
- Target cognitive defusion
- Experts: K. Witkiewitz, I. Yovel.
- Literacy level editor: A. Applegate
- HCI: M. Sharmin; Programmer: M. Hossain

Thought Shakeup
- Grounded in CBT
- Target cognitive restructuring
- Expert: I. Yovel.
- Literacy level editor: A. Applegate
- HCI: M. Sharmin; Programmer: M. Hossain

Head Space
- Grounded in ACT
- Mediation / Mindfulness
- Consistently rated as one of the best 5 commercial mediation apps
- Permission for free use in the trial

Wearable Sensors & Algorithms

PI: S. Kumar

SENSE

Ertin, et. al., ACM SenSys'11

ECG, Respiration

Accelerometer Gyroscope

GPS

4M samples/day

5M samples/day

50K samples/day

ANALYZE

[Hovsepian, et. al., ACM UbiComp'15]

cStress

Activity

Location

9K /day

5K /day

4-5 /day

ACT

[Sarker, et. al., ACM CHI'16]

Time series pattern mining

Stress Episode Detection

1-2 Interventions/day

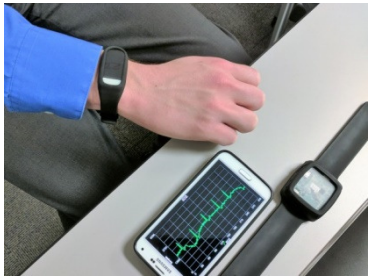
Intervention Trigger

- + High data rate streaming
- + Long battery life
- + High data yield
- + Real-time data quality screening

- + Personalized machine learning models
- + Biomarkers of health, behavior, and environment
- + Validated in both lab and field

- + Trend detection in noisy and rapidly varying time series
- + Robust to confounders and data losses
- + Trigger generation adaptive to current context (e.g., driving)

Sense^2 STOP



- Should the smartphone notify the user with a reminder to utilize app directed stress-management exercises when the user is stressed?

- We aim to improve the distal outcome:
  - Number of days smoke free after the smoker quits

- In the near term the reminder notification should reduce:
  - Probability of stress

Micro-Randomized Trial

- 10 day study beginning with user's quit date
- Randomize each minute of each user's day so that each user receives
  - an average of 1.5 reminders per day at minutes for which there is *sufficient* sensor evidence to classify the user's minute as stressed and
  - an average of 1.5 reminders per day at minutes for which there is *insufficient* sensor evidence to classify the user's minute as stressed

10 days

Pilot MRT for Stress Management in Newly Abstinent Smokers

Every minute of every day starting with quit date

For two hours after intervention is delivered

Measured via EMA and puffMarker over 10 days

Observations
- stress (via AutoSense sensor suite)
- motion (via accelerometer)
- smoking (via self report)

Available?

NO → No intervention

YES → Is stressed?

NO → R → Remainder of times → No intervention

R → Average 1.5x/day → Prompt use of stress-management exercises

YES → R → Average 1.5x/day → Prompt use of stress-management exercises

R → Remainder of times → No intervention

Proximal Outcome
Probability of stress episode

Distal Outcome
Relapse or smoking abstinence

Why Micro-Randomize?

- Randomization ensures that we can assess the causal, true, effect of the reminder.
- Address the question: Should the smartphone remind you to practice a stress-regulation exercise?
  - When you are stressed?
  - When you are not stressed?

What are we learning?

- Communication is *CRITICAL!*
  - Health Scientist requires a translation of the steps in the data algorithms ("machine learning algorithms/data analytics") into English
  - Health Scientist feeds back his/her understanding of the algorithm to Data Scientist
- The data algorithms are ***part*** of the clinical trial protocol.
- Data Scientist criterion for excellence is not always the same as the Health Scientist's criterion for excellence

Collaborators!