

JOOHEALTH

Just-in-Time Adaptive Interventions



Bari-Fit



HeartSteps

Susan A Murphy
Pedja Klasnja



The Methodology Center
advancing methods, improving health

Outline

- Motivating Examples
- What is a JITAI?
- Motivation
- Elements of a JITAI
- Example JITAI decision rules
- Questions to Ponder!



- Population: Chronic Smokers
- Stress predicts lapse/relapse → increasing state of risk
- Goal: help recently quit smokers regulate stress so they won't slip back to using smoking.

> 6 cigs per day.

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

- 95% of **lapses** (slips, few puffs) followed by **relapses**
- We encourage patients to call when tempted to smoke. ...but they rarely do

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

- Empirically supported treatments exist for stress.
- Good intervention target to prevent lapse/relapse?

But is stress a useful **tailoring variable**: basis for decision rule about **when** to trigger intervention?

Substance Abuse Research Assistant (SARA)

- Population: Youth who are engaged in problematic drinking or use of marijuana.
- Collect both self-report and sensor data to better understand near time potential determinants of use: perceptions of stress, loneliness, mood, hopefulness
- Goal: provide sufficient engagement and reinforcement so that participants continue to provide data.

Youth (age: 14-24, M=20.4, SD=2.1) recruited in the emergency department that reported past month marijuana use and/or binge drinking participated (N=55) in this 30-day study using the SARA app (Android/iOS). SARA uses a game-like aquarium environment to prompt completion of daily assessments (e.g., stress, hope) and weekly surveys (e.g., daily substance use).

Sensor data includes: location activity level

Low engagement

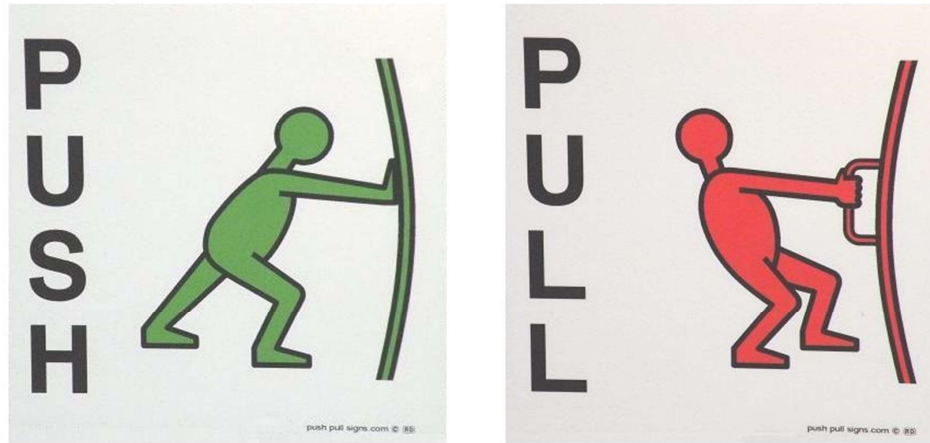
Flurry mobile. 2018. App Engagement: The Matrix Reloaded. (jun 2018).

<http://flurrymobile.tumblr.com/post/113379517625/>

945 app-engagement-the-matrix-reloaded

E Ray Dorsey, Michael V McConnell, Stanley Y Shaw, Andrew D Trister, Stephen H Friend, et al. 2017. The use of smartphones for health research. *Academic Medicine* 92, 2 (2017), 157–160.

Types of mHealth Intervention Components



As a reminder, we can think of mHealth as enabling two broad classes of interventions: push and pull.

Design Goal

Develop a mobile app intervention that includes the right combination of...

- pull components
- push components, *delivered at the right times in the appropriate context* to encourage positive behaviors/reduce risk throughout the day, as context changes

What is an Adaptive Intervention?

Adaptive Interventions are a type of treatment design

- This design aims to accommodate heterogeneity in response to treatment
- Intervention components are adapted to the unique and changing status of individuals

Adaptive interventions are by now a well-established framework that seeks to provide treatment in a way that addresses the unique and changing needs of patients. The idea is that the same treatment is not good for everyone, and different people need different things at different time point.

What is a Just-in-Time Adaptive Intervention (JITAI)?

- Adaptive intervention – includes adaptation
- Goal of the adaptation is to:
 - Provide the right type of support
 - At the right time
 - While minimizing waste & negative impact
- Timing is salient in support effectiveness
 - Timing is ‘event & context-based’
 - Time is short
- Conditions that define the ‘right time’ change rapidly, over short time-frames
 - ... a few days, hours, minutes, seconds

**Just in Time
Support**



Slide from Billie Nahum-Shani

A JITAI is an intervention design.

It is a special case of an adaptive intervention; it includes adaptation.

However, the goal of the adaptation is to explicitly provide the right type of support, at the right time, while minimizing waste.

This is in fact the definition of just in time support in education (teaching, interactive learning environment) and manufacturing (Toyota; Japan).

Here, the idea is that timing plays an important role in providing support.

Timing in this setting does not refer to clock-based time (e.g., at 2pm you need to remind a person to take medication); it refers to event-based time, namely what is the right time is defined by the events or conditions themselves; for example, when the student experiences difficulties, when the person experiences craving etc. Event-based time is unexpected, that is– we cannot fully/exactly predict when these event/conditions will occur.

Timing is typically salient when we don't have much time (when time is running out); we don't care so much about timing when we feel we have all the time in the world to do something.

Indeed the just in time approach in education and manufacturing is motivated by

settings in which the events/conditions that define the right time to intervene change rapidly, over short time frames; like when a student experiences difficulties when solving a math problems in the classroom and requires support before getting frustrated and abandoning the problem.

Timing can be event-based (at 2pm) or event-based (when craving occurs)– see Bluedorn (2002).

Time become salient when its constrained (Wessman & Gorman, 1977):

Wessman, A. E., & Gorman, B. S. (1977). The emergence of human awareness and concepts of time. In *The personal experience of time* (pp. 1-55). Springer US.

Bluedorn, Allen C. *The human organization of time: Temporal realities and experience*. Stanford University Press, 2002.

Ancona, D. G., Okhuysen, G. A., & Perlow, L. A. (2001). Taking time to integrate temporal research. *Academy of Management Review*, 26(4), 512-529.

In other words, we need to rely on mobile devices when the tailoring variables and intervention options have to be employed rapidly and ecologically.

Motivation for JITAIs

1. Individuals may need support when it is difficult or expensive to provide
2. Individuals are not always aware of when they need support
3. But interventions may have negative effects (burden, habituation)

Why JITAIs in Health Behavior Interventions?

- Need to address health-related events/contexts that
 - Change rapidly,
 - In the person's natural environment.
- While minimizing disruptions to the daily life and routine of the participant.

Just-in-Time Adaptive Intervention 5 Elements

The adaptation for each intervention component is guided by consideration of

(1) Near-time, Proximal Outcome and Distal Outcome

The adaptation process is composed of

(2) Tailoring Variables,

(3) Decision Rules and

(4) Intervention Options

The adaptation is triggered at

(5) Decision Points

11

Operationalizes an intervention with the goals on prior slide

Distal Outcomes

The goal is to improve a longer-term, distal, outcome

- Substance use cessation; maintain increased activity level; maintain lower weight; maintain adherence to meds; maintain engagement in data collection

To improve the distal outcome, the intervention options are formulated to target proximal outcomes

In SARA the distal outcome might be average self-report completion rate over study duration

In Sense2Stop the distal outcome might be time to relapse.

Proximal Outcomes

Mediators that may be critical to achieving the long-term goal

- 1) Short term targeted behavior
 - Substance use tomorrow
 - Self-report completion this evening
 - Adherence over next hour
- 2) Short term risk
 - Stress over next x hours
- 3) Engagement with mobile app/intervention burden

Likely multiple proximal outcomes

In MD2k study the proximal outcome might be stress over next x minutes.

Intervention options

- Intervention options:
 - Behavioral strategies, cognitive strategies, self-monitoring, social linkages, motivational messages, reinforcers, reminders
 - Whether to provide an intervention or whether to prompt self-monitoring
 - How to provide an intervention option
 - “Provide nothing” option
- Theoretically/scientifically driven (Klein et al., 2011; West & Michie, 2016)



Intervention options are typically designed to impact distal outcome via the proximal outcome.

In MD2K study the intervention option might be a recommendation to access one of the three stress-regulation apps (headspace; mood-surfing; and Thought Shakeup) residing on the smartphone vs. no recommendation.

Intervention options in JITAIs include types of support, sources of support (e.g., automated sources, social sources); and modes of support delivery.

Recommendations

Reach out recommendation (contact a friend)

Behavioral strategies (exercise; stay in locations that are supportive of change)

Cognitive strategies (relaxation; reframing)

Motivational messages (reasons for behavior change; barriers for change);

Setting goals; modifying goals

Feedback (often with visualization: fish; flower; garden)

Distractions (game, music, etc.)

Michel Klein et al. have a nice review of health behavior change theories used to inform EMIs

Klein, M., Mogles, N., & van Wissen, A. (2011). Why won't you do what's good for you? Using intelligent support for behavior change. In *Human Behavior Understanding* (pp. 104-115). Springer Berlin Heidelberg.

West, R., & Michie, S. (2016). *A Guide to Development and Evaluation of Digital Interventions in Healthcare*. London: Silverback

Tailoring variables

Tailoring variables are moderators that inform which intervention option is best when, where and for whom.

- Often past proximal outcomes: stress, adherence
- Risk, protective, receptivity factors: busyness of calendar, current mood or craving, location, social context, current use of phone
- Burden

© 15

In MD2K smoking study tailoring variables might be current classification of stressed or not and location (home, work), time of day (before work, during work, after work). Also weather.

indicate risk or vulnerability. --internal risk factors , external risk factors: behaviors, social context, geographical location,

When user ignores assessment requests or ignores intervention

Decision Points

Typical decision points in JITAIs:

- Intervals in time (every x seconds, every x minutes, every x hours)
- When user requests help (presses “help” button”)

Frequency is guided by the dynamics of the tailoring variables and “in-the-moment nature” of the intervention effect.

Recall that a decision point is the time in which we need to make critical decisions about the intervention options based on patient information.

decision points can result in the “do nothing intervention option,” hence a decision point every 3 minutes does not imply an intervention every 3 minutes.

Decision Rules

Link tailoring variables to intervention options at decision points

- A decision rule is implemented at each decision point
- A JITAI often includes multiple intervention components each with a different decision rule
- Development of decision rules is guided by an integration of empirical evidence, theory and clinical experience.

• 17

The decision rules are constructed with the aim to impact a proximal outcome.

We can use the data from the micro-randomized study along with behavioral science to construct decision rules.

SARA Decision Rule

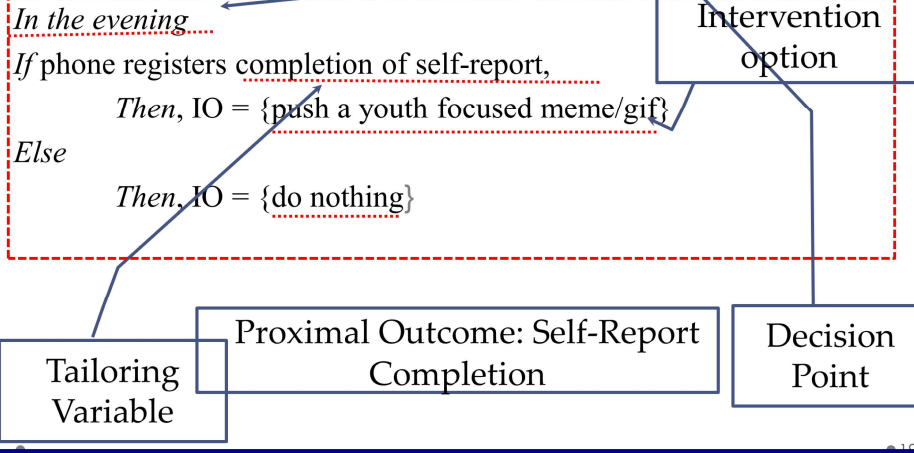
Example

- Phone monitors youth's completion of evening self-report
- Mobile device delivers a meme reinforcement *only* if youth completes the evening self-report.



SARA

Decision Rule Example



Sense2Stop

Decision Rule Example

- Wearable sensors monitor physiological stress, minute by minute
- Mobile device delivers suggestion to practice stress-regulation skills *only if* sensors indicate that the individual is currently physiologically stressed and the individual has not recently received a suggestion.

Sense2Stop

Decision Rule Example

Every minute

IF > 1 hour since last intervention prompt

Then,

If passively sensed stress = Yes,

Then IO= prompt stress-regulation

Else if passively sensed stress = No,

Then IO= 'do nothing'

ELSE IF < 1 hour since last intervention prompt

Then IO= 'do nothing'

Summary of JITAI elements

1. Outcomes

- Distal (scientific/clinical goal) & Proximal Outcome (guided by mediational theories pinpointing the necessary processes needed to achieve the distal outcome)

2. Intervention options

- Guided by the proximal outcomes

3. Tailoring variables

- Guided by theory concerning moderation.

4. Decision points

- Guided by the dynamics of the tailoring variable and in-the-moment nature of the effect of the intervention option.

5. Decision rules

© 22

Questions to Ponder!

- What personal and/or contextual conditions represent risk or opportunities with respect to the proximal outcomes.
- How rapidly these conditions are likely to change?
- What intervention options could address or capitalize on these conditions; hence affect the proximal outcomes?
- What personal and/or contextual conditions represent a risk that intervention provision be wasteful/disruptive/burdensome?

Open scientific questions

What personal and/or contextual conditions represent risk or opportunities with respect to the proximal outcomes.

Questions?

Your Turn!

1. Specify Population
2. Select one of three areas
 1. Recovery Support to Prevent Relapse
 2. Engagement in Data Collection
 3. Adjuvant Treatment to In-Person Care
3. Specify 2-3 different proximal outcomes you'd like to target
4. Specify 2-3 intervention options that target these proximal outcomes (think about the mechanism by which the intervention option should work)

After Pedja discusses the HeartSteps JITAI you will get the opportunity to revise!

Sleep

Stress

Health eating

Activity

Avoiding risky locations