

Just-In-Time Adaptive Interventions

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Challenge for health behavior change, in general, are limited access and limited amount of time for delivering intervention services. Require individual to apply what they have learned in the office to their real life, often at risky times, in risky situations.

91% of US adults have a mobile phone; 64% have a smartphone. Both African Americans and English-speaking Latinos are as likely as Whites to own any sort of mobile phone, and are more likely to use their phones for a wider range of activities

Outline

- Review of Adaptive Interventions
- Mobile Health →
Just In Time Adaptive Interventions
(JITAIs)

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Goal of this talk is to identify the components of a jitai so that behavioral/intervention scientists can play a dominate role in their development and so that we can identify exactly what we are testing so as to enhance replicabililty.

Review of Adaptive Interventions

- Intervention design that takes advantage of response heterogeneity
- Intervention options are individualized to the specific and changing needs of individuals
- **Example:** Adaptive drug court program for drug abusing offenders

Marlowe et al., 2008; 2009; 2012

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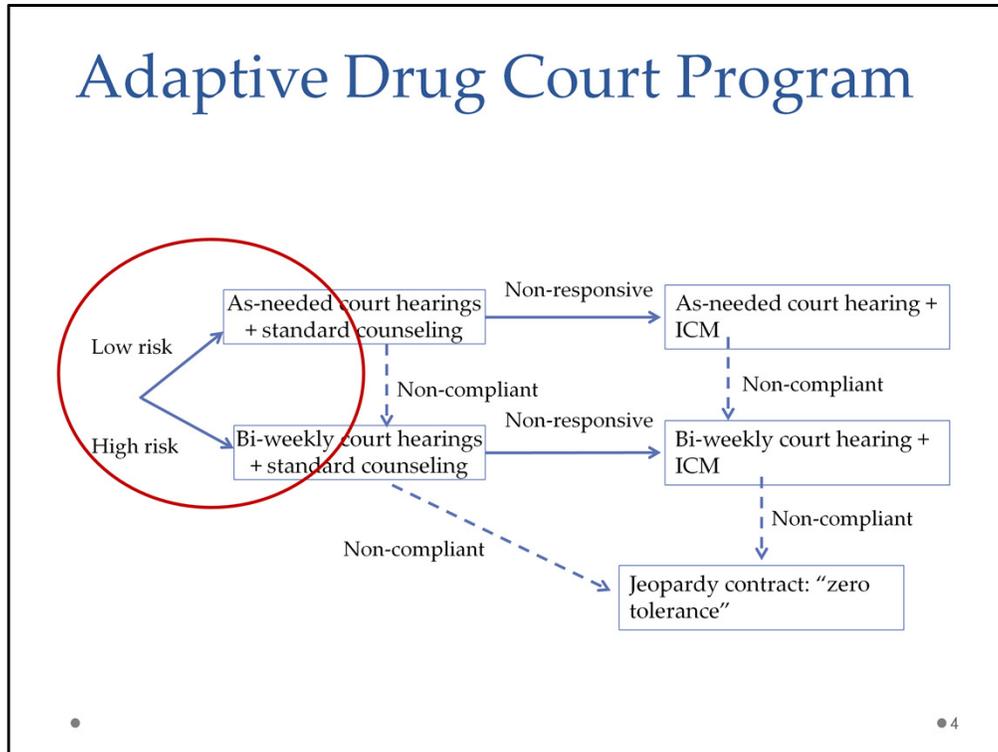
The idea is that the same treatment is not good for everyone, and different people need different things at different time point.

Adaptive Interventions in Drug Court: A Pilot Experiment. *Criminal Justice Review* 2008; 33; 343 Douglas B. Marlowe, David S. Festinger, Patricia L. Arabia, Karen L. Dugosh, Kathleen M. Benasutti, Jason R. Croft and James R. McKay

Adaptive interventions may optimize outcomes in drug courts: a pilot study. Marlowe DB, Festinger DS, Arabia PL, Dugosh KL, Benasutti KM, Croft JR. *Curr Psychiatry Rep.* 2009 Oct;11(5):370-6.

Adaptive Programming Improves Outcomes in Drug Court : An Experimental Trial *Criminal Justice and Behavior* 2012 39: 514 Douglas B. Marlowe, David S. Festinger, Karen L. Dugosh, Kathleen M. Benasutti, Gloria Fox and Jason R. Croft

Adaptive Drug Court Program



Douglas B. Marlowe: developed and implemented an adaptive intervention for drug offenders

Following their initial court hearing, risk was assessed.

High risk: ASPD (Antisocial Personality Disorder, based on Diagnostic Interview: APD-DI) or history of formal drug abuse treatment otherwise low risk.

These are assessed monthly:

Noncompliance: is (1) falls below threshold for attendance in counseling sessions or (2) fails to provide 2 or more scheduled urine specimens

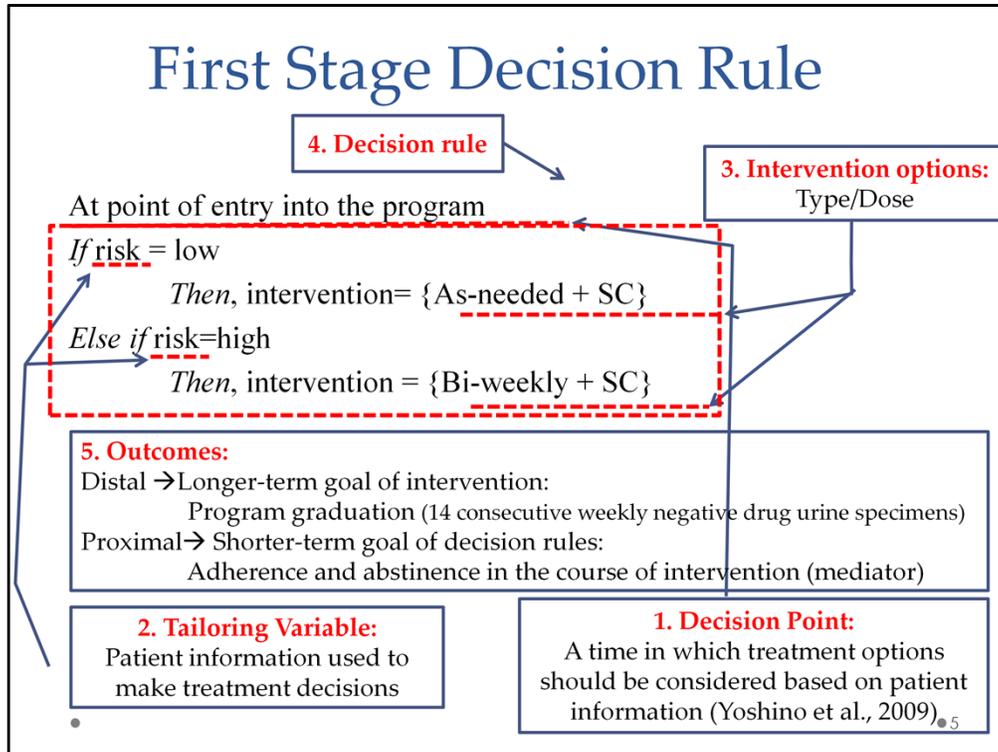
Nonresponsive = (1) is attending sessions and completing program requirements, and (2) is not committing new infractions, but (3) provides 2 or more drug-positive urine specimens.

If non compliance, contact with the judge is increased.

ICM– intensive clinical case management: Participants are required to meet twice weekly with an intensive clinical case manager who provides individual substance abuse counseling with an emphasis on motivational enhancement, relapse prevention, and cognitive restructuring (“criminal thinking”) techniques.

Jeopardy contract: involves “zero tolerance” for further violations of the rules of the program. Any further violation leads to a termination hearing, also known as a show-cause hearing. At the termination hearing, the individual is terminated from the program and sentenced on the original charge or charges unless he or she can provide a good reason to be given another chance. The decision of whether or not to grant another chance is within the discretion of the judge

To graduate offender must attend 12 counseling sessions; provide 14 consecutive weekly negative drug urine specimens; remain arrest-free; obey program rules and procedures; pay 200 dollar court fee.



This is one of the decision rules that operationalize that first stage of the drug court program.

In general decision rules specify how patient information is linked to intervention options.

Decision rules incorporate three elements:

- (1) A decision point – a critical time point in which intervention options should be considered based on patient information – in other words, it is a critical point in time in which you believe (theoretically or practically) that something needs to be done. In the drug court program this was at the point of entry into the program (i.e., following the initial court hearing).
- (2) A tailoring variable – patient information based on which you make the decision
- (3) Intervention options: typically this would be the type or dose of the intervention. But, intervention options can also be the timing of obtaining assessments. For example, if you are at low risk, I will give you more time until I classify you as a non-responder; whereas if you are at high risk I will classify you sooner.

Another element that is not part of the decision rule, but it is guiding the decision

rule– the outcome of interest.

This decision rule, and the other decision rule that operationalize this adaptive interventions, were designed with an outcome in mind. This outcome is typically a long-term outcome, and in this case it is program graduation.

To graduate offender must attend 12 counseling sessions; provide 14 consecutive weekly negative drug urine specimens; remain arrest-free; obey program rules and procedures; pay 200 dollar court fee

Yoshino et al., 2009: Decision points: The critical **decision points are defined** in the course of treatment, at which time the therapeutic response is to be assessed. On the basis of this assessment, specific treatment revisions are recommended according to the preset if–then rules

Yoshino, A., Sawamura, T., Kobayashi, N., Kurauchi, S., Matsumoto, A., & Nomura, S. (2009). Algorithm-guided treatment versus treatment as usual for major depression. *Psychiatry and clinical neurosciences*, 63(5), 652-657.

Adaptive Intervention: 5 Elements

The adaptation is guided by consideration of

(1) Proximal and Distal Outcomes

The adaptation process is composed of

(2) Tailoring Variables,

(3) Decision Rules and

(4) Intervention Options

The adaptation is triggered at

(5) Decision Points

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Monitoring, individualizing, delivering

JITAI: Just In Time Adaptive Interventions

- A JITAI is an adaptive intervention
- That is
 - Delivered via mobile devices
 - When needed
 - Where-ever needed



(Heron & Smyth, 2010; Kaplan & Stone, 2013; Riley et al., 2011)

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The same elements that we used to describe an adaptive intervention can be used to describe JITAIs, only that now all these elements are momentary.

Kaplan, R. M., & Stone, A. A. (2013). Bringing the Laboratory and Clinic to the Community: Mobile Technologies for Health Promotion and Disease Prevention. *Annual review of psychology, 64*, 471-498.

Riley, W. T., Rivera, D. E., Atienza, A. A., Nilsen, W., Allison, S. M., & Mermelstein, R. (2011). *Health behavior models in the age of mobile interventions: are our theories up to the task?* : Springer.

Different terms have been used in various fields to describe a JITAI, including dynamic tailoring, intelligent real-time therapy, and dynamically and individually tailored EMI

Examples:

Intervention to reduce heavy drinking and smoking by young adults

- Participants prompted 3/day by mobile device for assessments
 - Smoking urge, affect, drinking behaviors
- Urge-management interventions delivered by the mobile device *only* if an individual reports an urge to smoke at an assessment.



(Witkiewitz et al., in press)

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Complete assessments such as smoking urge, drinking and affective state

Witkiewitz, K., Desai, S. A., Bowen, S., Leigh, B. C., Kirouac, M., & Larimer, M. E. (in press). Development and evaluation of a mobile intervention for heavy drinking and smoking among college students. *Psychology of Addictive Behaviors*.

Examples:

Reducing Sedentary Behavior by Office Workers

- Software on the computer measures uninterrupted computer time via mouse and keyboard activity
- Smartphone delivers message to encourage a walking activity *only* if 30 min. of uninterrupted computer activity occurs



(Dantzig et al., 2013)

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Quote from paper: whenever 30 min of nearly uninterrupted computer activity was recorded, a short text message (SMS) containing a hyperlink was sent to the participant's smart phone. When participants clicked on this hyperlink, they were shown a message persuading them to be more active. Although all messages contained the same general advice, this advice was phrased in various ways, using four different persuasive strategies. The four strategies are a subset of the six social influence strategies defined by Cialdini [22].

Dantzig, S., Geleijnse, G., & Halteren, A. T. (2013). Toward a persuasive mobile application to reduce sedentary behavior. *Personal and ubiquitous computing, 17(6)*, 1237-1246.

Commonalities?

- The interventions are adaptive
- Technology plays a critical role
 - Information can be obtained when/where needed
 - Interventions can be delivered when/where needed

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The same elements that compose an adaptive intervention, also compose a JITAI. However, in a JITAI these elements are momentary – they can occur at any moment.

Just in Time Adaptive Intervention 5 Elements

The adaptation is guided by consideration of

(1) Proximal and Distal Outcomes

Momentary



The adaptation process is composed of

(2) Tailoring Variables,

(3) Decision Rules and

(4) Intervention Options

The adaptation is triggered at

(5) Decision Points

Real-Time



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Monitoring, individualizing, delivering

Distal Outcomes in JITAI

Our goal is to improve a long-term, distal, outcome

- Reduce substance use; substance use cessation; increase activity level

To improve the distal outcome, the decision rules are formulated to target proximal outcomes

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In a typical adaptive intervention that is not a JITAI (e.g., the drug court program) the outcome is long-term – program graduation at the end of study. This outcome guided the investigators when constructing the decision rule. JITAIs are also guided by a long-term outcome, because the overall purpose is to make some long-term distal impact (e.g., smoking cessation; relapse prevention; promoting a healthier lifestyle etc.). However, the decision rules in a JITAI are also guided by a momentary outcome.

This is because the aim of JITAIs is to generate some immediate impact (otherwise why would you intervene in real-time). The idea is that in real-time the participants needs something, and by providing an intervention, these momentary needs will be met.

This outcome can occur at any time, and is more proximal than the primary long-term outcome

The decision rules are constructed with the aim to manipulate a more proximal/short term.

The term momentary outcome was used by Schwartz & Stone (2007).

Schwartz, J. E., & Stone, A. A. (2007). The analysis of real-time momentary data: A practical guide. *The science of real-time data capture: Self-reports in health research*, 76-113.

Proximal Outcomes in JITAI

Mediators that are critical to achieving the long-term goal

- 1) Short term targeted behavior
 - Substance use over x hours
 - Activity over x minutes
- 2) Short term experiences of risk or protective mechanisms
 - Momentary urge/craving
- 3) Engagement in intervention

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Response-based mediators: Proximal measures of distal outcome

Performance-based mediators-- momentary behavioral, biological, cognitive, or emotional processes, that are critical to address in order to achieve the distal outcome

Engagement-based mediators: concern the type and extent of engagement/adherence needed for participants to attend to, fully take advantage of and benefit from the intervention, burden

Recall that the outcome of interest, is the outcome that guides you when constructing the decision rules.

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Intervention options in JITAI

- Intervention options:
 - Recommendations, self-monitoring prompts
 - Support health behavior change, self-management, sense of control
 - When/where to provide recommendations or initiate self-monitoring prompts
 - How to provide recommendation
 - “Do nothing” option
- Theoretically/scientifically driven (Klein et al., 2011)



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Intervention options in JITAIs include types of support (e.g., instrumental, emotional), sources of support (e.g., automated sources, social sources); and modes of support delivery (e.g., support provision and/or support availability).

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 all the 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.

Kennedy et al., (2012) conceptualize the EMIs as active assistance.

Kennedy, C. M., Powell, J., Payne, T. H., Ainsworth, J., Boyd, A., & Buchan, I. (2012). Active assistance technology for health-related behavior change: an interdisciplinary review. *Journal of Medical Internet Research*, 14(3).

Tailoring variables in JITAI

Moderators of the effect of the intervention option on the proximal outcomes.

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

- Often proximal outcomes: urge
- Risk and protective factors: momentary mood, momentary stress, location, social context
- Adherence & burden (recent intervention dose and user indications of burden)

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indicate risk or vulnerability. --internal risk factors , external risk factors: behaviors, social context, geographical location,
When user ignores assessment requests or ignores intervention

the JITAI is often designed to affect the distal outcome by influencing three types of pathways, corresponding to response-based proximal outcomes, performance-based proximal outcomes and engagement-based proximal outcomes. In many cases, intervention scientists might be interested in influencing the distal outcome by building a JITAI that targets all three pathways. In this case, different tailoring variables might be considered for each pathway. For example, assume that an intervention scientist is interested in developing a JITAI that will reduce smoking (i.e., the distal outcome) by (a) reducing momentary smoking urge, and momentary stress, which are two different performance-based pathways, (b) by reducing the number of cigarettes smoked per day, which is a response-based pathway; and by (c) enhancing engagement in the recommended interventions, which is an engagement-based pathway. In this case, different information from the participant

(i.e., tailoring variables) might be needed in order to make decisions that will affect each proximal outcome.

For example, to reduce stress a stress-management intervention might be recommended depending on the participant's momentary level of stress (tailoring variable #1), and to reduce smoking-urge, an urge-management intervention might be recommended depending on the participant's momentary level of smoking urge (tailoring variable #2). Additionally, to reduce the number of cigarettes smoked per day, an encouraging message might be offered at the end of each day depending on the number of cigarettes smoked during that day (tailoring variable #3). Finally, to enhance engagement in the recommended interventions (by minimizing burden), the frequency of intervention options delivered per day might be reduced depending on the number of intervention options the participant received in the prior day (tailoring variable #4). Overall, a JITAI might include multiple tailoring variables and their selection should be guided by the various proximal outcomes the JITAI is intended to achieve.

Decision Points in JITAI

Typical decision points in JITAIs

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

Choice is guided by the dynamics of the tailoring variables and the momentary effect of the intervention options on proximal outcomes

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The decision points in a JITAI are also momentary.

Recall that a decision point is the time in which we need to consider intervention options based on what we know about the patient.

In other words, it's the time in which we need to make critical decisions about the intervention options based on patient information.

the selection should be guided by what is known about the extent to which the tailoring variables are expected to change systematically over time, and whether and how change in proximal outcome can be influenced by the intervention options. If the tailoring variable is likely to change in a meaningful manner every (e.g., location), and the intervention options are thought to impact the proximal outcome in 1-2 minutes (e.g., send a warning to the participant), then there should be a decision point every minute. Recall that 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 in JITAI

Link patient information to intervention options
at decision points

- A decision rule is implemented at each decision point
- A JITAI often includes many different decision rules
- Choice is guided by an integration of empirical evidence, theory and prior clinical, prevention experience.

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for every decision point, the investigator should be able to articulate the proximal outcomes and the distal outcome that is reasonable to expect if an individual with a specific value of the tailoring variable receives each of the intervention options under consideration. This has to be expressed for all values of the tailoring variable, and for each one of the proximal outcomes. This is necessary in order to identify the most effective intervention option, for a given value of the tailoring variable, in order to maximally impact the proximal outcome.

Decision Rules: Example 1

What to do when composite risk assessment at random prompt indicates risk

At self-report assessment

If composite substance abuse risk $\geq R_0$
Then, IO = {reminder to access intervention}
Else if composite substance abuse risk $< R_0$
Then, IO = {do nothing}

Intervention options

Decision Point

Tailoring Variable

Proximal outcome: craving/stress

Distal: long term substance abuse abstinence

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Decision Rules: Example 2

What to do when composite risk assessment indicate risk + user does not access intervention

At M minutes following a self-report assessment:

If composite risk $\geq R_0$

and intervention access in past M minutes= NO

Then, IO = {message encouraging intervention use}

Else if risk $< R_0$ or intervention access in past M minutes= YES

Then, IO= {do nothing}

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Specifies what to do when a composite measure indicates that the patient is at risk but he/she would not access EMI or request help after a certain amount of time

Decision Rules: Example 3

At 5 second intervals

If current accumulated computer activity $> P_0$

Then, IO = {recommend movement}

Else if current accumulated computer activity $\leq P_0$

Then, IO = {do nothing}

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Consideration of JITAI elements

1. Outcomes

- Distal (scientific clinical goal) & Proximal (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 tailoring variable and momentary effect of intervention option on the proximal outcome

5. Decision rules

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Methodology Center Technical Report 14-126;

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