On Different Kinds of Adaptive Interventions:

And experimental designs to optimize them

Inbal Billie Nahum-Shani

Collaborators and Funding

John Dziak · UIC
Maureen Walton · UM
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U01 CA229437 · NIH, NCI

All examples are based on R01 AA026574 · PI: Walton.

Examples are modified for illustrative purposes.

The Gap

Any sufficiently advanced technology is equivalent to magic.

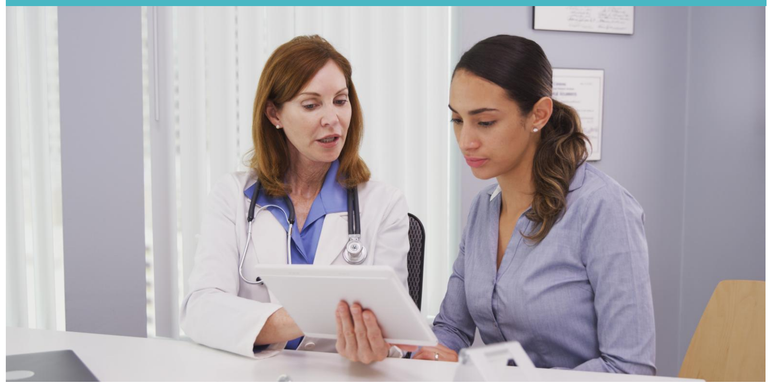
Arthur C. Clarke

The Gap

How to deliver support in real-time ?

How to adapt and personalize ?

How to integrate human support ?



Overview

Components	Time Scale for Adaptation	Intervention Framework	Experimental Design
Human-delivered	*Slow*	Adaptive Interventions	**SMART**
Digital	*Fast*	Just-in-Time Adaptive Interventions	**MRT**
Human-delivered & Digital	*Multiple Time Scales*	Multimodal Adaptive Interventions	**HED**

What tools do we have?

Components	Time Scale for Adaptation	Intervention Framework	Experimental Design
Human-delivered	*Slow*	Adaptive Interventions	**SMART**
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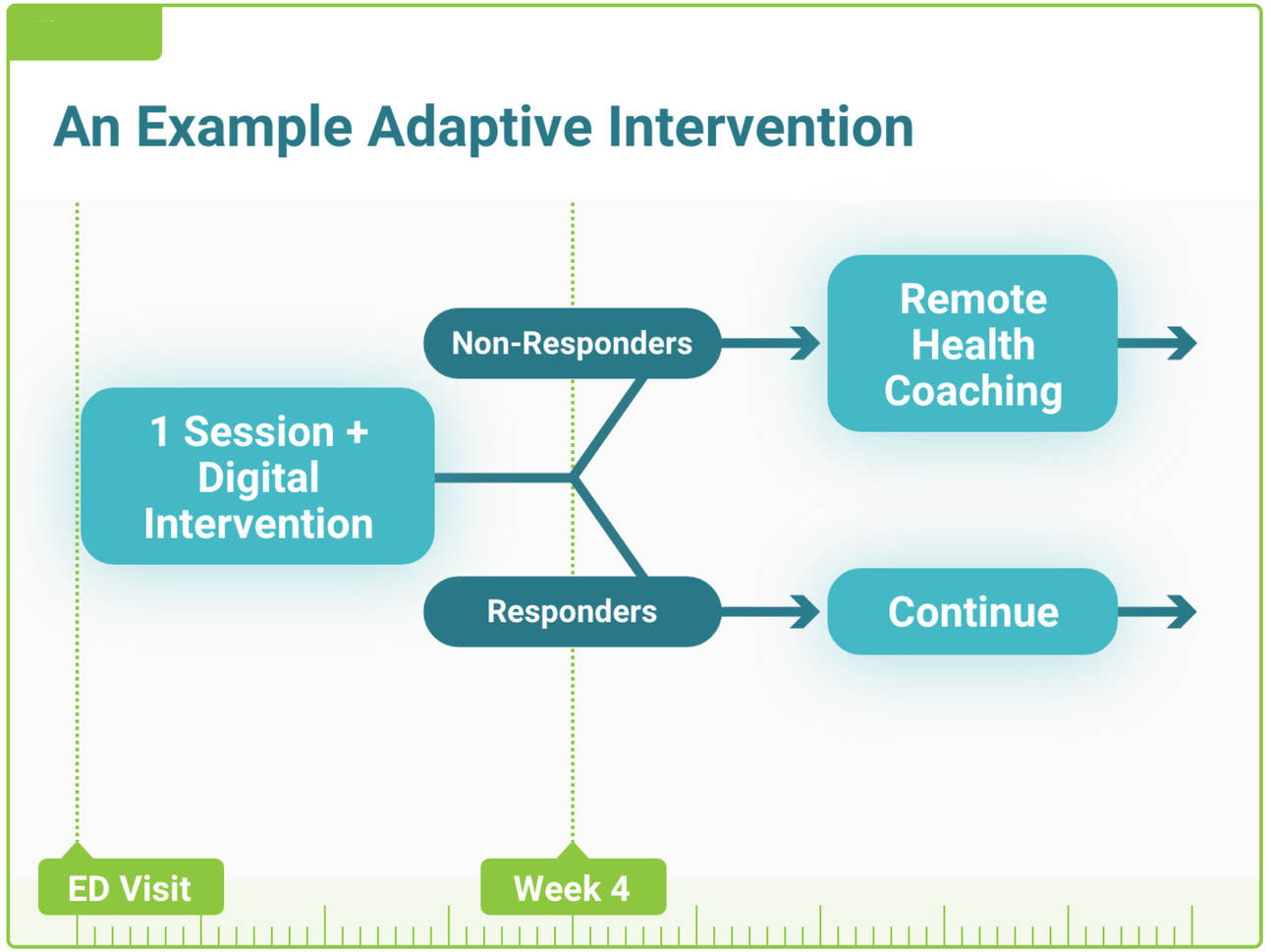
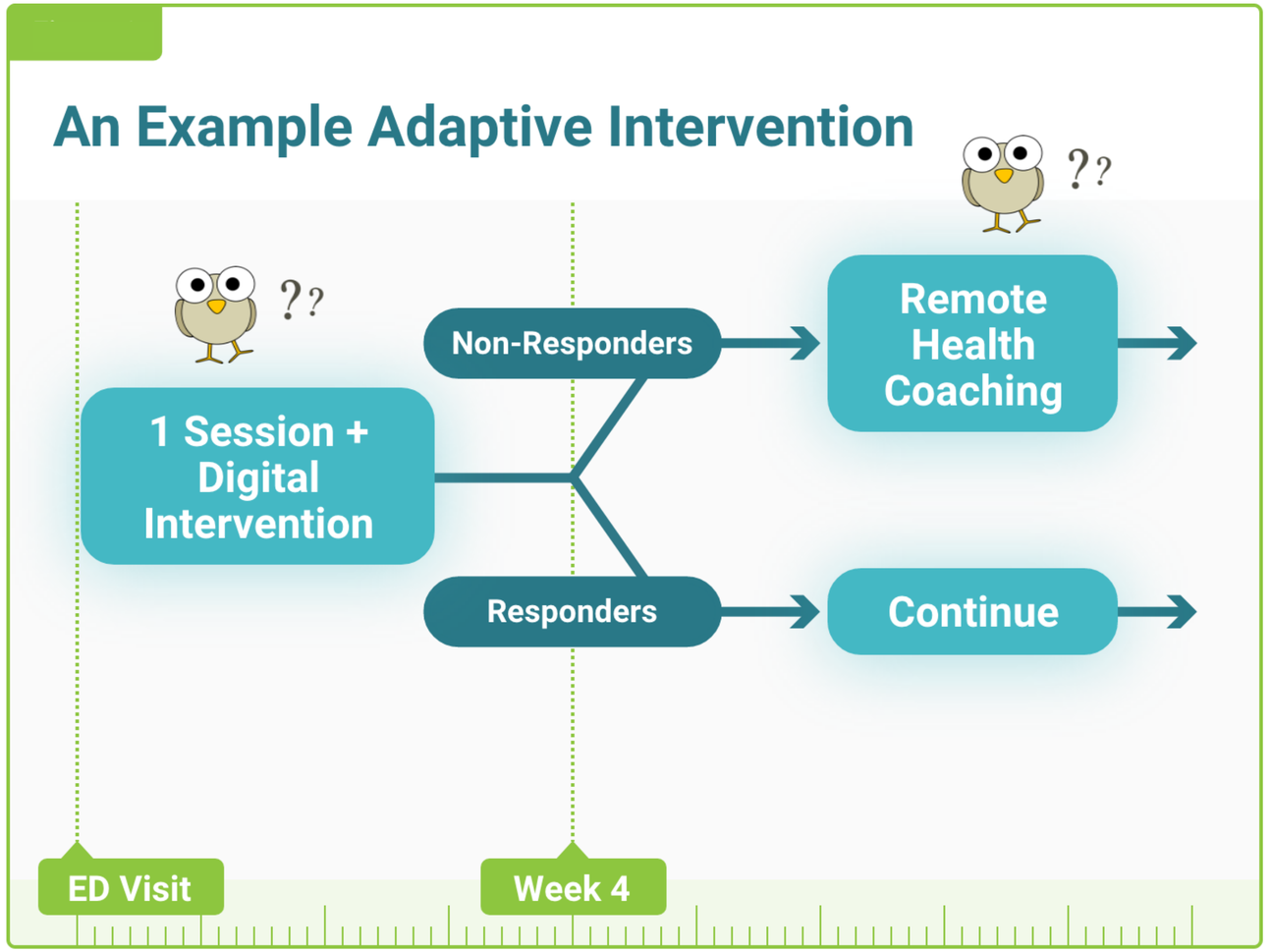
Adaptive Interventions

- Intervention delivery framework
- Use ongoing information about the person to decide whether and how to intervene
- Address conditions that change relatively slowly
- Guide the adaptation of human-delivered components



Adaptive Interventions

- At ED visit—is it beneficial to start with or without RHC?
- At Week 4—is it beneficial to step up the intensity or continue for non-responders?



Beneficial = reducing number of substance use days by week 16

Sequential Multiple Assignment Randomized Trial (SMART)

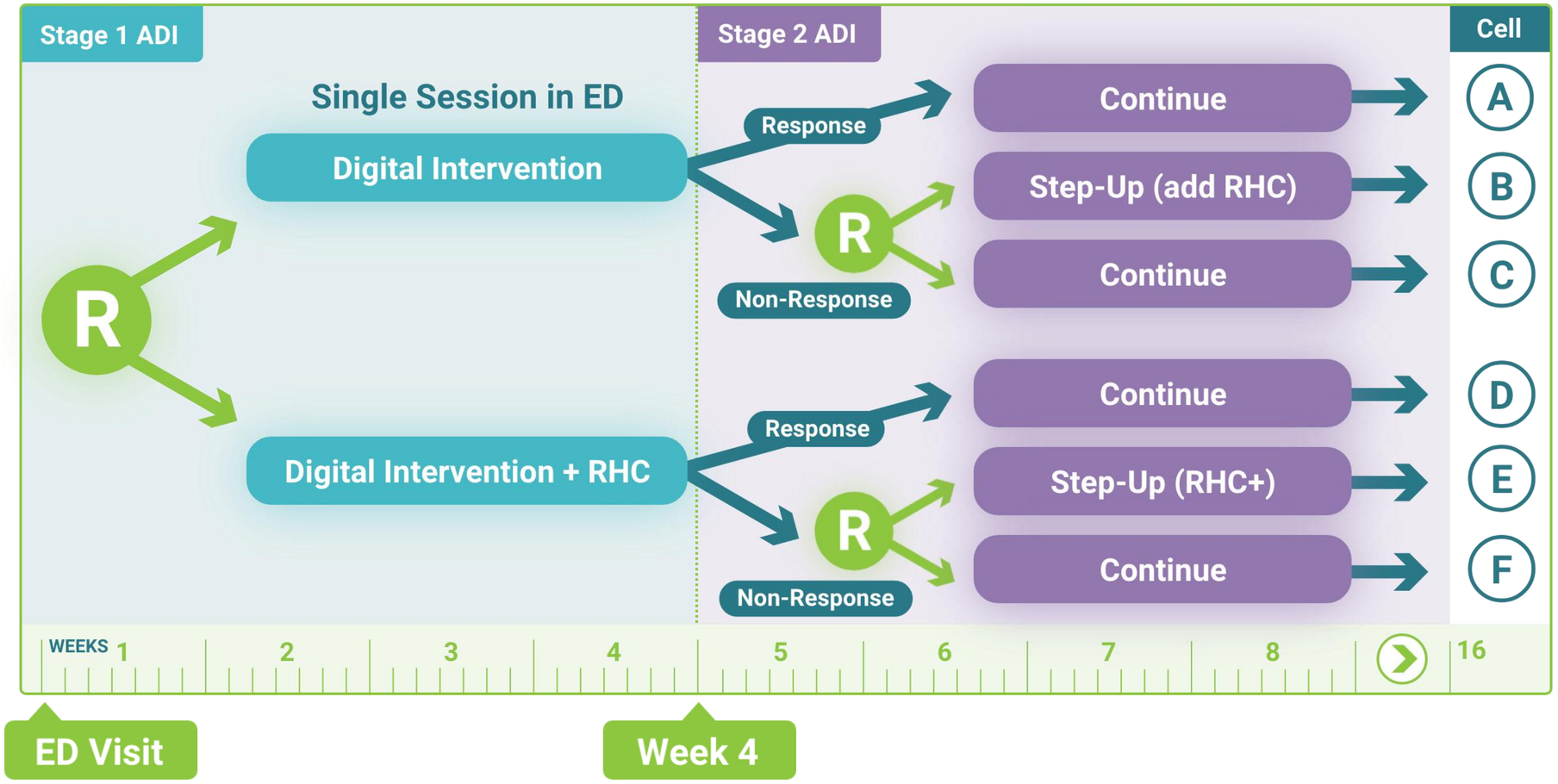
- **Randomized Trial**
  - Multiple stages of randomization
  - Each stage corresponds to a point in time
  - —at which we have scientific questions about the selection and adaptation of components

Lavori PW, Dawson R. A design for testing clinical strategies: biased adaptive within-subject randomization. Journal of the Royal Statistical Society: Series A (Statistics in Society). 2000;163(1):29-38.

Murphy SA. An experimental design for the development of adaptive treatment strategies. Statistics in Medicine. 2005;24(10):1455-1481.

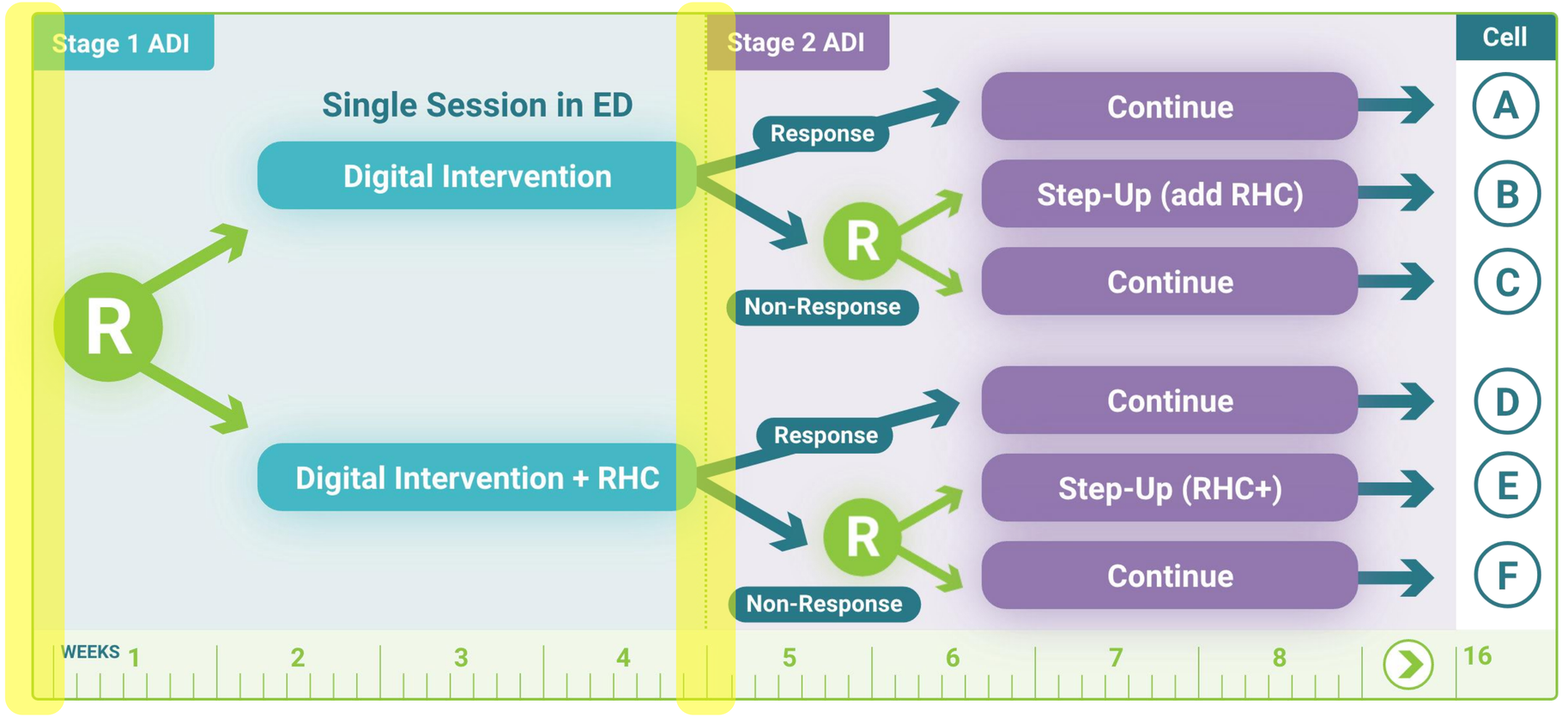
The SMART

- At ED visit—is it beneficial to start with or without RHC?
- At Week 4—is it beneficial to step up the intensity or continue for non-responders?



The SMART

- Time scale for randomization: slow
- Questions: sequencing and adaptation at slow time scales



The SMART

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Experimental Design and Primary Data Analysis Methods for Comparing Adaptive Interventions

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In recent years, research in the area of intervention development has been shifting from the traditional fixed-intervention approach to *adaptive interventions*, which allow greater individualization and adaptation of intervention options (i.e., intervention type and/or dosage) over time. Adaptive interventions are operationalized via a sequence of decision rules that specify how intervention options should be adapted to an individual's characteristics and changing needs, with the general aim to optimize the long-term effectiveness of the intervention. Here, we review adaptive interventions, discussing the potential contribution of this concept to research in the behavioral and social sciences. We then propose the sequential multiple assignment randomized trial (SMART), an experimental design useful for addressing research questions that inform the construction of high-quality adaptive interventions. To clarify the SMART approach and its advantages, we compare SMART with other experimental approaches. We also provide methods for analyzing data from SMART to address primary research questions that inform the construction of a high-quality adaptive intervention.

Keywords: adaptive interventions, experimental design, sequential multiple assignment randomized trial (SMART)

Case Studies Using SMARTs

SMARTs

Adaptive Approach to Naltrexone Treatment for Alcoholism

Naltrexone (NTX) is an opioid receptor antagonist used to prevent alcoholism relapse. This trial examines how to define "non-response" to treatment with NTX and what treatments are most effective for those who do or do not respond to the initial treatment.

SMARTs

Adaptive Intervention for Adolescent Marijuana Use

Researchers in this study are developing an adaptive treatment for adolescent marijuana users. They are studying the use and combination of several efficacious treatments, including behavioral therapy, contingency management, behavioral parent training, and working memory training via a SMART trial.

SMARTs

Adaptive Intervention for Suicide Prevention Among College Students

Researchers in this study are developing an adaptive treatment to address suicidality in college students seeking services at college counseling centers. They are developing the first empirically validated approach to sequence treatments for students seeking services.

SMARTs

Adaptive Intervention Strategies in Conduct Problem Prevention: Pilot Study

This study compares two types of interventions for youth (ages 10-15) with conduct disorders. Participants received either a teen-focused or parent-focused intervention. The appropriate intensity of the interventions was also studied.

SMARTs

Adaptive Interventions for Children with ADHD

What tools do we have?

Components	Time Scale for Adaptation	Intervention Framework	Experimental Design
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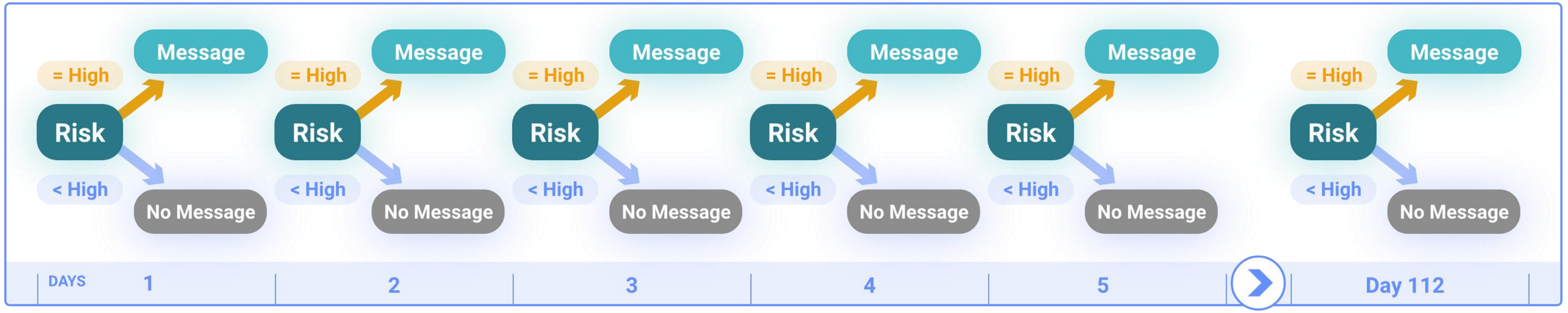
Human-delivered & Digital	*Multiple Time Scales*	Multimodal Adaptive Interventions	**HED**

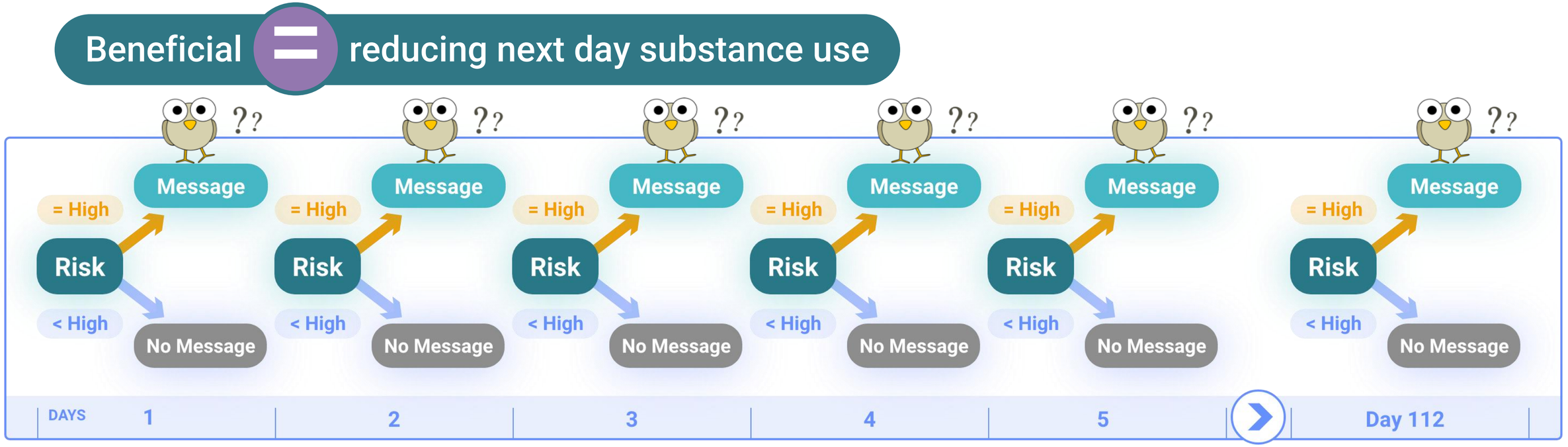
Just-in-Time Adaptive Interventions (JITAI)

- Use ongoing information about the person to decide whether and how to intervene
- Address conditions that change relatively rapidly
- Guide the adaptation of digital interventions



Just-in-Time Adaptive Interventions (JITAI)

- On average, is it beneficial to deliver (vs. not deliver) a message?
- Under what conditions would delivering a message be beneficial?



Micro-Randomized Trial

(MRT)

- **Randomized Trial**
  - Sequential randomizations: each participant randomized between intervention options at each decision point
  - Each person may be randomized 100s or 1000s of times, multiple times per day

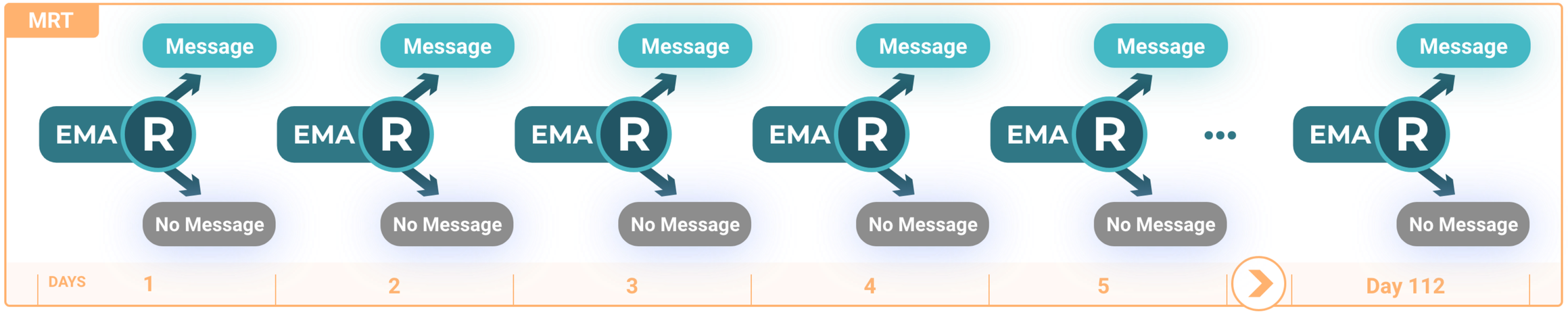
Liao P, Klasnja P, Tewari A, Murphy SA. Sample size calculations for micro-randomized trials in mHealth. Statistics in Medicine. 2016;35(12):1944–1971.

Qian T, Walton AE, Collins LM, ... , Murphy SA. The Micro-Randomized Trial for Developing Digital Interventions: Experimental Design and Data Analysis Considerations. Psychological Methods.

Micro-Randomized Trial

(MRT)

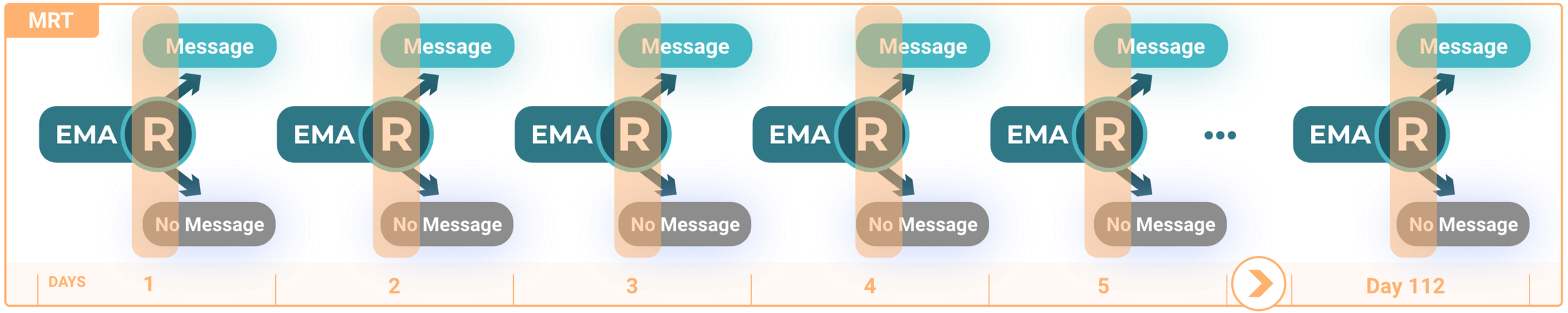
- Is it beneficial to deliver a message in terms of reducing next-day substance use?
- Under what conditions would delivering a message be beneficial?



Micro-Randomized Trial

(MRT)

- Time scale for randomization: fast
- Questions: sequencing and adaptation at fast time scales



Micro-Randomized Trial (MRT)

AMERICAN PSYCHOLOGICAL ASSOCIATION

Psychological Methods

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The Microrandomized Trial for Developing Digital Interventions: Experimental Design and Data Analysis Considerations

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[6] Edna Bennett Pierce Prevention Research Center, Pennsylvania State University
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[13] Computer Science at the Harvard School of Engineering

Abstract

Just-in-time adaptive interventions (JITAIs) are time-varying adaptive interventions that use frequent opportunities for the intervention to be adapted—weekly, daily, or even many times a day. The microrandomized trial (MRT) has emerged for use in informing the construction of JITAIs. MRTs can be used to address research questions about whether and under what circumstances JITAI components are effective, with the ultimate objective of developing effective and efficient JITAI. The purpose of this article is to clarify why, when, and how to use MRTs; to highlight elements that must be considered when designing and implementing an MRT; and to review primary and secondary analyses methods for MRTs. We briefly review key elements of JITAIs and discuss a variety of considerations that go into planning and designing an MRT. We provide a definition of causal excursion effects suitable for use in primary and secondary analyses of MRT data to inform JITAI development. We review the weighted and centered least-squares (WCLS) estimator which provides consistent causal excursion effect estimators from MRT data. We describe how the WCLS

Case Studies Using MRTs

Home / Experimental Designs / Case Studies / MRTs

MRTs

BariFit MRT

Researchers are conducting this quality-improvement MRT aiming to promote weight maintenance through increased activity and improved diet among people who received bariatric surgery. At the time it was developed, this project was novel in that it implemented separate randomizations at the start of the study, on a daily basis, and five times throughout the day.

MRTs

Heartsteps

This project tests the feasibility and effectiveness of providing, via a smartphone, just-in-time tailored physical activity suggestions as well as evening prompts to plan the following day's physical activity so as to help sedentary individuals increase their activity. The resulting data will be used to inform the development of a JITAI for increasing physical activity.

MRTs

MRT to Improve EMA Engagement in Oral Chemotherapy Adherence for Adolescents and Young Adults

This study seeks to examine the time-varying, contextual factors that influence daily oral chemotherapy adherence in adolescents and young adults with leukemia.

MRTs

MRT to Improve Oral Chemotherapy Adherence for Adolescents and Young Adults

This study employs an MRT to test different strategies for promoting adherence to oral chemotherapy in adolescents and young adults with leukemia. It delivers individually-tailored content, including messages targeting disease self-management and preferred app engagement strategies.

What tools do we have?

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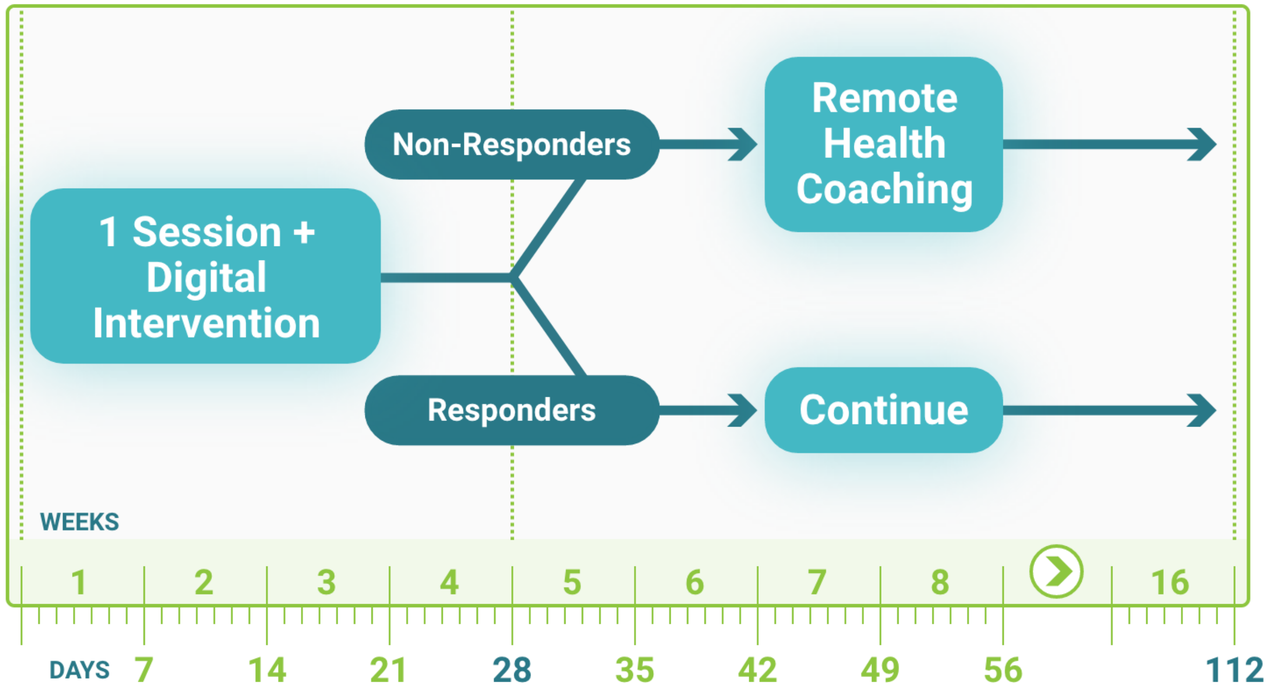
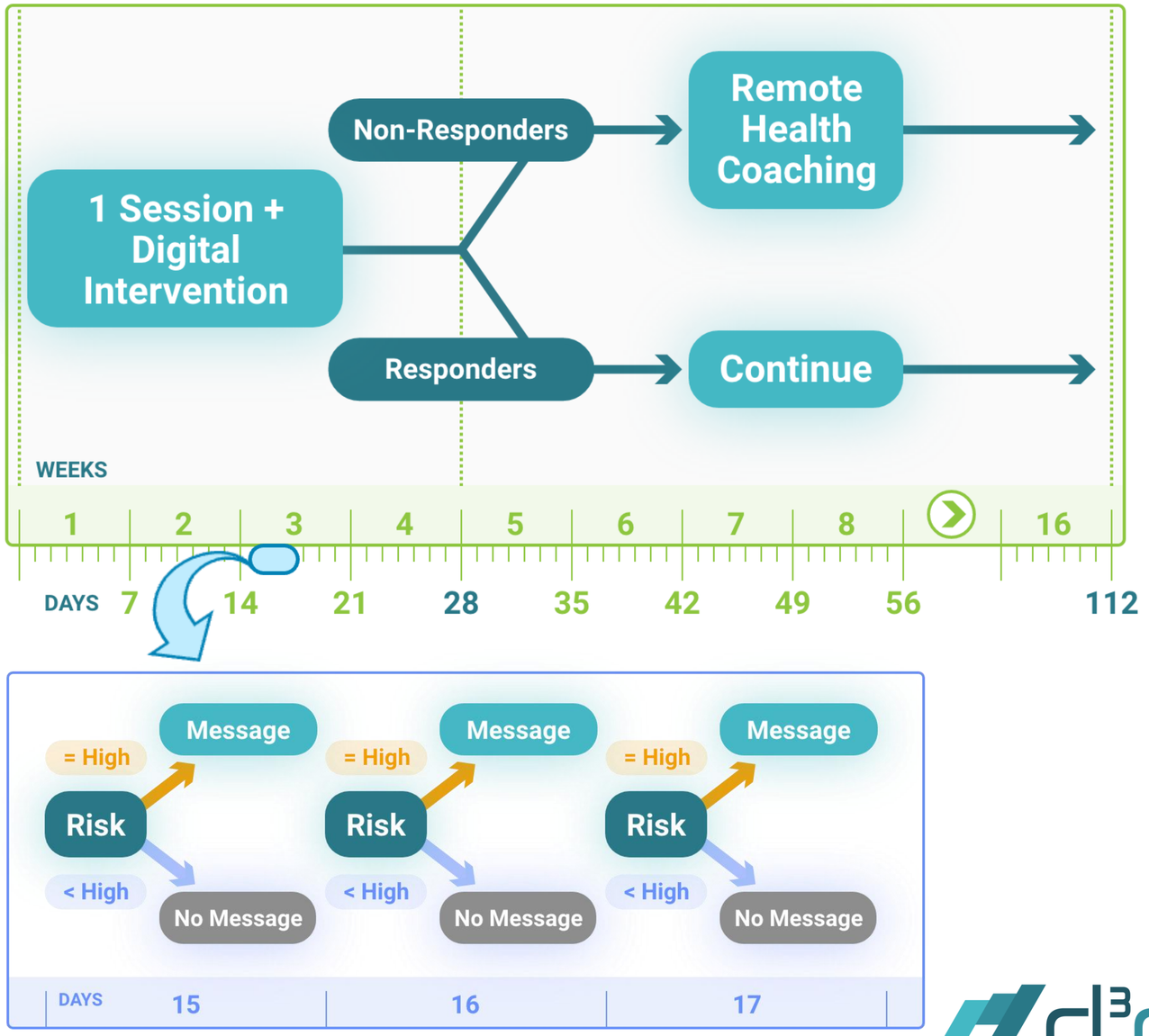
Multimodal Adaptive Intervention

(MADI)



Multimodal Adaptive Intervention

(MADI)



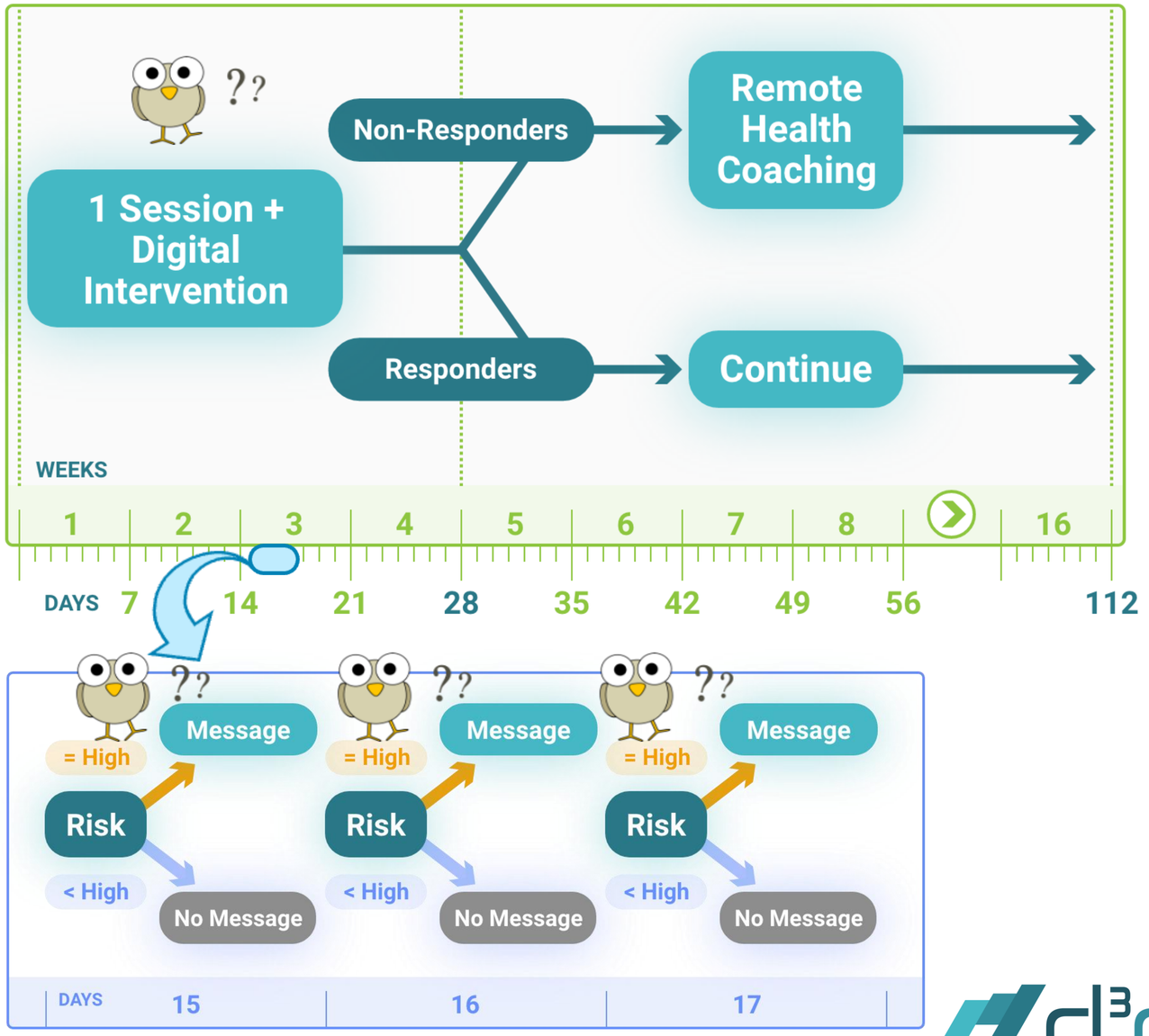
Multimodal Adaptive Intervention

(MADI)

- Intervention delivery framework
- Both human-delivered and digital components are sequenced and adapted over time, at different time scales
- Can be operationalized as the integration between an adaptive intervention and a JITAI

Multimodal Adaptive Intervention

(MADI)



Hybrid Experimental Design

(HED)

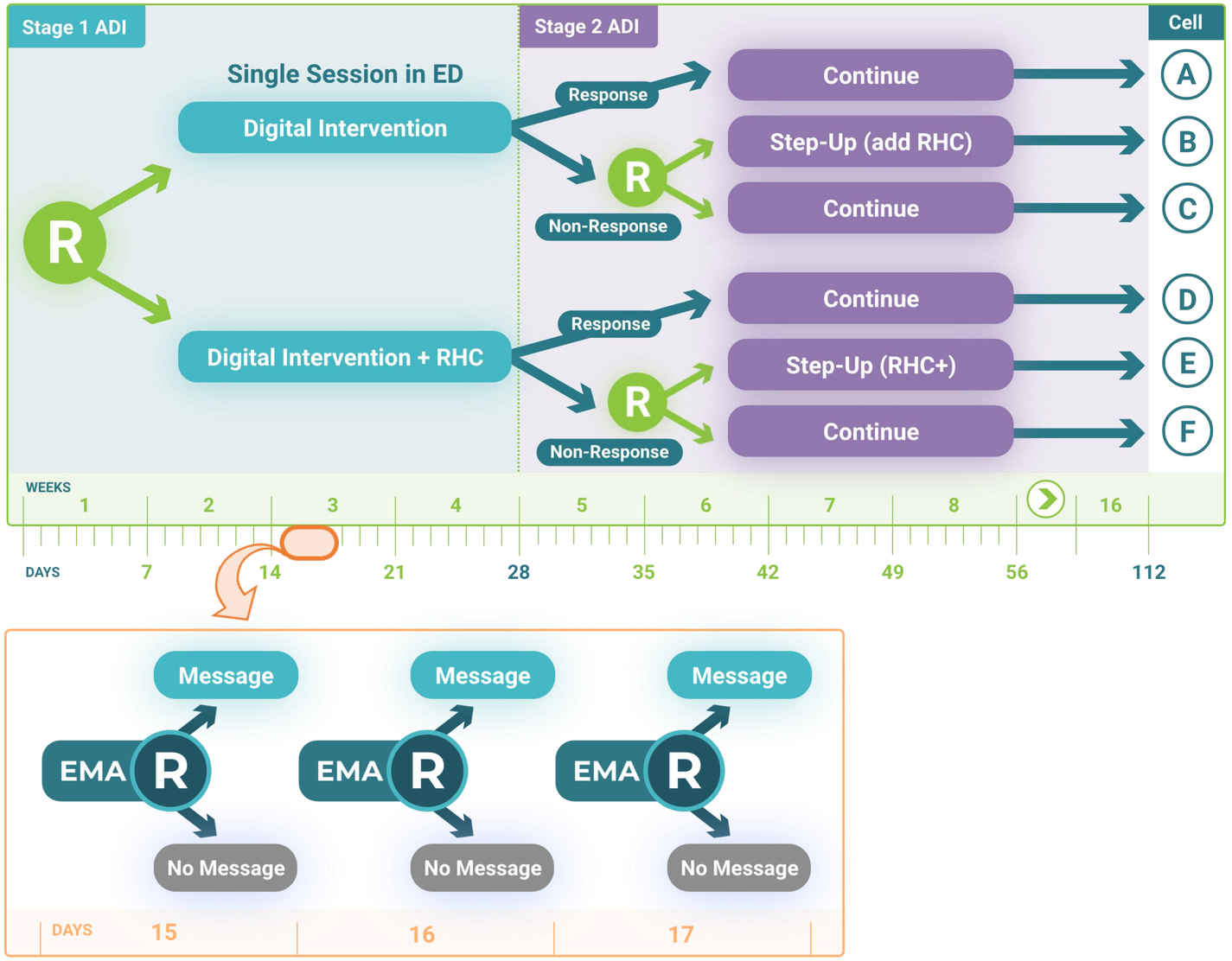
- **Randomized Trial**
  - **Sequential randomizations**
  - **On multiple time scales**

Nahum-Shani, I., Dziak, J. J., Walton, M. A., & Dempsey, W. (2022). Hybrid Experimental Designs for Intervention Development: What, Why and How. Advances in Methods and Practices in Psychological Science, 5(3), 1–15.

Nahum-Shani, I., Dziak, J. J., Venera, H., Pfammatter, A. F., Spring, B., & Dempsey, W. (2023). Design of experiments with sequential randomizations on multiple timescales: the hybrid experimental design. Behavior Research Methods, 1-23.

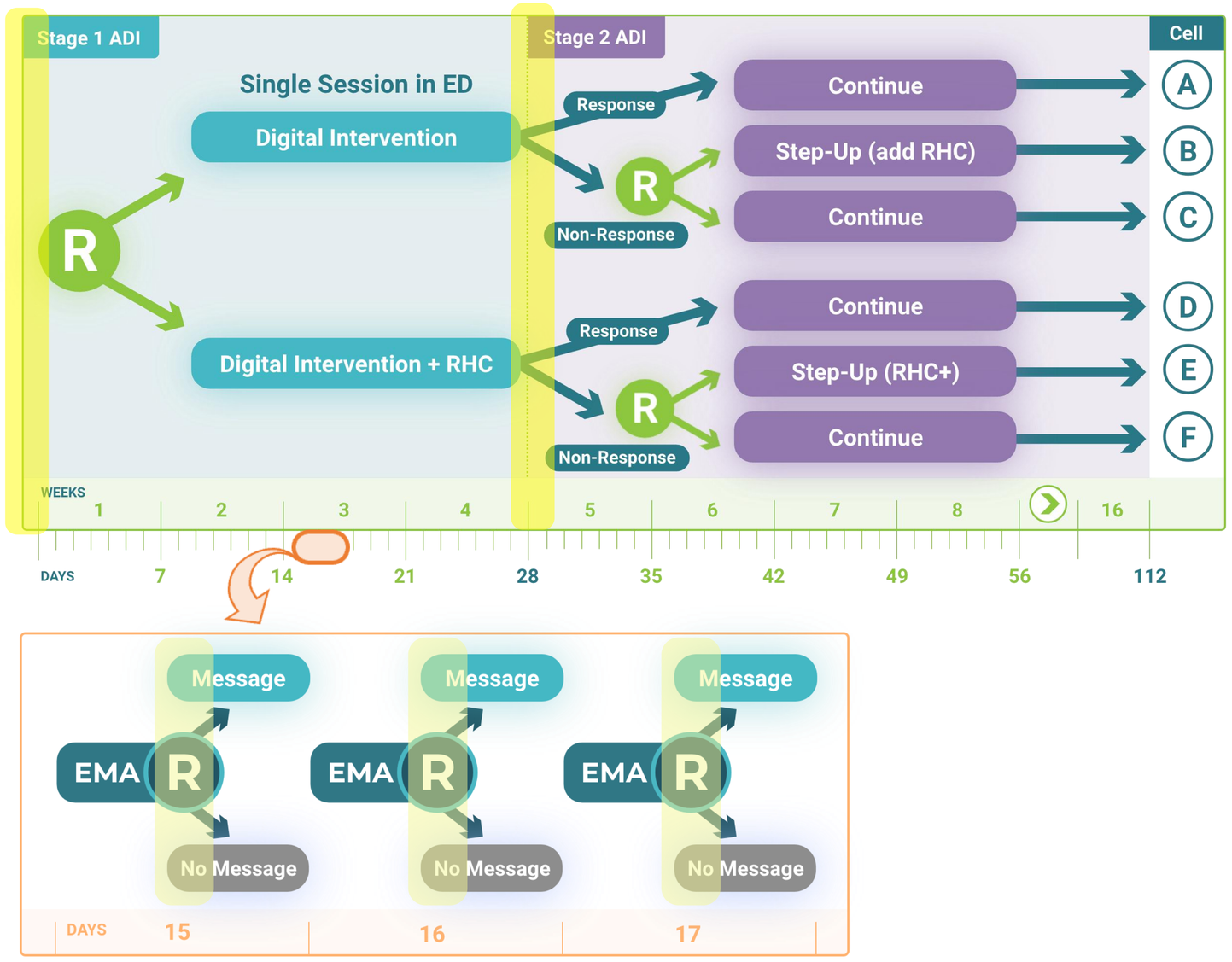
Hybrid Experimental Design

(HED)



Hybrid Experimental Design

(HED)



Hybrid Experimental Design (HED)

General Article

Hybrid Experimental Designs for Intervention Development: What, Why, and How

Inbal Nahum-Shani[1], John J. Dziak[2], Maureen A. Walton[3], and Walter Dempsey[4]

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Advances in Methods and Practices in Psychological Science
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DOI: 10.1177/25152459221114279
www.psychologicalscience.org/AMPPS

Abstract

Advances in mobile and wireless technologies offer tremendous opportunities for extending the reach psychological interventions and for adapting interventions to the unique and changing needs of individ insufficient engagement remains a critical barrier to the effectiveness of digital interventions. Hum interventions (e.g., by clinical staff) can be more engaging but potentially more expensive and burde

Current HIV/AIDS Reports
https://doi.org/10.1007/s11904-023-00671-z

Digital Adaptive Behavioral Interventions to Improve HIV Prevention and Care: Innovations in Intervention Approach and Experimental Design

Inbal Nahum-Shani[1] · Sylvie Naar[2]

Accepted: 6 October 2023

Abstract

Purpose of Review Recent advances in digital technologies can be leveraged to adapt HIV prevention and treatment services to the rapidly changing needs of individuals in everyday life. However, to fully take advantage of these technologies, it is critical to effectively integrate them with human-delivered components. Here, we introduce a new experimental approach for optimizing the integration and adaptation of digital and human-delivered behavioral intervention components for HIV prevention and treatment.

Behavior Research Methods
https://doi.org/10.3758/s13428-023-02119-z

Design of experiments with sequential randomizations on multiple timescales: the hybrid experimental design

Inbal Nahum-Shani[1] · John J. Dziak[2] · Hanna Venera[3] · Angela F. Pfammatter[4,5] · Bonnie Spring[5] · Walter Dempsey[3]

Accepted: 28 March 2023

Abstract

Psychological interventions, especially those leveraging mobile and wireless technologies, often include multiple components that are delivered and adapted on multiple timescales (e.g., coaching sessions adapted monthly based on clinical progress, combined with motivational messages from a mobile device adapted daily based on the person's daily emotional state). The hybrid experimental design (HED) is a new experimental approach that enables researchers to answer scientific questions about the construction of psychological interventions in which components are delivered and adapted on different timescales. These designs involve sequential randomizations of study participants to intervention components, each at an appropriate timescale (e.g., monthly randomization to different intensities of coaching sessions and daily randomization to different forms of motivational messages). The goal of the current manuscript is twofold. The first is to highlight the flexibility of

Thank You!

Statistical Software

Experimental Design Applets

Learning Resources

Workshop Information