The multiphase optimization strategy (MOST)

Linda M. Collins, Ph.D.
The Methodology Center and
Department of Human Development & Family Studies
Penn State

Presented at Turning the Tide: A New Generation of Public Health Interventions
Columbia University
April 28, 2017

The Methodology Center

PennState

Outline

- What's wrong with business as usual?
- What is MOST? What is optimization?
- OK, how do you do this?
- Concluding remarks

Outline

- What's wrong with business as usual?
- What is MOST? What is optimization?
- OK, how do you do this?
- Concluding remarks

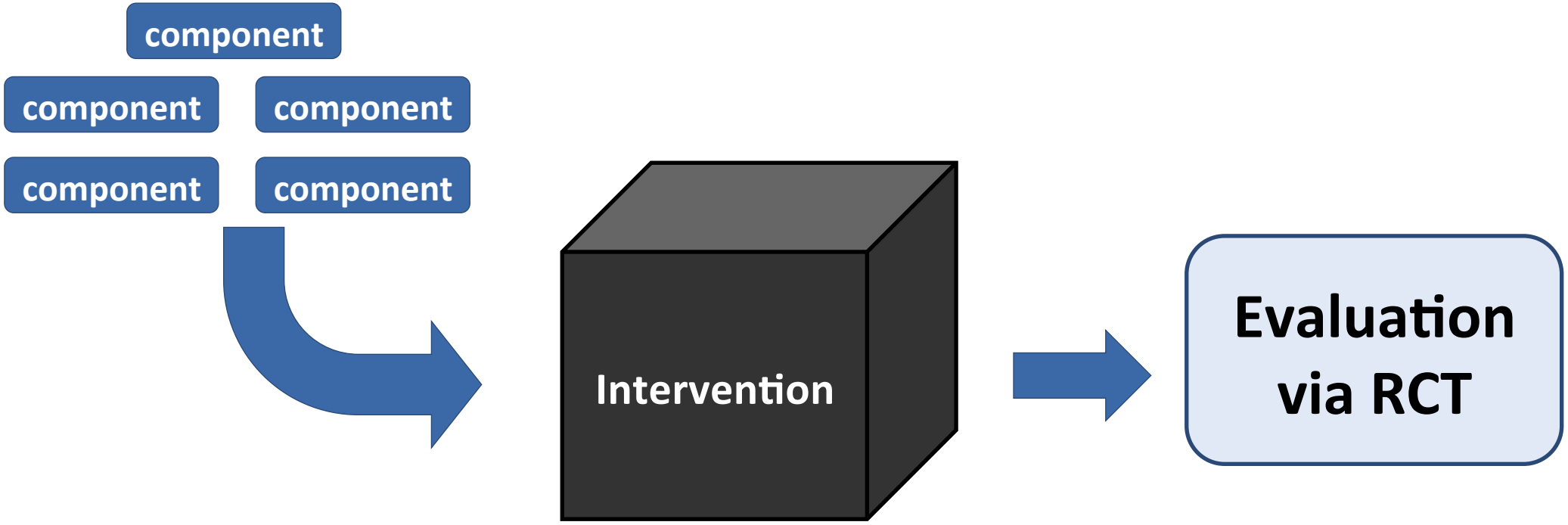
What is an intervention component?

- Definition: *Any aspect of an intervention that can be separated out for study*
  - Parts of intervention content
    - e.g., each major topic to be covered
  - Features that promote engagement/compliance/adherence
    - e.g., MEMS® caps
  - Features aimed at improving fidelity of delivery
    - e.g., 800 number for program delivery staff to call with questions

How inventions are typically developed and evaluated

- Intervention components are chosen based on scientific theory, clinical experience, etc.
- Combined into a package
- Package is evaluated via a randomized controlled trial (RCT)
- Let's call this the *classical approach*

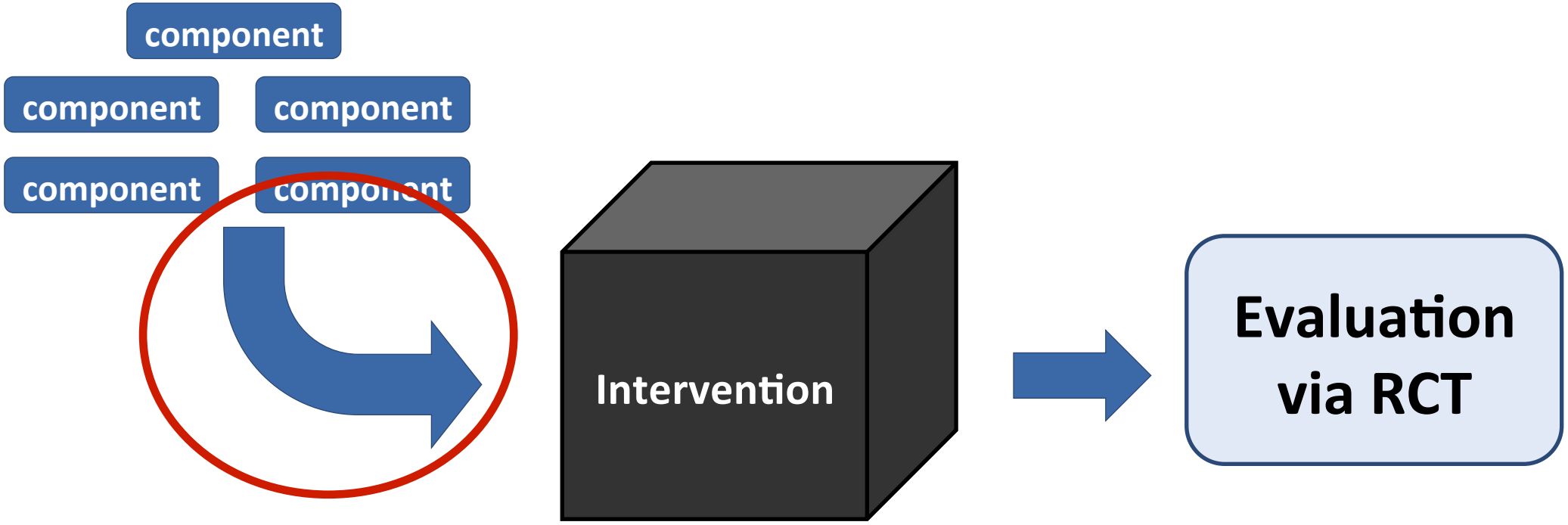
Classical approach



This is what am I suggesting is wrong with evaluating an intervention by means of an RCT:

Absolutely nothing!

Classical approach



What the RCT cannot not tell us

An RCT that finds a <u>significant</u> effect DOES NOT tell us

- Which components are making positive contributions to overall effect
- Whether the inclusion of one component has an impact on the effect of another
- Whether a component's contribution offsets its cost
- How to make the intervention more effective, efficient, and scalable

What the RCT cannot not tell us

An RCT that finds a <u>non-significant</u> effect DOES NOT tell us

- Whether any components are worth retaining
- Whether one component had a negative effect that offset the positive effect of others
- Specifically what went wrong and how to do it better the next time

What's the alternative?

- When engineers build products they take an approach that is
  - Systematic
  - Efficient
  - Focused on the clear objective of optimizing the product
- MOST integrates methodological perspectives from the behavioral and engineering sciences…
- … to build optimized behavioral interventions

Outline

- What's wrong with business as usual?
- What is MOST? What is optimization?
- OK, how do you do this?
- Concluding remarks

The multiphase optimization strategy (MOST)

- An engineering-inspired framework for development, optimization, and evaluation of behavioral interventions
- Using MOST it is possible to engineer an intervention to meet a specific criterion

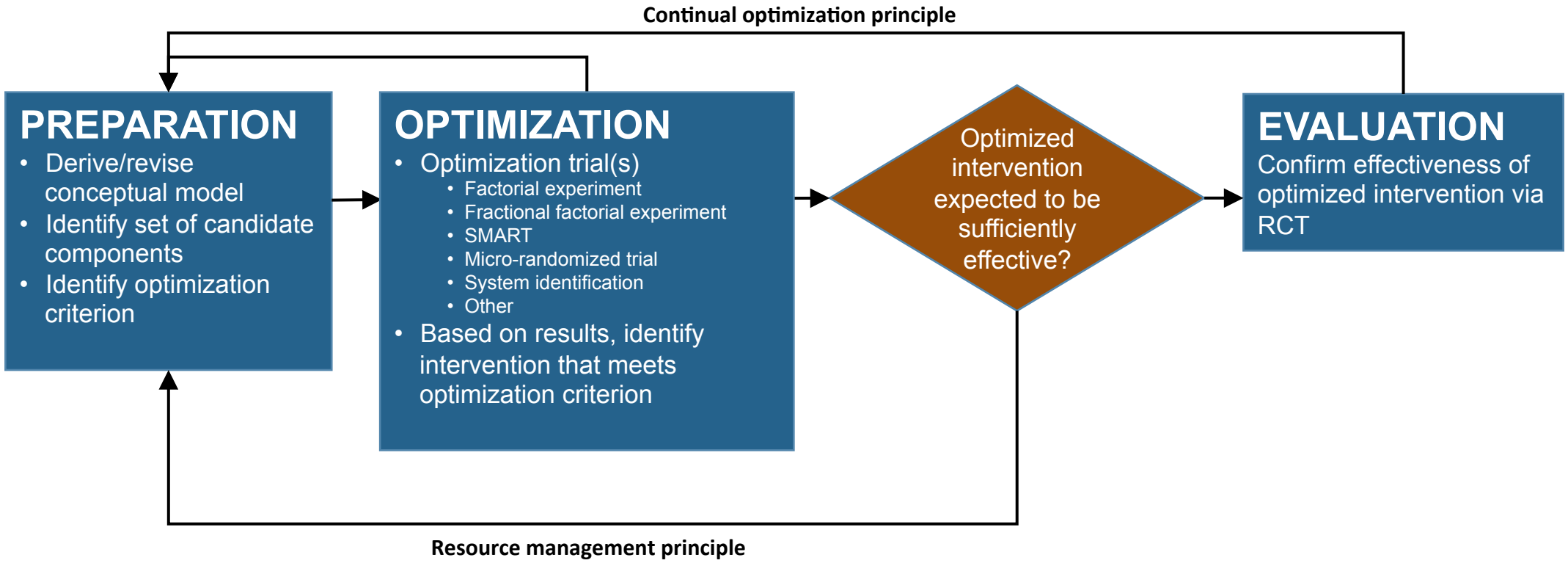
Desiderata for behavioral/ biobehavioral interventions

- Effectiveness
  - Extent to which the intervention does more good than harm (under real-world conditions; Flay, 1986)
- Efficiency
  - Extent to which the intervention avoids wasting time, money, or other valuable resources
- Economy
  - Extent to which the intervention is effective without exceeding budgetary constraints, and offers a good value
- Scalability
  - Extent to which the intervention can be implemented widely with fidelity

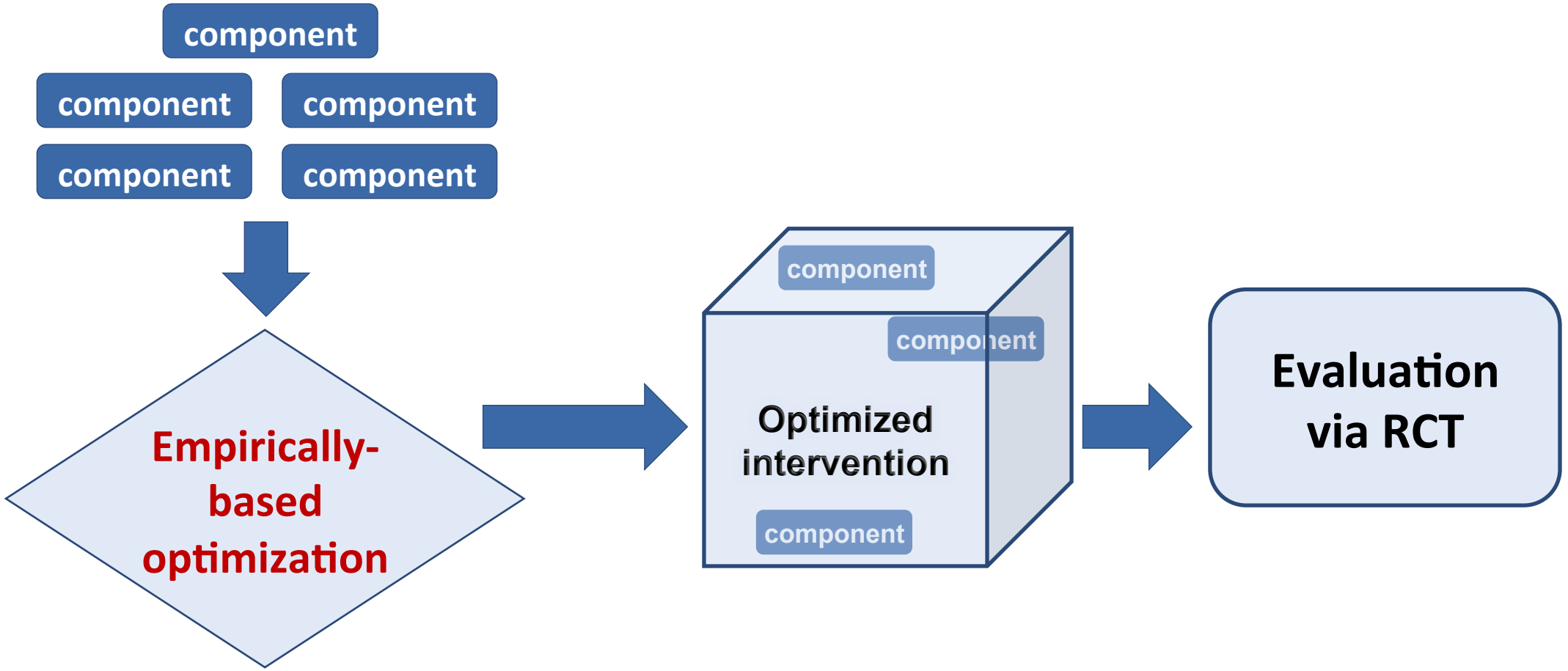
Definition of optimization of a behavioral/ biobehavioral intervention

- *Optimization of a behavioral/biobehavioral intervention is*
  - *the process of identifying the intervention that provides the highest expected level of effectiveness obtainable…*
  - *…within key constraints imposed by the need for efficiency, economy, and/or scalability.*
- Note tension between effectiveness and the other three desiderata

The Multiphase Optimization Strategy (MOST)



Multiphase optimization strategy (MOST)



Outline

- What's wrong with business as usual?
- What is MOST? What is optimization?
- OK, how do you do this?
- Concluding remarks

Example: Clinic-based smoking cessation study

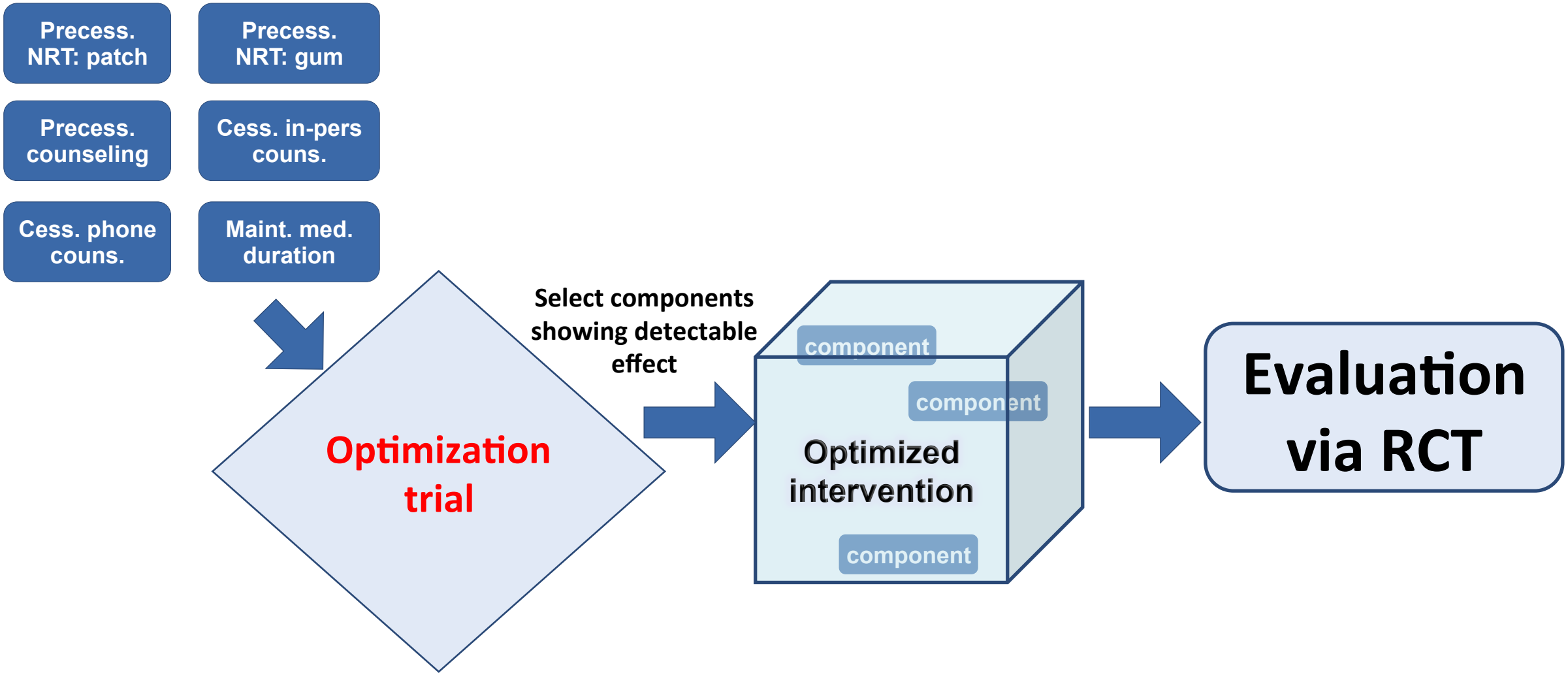
Objective: Develop a highly effective smoking cessation intervention with no inactive components

- Part of a P01; PIs: Mike Fiore and Tim Baker, University of Wisconsin
- Funded by the National Cancer Institute

Components being considered for the smoking cessation intervention

- Precessation nicotine patch (No, Yes)
- Precessation ad lib nicotine gum (No, Yes)
- Precessation in-person counseling (No, Yes)
- Cessation in-person counseling (Minimal, Intensive)
- Cessation phone counseling (Minimal, Intensive)
- Maintenance medication duration (Short, Long)

MOST as implemented in smoking cessation study



Choosing an efficient design for the optimization trial

Design	N to achieve power≥.8	Number of experimental conditions	Can interactions be examined?
Option 1: Six individual experiments	3,072	12	None
Option 2: Comparative treatment	1,792	7	None
Option 3: Factorial experiment	512	64	Yes, all
Option 4: Fractional factorial experiment	512	8, 16, or 32 depending on design chosen	Yes, selected subset

Did you know…?

- When used to address suitable research questions, balanced factorial experimental designs often require many FEWER subjects than alternative designs.
- It is often possible to add one or more factors to a factorial experiment and maintain the same level of power WITHOUT ANY INCREASE IN THE NUMBER OF SUBJECTS.
- The primary motivation for conducting a factorial experiment may be economy rather than examination of interactions.
- When effect coding is used to analyze data from a balanced factorial experiment, all effect estimates are uncorrelated.

Using data from the experiment to optimize

- Conduct an analysis of variance, obtain estimates of effects of each of the components
- Use this information to select components
  - Discard components that do not perform adequately
  - Use size of effects in combination with other data (e.g., cost) or prediction model to select components that will make up optimized intervention

Outline

- What's wrong with business as usual?
- What is MOST? What is optimization?
- OK, how do you do this?
- Concluding remarks

Feasibility

- NIH has funded >20 projects using MOST
- Factorial experiments with 32 conditions have been successfully implemented in field settings
- Used or being used to develop interventions for, e.g.
  - Smoking cessation
  - Weight loss
  - Prevention of STIs in college students
  - Weight management in pregnant women
  - Getting HIV+ individuals not currently on ART engaged in health care

Imagine the state of the art if MOST were widely implemented

- **A bar for effectiveness, efficiency, economy, and scalability would be set and then raised with each new evidence-based behavioral/ biobehavioral intervention**
- Over time, increases in effectiveness, efficiency, economy, and scalability
- A coherent base of knowledge would be accumulated about what works

For more information:

- http://methodology.psu.edu
  - Sign up for eNews
  - Section on MOST with
    - Suggested reading
    - FAQ
    - Advice for people writing grant proposals involving MOST
- TED talk online (search for Collins TED talk)
- I HOPE: One-week training on optimization of behavioral and biobehavioral interventions in 2018
  - To receive an announcement about how to apply, sign up for The Methodology Center's e-news
- WATCH FOR 2 books to be published in early 2018 (Springer)

Extra slides

Factorial experiments 101

- Example: 2 X 2, or 2^2, factorial design

		Component A	
Component B		Off	On
	Off	A,B off	A on, B off
	On	A off, B on	A,B on

- Factorial experiments can have
  - ≥ 2 factors
  - ≥ 2 levels per factor
- On the next slide is a 2^4 factorial design

Experimental conditions in a factorial experiment with four factors

Experimental condition	Factor A	Factor B	Factor C	Factor D
1	Off	Off	Off	Off
2	Off	Off	Off	On
3	Off	Off	On	Off
4	Off	Off	On	On
5	Off	On	Off	Off
6	Off	On	Off	On
7	Off	On	On	Off
8	Off	On	On	On
9	On	Off	Off	Off
10	On	Off	Off	On
11	On	Off	On	Off
12	On	Off	On	On
13	On	On	Off	Off
14	On	On	Off	On
15	On	On	On	Off
16	On	On	On	On

What are we trying to estimate with a factorial experiment?

- Most important for decision making: Main effect of each factor
  - DEFINITION OF MAIN EFFECT OF FACTOR A:
  - Effect of Factor A averaged across all levels of all other factors
- Also selected interactions
  - DEFINITION OF INTERACTION BETWEEN FACTOR A AND FACTOR B (assuming each factor has two levels):
  - ½ ((effect of Factor A at level 1 of Factor B) – (effect of Factor A at level 2 of Factor B))

- MAIN EFFECT OF FACTOR A is mean of conditions 1-8 vs. mean of conditions 9-16

Experimental condition	Factor A	Factor B	Factor C	Factor D
1	Off	Off	Off	Off
2	Off	Off	Off	On
3	Off	Off	On	Off
4	Off	Off	On	On
5	Off	On	Off	Off
6	Off	On	Off	On
7	Off	On	On	Off
8	Off	On	On	On
9	On	Off	Off	Off
10	On	Off	Off	On
11	On	Off	On	Off
12	On	Off	On	On
13	On	On	Off	Off
14	On	On	Off	On
15	On	On	On	Off
16	On	On	On	On

- MAIN EFFECT OF FACTOR B is mean of conditions 5—8 and 13—16 vs. mean of conditions 1—4 and 9—12

Experimental condition	Factor A	Factor B	Factor C	Factor D
1	Off	Off	Off	Off
2	Off	Off	Off	On
3	Off	Off	On	Off
4	Off	Off	On	On
5	Off	On	Off	Off
6	Off	On	Off	On
7	Off	On	On	Off
8	Off	On	On	On
9	On	Off	Off	Off
10	On	Off	Off	On
11	On	Off	On	Off
12	On	Off	On	On
13	On	On	Off	Off
14	On	On	Off	On
15	On	On	On	Off
16	On	On	On	On

- MAIN EFFECT OF FACTOR C is mean of conditions 3,4,7,8,11,12,15, and 16 vs. mean of conditions 1,2,5,6,9,10, 13, and 14

Experimental condition	Factor A	Factor B	Factor C	Factor D
1	Off	Off	Off	Off
2	Off	Off	Off	On
3	Off	Off	On	Off
4	Off	Off	On	On
5	Off	On	Off	Off
6	Off	On	Off	On
7	Off	On	On	Off
8	Off	On	On	On
9	On	Off	Off	Off
10	On	Off	Off	On
11	On	Off	On	Off
12	On	Off	On	On
13	On	On	Off	Off
14	On	On	Off	On
15	On	On	On	Off
16	On	On	On	On

- MAIN EFFECT OF FACTOR D is mean of conditions 1,3,5,7,9,11,13,15 vs. mean of conditions 2,4,6,8,10,12,14,16

Experimental condition	Factor A	Factor B	Factor C	Factor D
1	Off	Off	Off	Off
2	Off	Off	Off	On
3	Off	Off	On	Off
4	Off	Off	On	On
5	Off	On	Off	Off
6	Off	On	Off	On
7	Off	On	On	Off
8	Off	On	On	On
9	On	Off	Off	Off
10	On	Off	Off	On
11	On	Off	On	Off
12	On	Off	On	On
13	On	On	Off	Off
14	On	On	Off	On
15	On	On	On	Off
16	On	On	On	On

Experimental design used to examine components of smoking cessation intervention

- Factorial experiment with six factors.
- It is a 2^{6-1} fractional factorial.
- The design has 32 experimental conditions.
- Each main effect aliased with one 5-way interaction; each 2-way aliased with one 4-way; each 3-way with one 3-way
- HEY! Where is the control group???

Table 1. Experimental Conditions

	Precessation Interventions			Pericessation Interventions		
Condition	Precessation Medication Type (Patch vs. none)	Precessation Medication Type (Ad Lib NRT vs. none)	Precessation Counseling (Intensive vs. none)	In-Person Counseling (Minimal vs. Intensive)	Phone Counseling (Minimal vs. Intensive)	Medication (8 weeks vs. 16 weeks)
1	Patch	Ad Lib	Intensive	Minimal	Minimal	Standard
2	Patch	Ad Lib	Intensive	Minimal	Intensive	Long-term
3	Patch	Ad Lib	Intensive	Intensive	Minimal	Long-term
4	Patch	Ad Lib	Intensive	Intensive	Intensive	Standard
5	Patch	Ad Lib	None	Minimal	Minimal	Long-term
6	Patch	Ad Lib	None	Minimal	Intensive	Standard
7	Patch	Ad Lib	None	Intensive	Minimal	Standard
8	Patch	Ad Lib	None	Intensive	Intensive	Long-term
9	Patch	None	Intensive	Minimal	Minimal	Long-term
10	Patch	None	Intensive	Minimal	Intensive	Standard
11	Patch	None	Intensive	Intensive	Minimal	Standard
12	Patch	None	Intensive	Intensive	Intensive	Long-term
13	Patch	None	None	Minimal	Minimal	Standard
14	Patch	None	None	Minimal	Intensive	Long-term
15	Patch	None	None	Intensive	Minimal	Long-term
16	Patch	None	None	Intensive	Intensive	Standard
17	None	Ad Lib	Intensive	Minimal	Minimal	Long-term
18	None	Ad Lib	Intensive	Minimal	Intensive	Standard
19	None	Ad Lib	Intensive	Intensive	Minimal	Standard
20	None	Ad Lib	Intensive	Intensive	Intensive	Long-term
21	None	Ad Lib	None	Minimal	Minimal	Standard
22	None	Ad Lib	None	Minimal	Intensive	Long-term
23	None	Ad Lib	None	Intensive	Minimal	Long-term
24	None	Ad Lib	None	Intensive	Intensive	Standard
25	None	None	Intensive	Minimal	Minimal	Standard
26	None	None	Intensive	Minimal	Intensive	Long-term
27	None	None	Intensive	Intensive	Minimal	Long-term
28	None	None	Intensive	Intensive	Intensive	Standard
29	None	None	None	Minimal	Minimal	Long-term
30	None	None	None	Minimal	Intensive	Standard
31	None	None	None	Intensive	Minimal	Standard
32	None	None	None	Intensive	Intensive	Long-term

Some funded projects using MOST (that I know of)

- Smoking cessation intervention for adults (M. Fiore & T. Baker, U of Wisconsin, P01CA180945)
- Prevention of drug abuse and HIV in South Africa (L. Caldwell, PSU, R01DA 029084)
- Substance use prevention program aimed at American Indian families (N. Whitesell, U. of Colorado, R01DA035111)
- Moderation of gestational weight gain (D. Downs, PSU, R01HL119245)
- Intervention to get HIV positive individuals into the health care system and on ART (M. Gwadz, NYU & L. Collins, PSU, R01DA040480)

Some funded projects using MOST (that I know of)

- Weight reduction program for adults (B. Spring, NWU and L. Collins, PSU, R01DK097364)
- Online intervention to prevent excessive alcohol use and risky sex in college students (L. Collins, PSU, R01AA022931)
- Positive psychology intervention for cardiac patients to improve health behaviors (J. Huffman, Harvard U, R01HL113272)
- Tobacco treatment for smokers getting lung cancer screening (J. Ostroff, Sloan-Kettering, R01CA207442)

Some funded projects using MOST (that I know of)

- Intervention to reduce fear of recurrence in breast cancer patients (L. Wagner, now at Wake Forest, R21CA173193)
- Intervention to prevent childhood obesity (L. Francis, USDA)
- Adherence intervention to promote use of insulin pumps among adolescents (K. Driscoll, U of Florida, K23DK091558)
- Maternal depression care-seeking (E. Fernandez y Garcia, UC Davis, K23MH101157)
- Physical activity for breast cancer survivors (S. Phillips, NWU, K07CA196840)