Building more efficacious and effective behavioral interventions: One view of the future of intervention development

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Presented at the Annual Meeting of the Society of Behavioral Medicine
March 29, 2008

One view of the future of intervention development

- Research aimed at optimization of behavioral interventions
- Continual, programmatic improvement of efficacy, effectiveness, cost-effectiveness
- Coherent empirical knowledge base continually growing
- No dramatic increase in intervention research resources

Overview

- Some ideas borrowed from engineering
- The optimization cycle framework
- Some comments and responses
- Is the future within our reach?

Engineering, manufacturing, and product development

- Theory suggests many different components that can make up a prototype
- Goal: find best one(s)

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Definition: intervention components

- Intervention components: Any aspects of an intervention that can be separated out for study, such as
  - Parts of intervention content
  - Features that promote compliance/adherence
  - Aspects of program delivery
- Can impact efficacy, effectiveness, cost-effectiveness

Engineering, manufacturing, and product development

- Theory suggests many different components that can make up a prototype
- Goal: find best one(s)

Intervention science

- Theory suggests many different components that can make up an intervention
- Goal: find best one(s)
- Impractical to test all the 100's or 1000's of combinations
- Strategy:
  - First, devise a priori a combination of components and levels/doses ("treatment package") deemed likely to be efficacious.
  - Then, test as a package.

Engineering, manufacturing, and product development

- Theory suggests many different components that can make up a prototype
- Goal: find best one(s)
- Impractical to test all the 100's or 1000's of combinations
- Strategy:
  - First, conduct a principled empirical search aimed at identification of the components and levels/settings that comprise the optimal combination(s).
  - Then, test as a package.

Can the treatment package approach be used for intervention optimization?

- Standard RCT intended for confirmation, not optimization
  - In a standard RCT all intervention components are confounded
- Post-hoc analyses unreliable way to tease out individual effects
- Not efficient

How engineers think: Lesson 1

- This is what I need to find out: _____
- These are the resources I have: _____
- How can I manage my resources strategically to find out what I need to know?

Resource management principle

- Manage research resources strategically to:
  - Gain the most information
  - Gain the most reliable information
  - Move science forward fastest
- Decide what information most important, and target resources there
- Choose designs for efficiency

How engineers think: Lesson 2

- I have finished developing this product and it is ready to market.

- Now I am going to start developing the new, improved product.

Cyclic optimization principle

- Optimization is an ongoing process
- As soon as one round of optimization is done, a new round is begun

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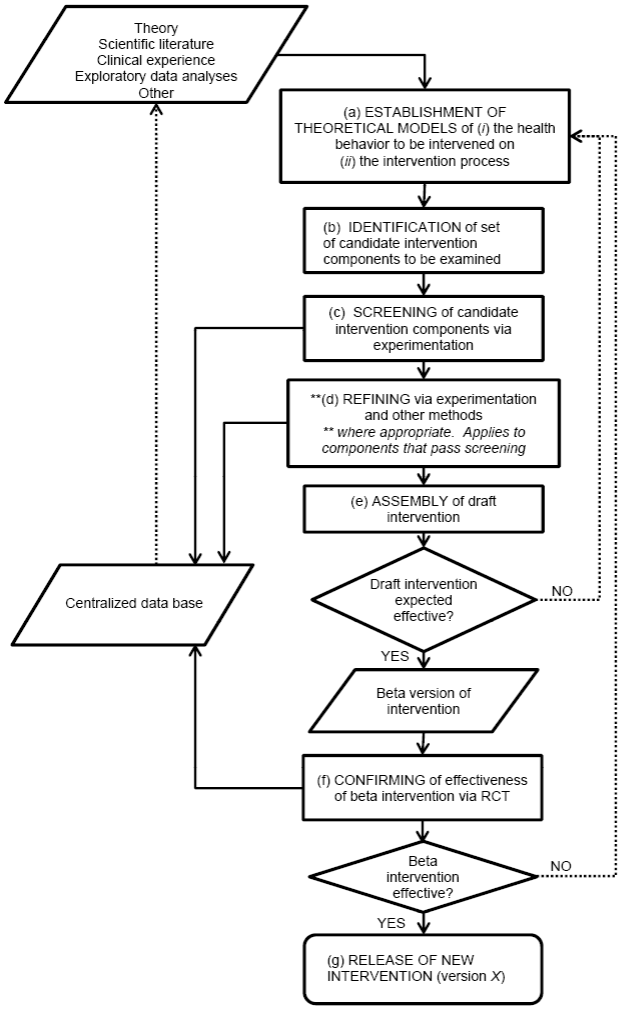

Flowchart of the optimization cycle

Optimization cycle astronauts

Vic Strecher

University of Michigan

Smoking cessation e-health intervention

Optimization cycle astronauts

Tim Baker Mike Fiore

University of Wisconsin

Clinic-based smoking cessation intervention

Steps in the optimization cycle

What to do	How to do it	Notes
(a) Identify theoretical models	Draw on theory, exploratory analyses, clinical experience, scientific literature	
(b) Select intervention components for study	Draw on theoretical models	
(c) Screen intervention components to determine (i) whether a component should be included or (ii) whether there is a difference between two (or more) levels	Efficient randomized experimentation to obtain individual component effects and key interactions.	Factorial and fractional factorial designs used. Theoretical models and resource management principle directly inform design choices.
(d) Refine (fine-tune) combination of components.	Randomized experimentation; engineering-based optimization algorithms	
(e) Assemble draft (beta) intervention.	Decide based on results of steps (c) and (d).	Return to beginning if draft intervention not sufficiently efficacious/effective/ cost-effective.
(f) Confirm efficacy/effectiveness /cost-effectiveness	Conduct standard RCT.	Return to beginning if intervention not confirmed efficacious/effective/ cost-effective.
(g) Release new version of intervention		
Next: new optimization cycle		

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Examples of intervention components to be examined

Vic Strecher & collaborators: web-based smoking cessation intervention

- High vs low message tailoring – success story
- High vs low message tailoring – outcome expectations
- High vs low message tailoring – efficacy expectations
- High vs low personalized source
- Multiple vs single exposure

Examples of intervention components to be examined

Tim Baker, Mike Fiore & collaborators: clinical smoking cessation intervention (partial list)

- Pericessation medication vs placebo
- Min. vs intensive pericessation clinician counseling
- Min. vs intensive post-quit phone counseling
- Std. vs enhanced prep. phase med
- Std. vs enhanced prep. phase counseling
- Std. vs enhanced maint. phase med
- Std. vs enhanced maint. phase counseling

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Searching through the alternative combinations of components and levels

- DO NOT examine combinations one by one
- INSTEAD
  - FIRST screen for components where there is a difference between the highest and lowest levels; select these
  - THEN refine
    - e.g.: suppose Component 2 ranges from 1-10 – find optimal setting

Conducting the Screening step

- Approach: randomized experiment(s) that identify the effects attributable to each component
- Resource mgt principle: Use most experimental efficient design
- We emphasize **factorial** designs

Vic Strecher's Screening step

- Experimental design:
  - All 5 components in one experiment
  - Fractional factorial design (16 conditions)
  - Compared to 5 separate experiments:
    - Requires 20 percent *N* to achieve same power
    - Enables estimation of all two-way and some three-way interactions

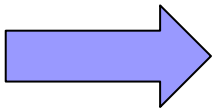
Vic Strecher's Screening step

- Some highlights of results:
  - Abstinence most influenced by
    - Success stories (high tailoring better)
    - Message source (highly personalized better)
  - Results suggest tailoring depth important, with greater depth more successful

Tim Baker & Mike Fiore's Screening step (planned)

- Experiment 1: 2X2X2 factorial
  - pericessation phased med X clinician counseling X phone counseling
- Experiment 2: 2X2X2X2 factorial
  - prep. phase med X counseling X maint. phase med X counseling
- Compared to 7 separate experiments:
  - Requires less than 30 percent *N* to achieve same power
  - Enables estimation of all interactions within an experiment

Steps in the optimization cycle



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Conducting the Refining step

- Include only components that made it through screening
- Fine-tuning intervention
  - Example: Strecher plans to investigate tailoring depth further to see what depth is optimal
- Another Refining step idea: applying engineering control principles

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Assembly of draft intervention

- Based on this information:
  - effect of each intervention component
  - additional information about best levels/doses
- **Identify optimal combination** of components and level/doses
- This forms a draft (beta) intervention

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Responses to comments

Comment:

What if it doesn't make sense to break my intervention down into components?

Response:

You may still be interested in using this approach to optimize effectiveness.

Responses to comments

Comment:

NIH funding is ≤ 5 years, and it will take > 5 years to complete an optimization cycle.

Response:

(1) You can propose part of the cycle up to (say) the Assembly of draft intervention step

(2) Vic Strecher has been funded by NCI

Responses to comments

Comment:

My outcome of ultimate interest is long-term. How can I conduct an optimization cycle in a reasonable period of time?

Response:

Measures of mediators can be used as short-term outcomes.

Responses to comments

Comment:

Will results of the screening and refining experiments be publishable?

Response:

Strecher, V.J., McClure, J., Alexander, G., Chakraborty, B., Nair, V., Konkel, J., Greene, S., Collins, L.M., Carlier, C., Wiese, C., Little, R., Pomerleau, C., & Pomerleau, O. (In press). Web-based smoking cessation program: Results of a randomized trial. *American Journal of Preventive Medicine*.

Responses to comments

Comment:

Will I be able to get enough research subjects for all those experiments?

I'm concerned about having to implement too many experimental conditions.

Response:

There are highly efficient design alternatives that are frugal with both subjects and conditions.

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One view of the future of intervention development revisited

- Research aimed at optimization of behavioral interventions
  - OC aimed at identifying optimal combination of components and levels/doses
  - RCT used to confirm efficacy/effectiveness
- Continual, programmatic improvement of efficacy, effectiveness, cost-effectiveness
  - Straightforward to test new intervention components
  - Previous intervention can be SOC control
  - Natural way to include cost in decision making

One view of the future of intervention development revisited

- Coherent empirical knowledge base continually growing
  - Randomized experiments
  - Determine WHICH components work
  - More precise mediation analyses
- No dramatic increase in intervention research resources - but a realignment
  - Principled, systematic approach
    - Likely fastest route to optimization in the long run
  - Framework for resource allocation

A future of much more efficacious, effective, and cost-effective interventions is within our reach…

…if we are willing to make some bold changes in our approach to building and evaluating behavioral interventions.

Collaborators on this research

- Timothy Baker, U Wisconsin
- John Dziak, Penn State
- Michael Fiore, U Wisconsin
- Runze Li, Penn State
- Susan A. Murphy, U Michigan
- Vijay Nair, U Michigan
- Daniel Rivera, Arizona State
- Victor Strecher, U Michigan

For additional information:

- Collins, L.M., Dziak, J.R., & Li, R. (Under review). Choosing among complete factorial, fractional factorial and other designs to maximize scientific gain in relation to resources expended.
- Collins, L.M., Murphy, S.A., & Bierman, K. (2004). A conceptual framework for adaptive preventive interventions. *Prevention Science, 3*, 185-196.
- Collins, L.M., Murphy, S.A., Nair, V., & Strecher, V. (2005). A strategy for optimizing and evaluating behavioral interventions. *Annals of Behavioral Medicine*, *30,* 65-73.
- Collins, L.M., Murphy, S.A., & Strecher, V. (2007). The Multiphase Optimization Strategy (MOST) and the Sequential Multiple Assignment Randomized Trial (SMART): New methods for more potent e-health interventions. *American Journal of Preventive Medicine, 32,* S112-S118 .
- Rivera, D.E., Pew, M.D., & Collins, L.M. (2007). Using engineering control principles to inform the design of adaptive interventions. *Drug and Alcohol Dependence, 88,* S31-S40.
- Strecher, V.J., et al. (in press). Web-based smoking cessation program: Results of a randomized trial. *American Journal of Preventive Medicine.*

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Choosing a design

- Suppose three intervention components
  - For a small (d=.2) effect, power of .8 achieved with *N*=200
- Three separate experiments
  - Requires total *N* of 600
- What if you did a factorial experiment instead?

What are factorial designs?

- 2 X 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

For three components:

- 2 X 2 X 2 (3-way) factorial design

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

- To achieve power of .8, this design requires *N*=200
- COMPARE with *N*=600!

Factorial experimental designs:

- SAVE TIME by enabling experimentation on many components simultaneously
- REQUIRE MANY FEWER SUBJECTS than other design approaches
  - **Adding a factor does NOT typically require increasing *N***
- ENABLE STRONGER INFERENCE when random assignment used
- ENABLE EXAMINATION OF INTERACTIONS
- REQUIRE MORE EXPERIMENTAL CONDITIONS but fractional factorial designs a possibility

An intervention through the eyes of an engineer

- From Rivera, Pew, & Collins (2007)