

# Designing and Evaluating Health Behavior Change Technologies In HCI



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## Dashboard for James P

Monday, Jan 16, 2008

pick a day or see next day, previous day

	Actual	Goal
Steps	10,879	12,874
Calories burned	2,487	2,200
Calories eaten	1,974	2,025

### How you did over the day

For the day, excluding sleep, you were

83.7% sedentary 10.2% lightly active 5.3% fairly active 0.8% very active

Calories burned every 15 minutes

### Your sleeping pattern

Updates from your friends

Recent comments from friends

Joe P. @ 2:15pm on Jan 16, 2008  
Hey this is a comment that I am writing to you.  
Please write back.

Dan L. @ 2:15pm on Jan 16, 2008  
Hey this is a comment that I am writing to you.  
Please write back.

[read more comments...](#)

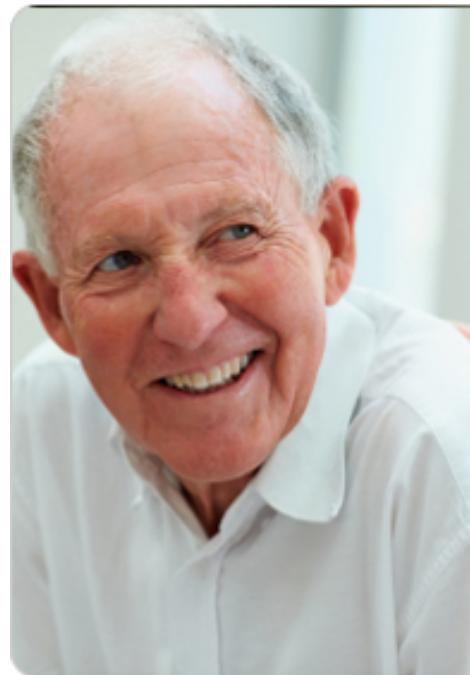
[Recent actions](#)

[Sync Devices](#) [Track Weight](#) [Track Activity](#)

[Track Food](#) [Write in Journal](#)

**97,000+** mobile apps for health & fitness

**\$20 billion:** mHealth industry size by 2018



**86%** of U.S. healthcare spending  
**63%** of deaths globally

Due to conditions influenced by **4** behaviors:

- physical inactivity
- poor diet
- tobacco use
- excessive alcohol consumption

**20%** adherence to heart-healthy behaviors<sup>1</sup>

**7%** adherence to recommendations for diabetes self-management<sup>2</sup>

<sup>1</sup>Miller et al. 2005. *Preventing Chronic Disease*, 2(2), A18

<sup>2</sup>Deakin et al. 2005. *Cochrane Database Syst Rev*, 2

Behavior change is a hugely important public health issue

Technology can play a key role in effectively supporting behavior change

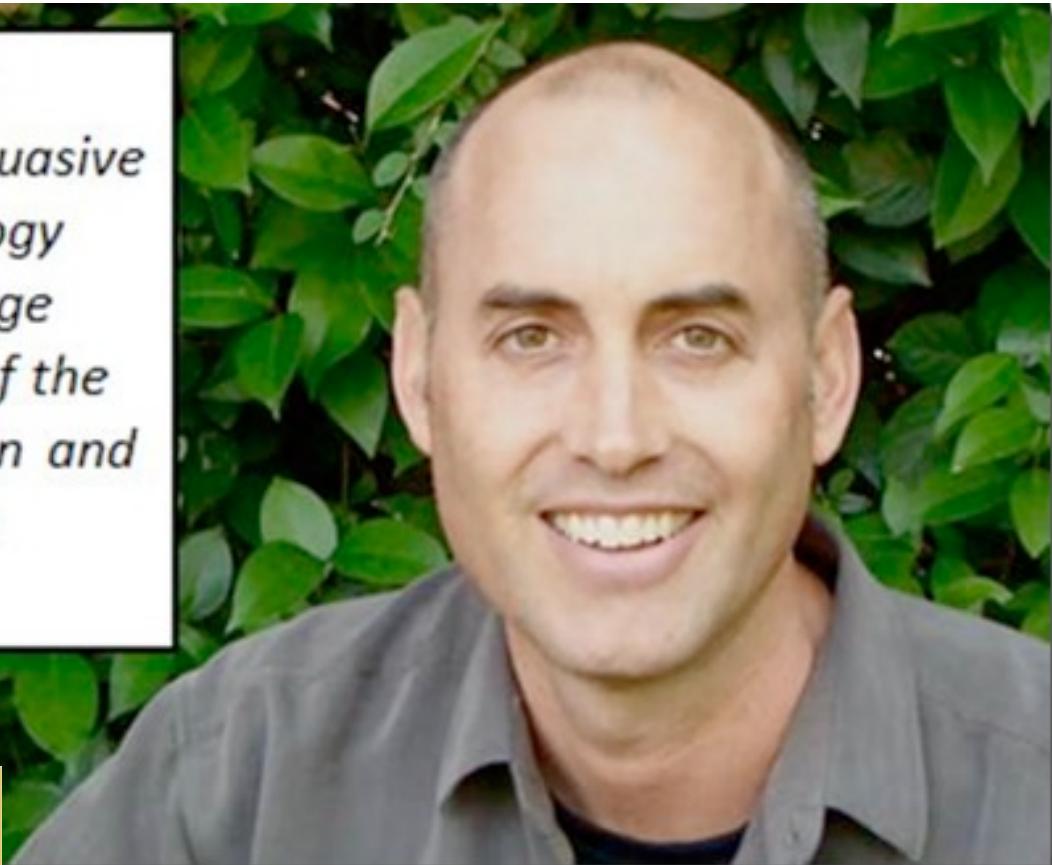
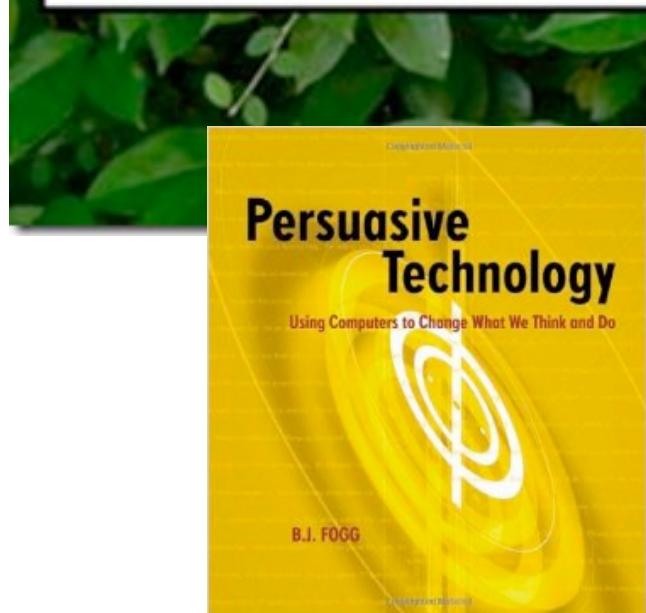
HCI Work on Behavior Change Technologies



Persuasive Technology Lab  
Stanford University



*Persuasive design is the process of creating persuasive technology, or “technology that is designed to change attitudes or behaviors of the users through persuasion and social influence, but not through coercion.”*



# Persuasive Technology

- **Def:** Interactive technology that changes attitudes or behavior
- **Intent:** endogenous, exogenous, autogenous
- **Roles:** tool, media, social actor
- Can function at different **levels of analysis**

# Persuasion → Support

BCTs aim to help individuals to more effectively pursue *their* own health goals



Community-based  
participatory research

t h e o r y

Theory (sometimes) guides what elements go into a BCT: its **intervention components**



# A Taxonomy of Behavior Change Techniques Used in Interventions

Charles Abraham  
University of Sussex

Susan Michie  
University College London

**Objective:** Without standardized definitions of the techniques included in behavior change interventions, it is difficult to faithfully replicate effective interventions and challenging to identify techniques contributing to effectiveness across interventions. This research aimed to develop and test a theory-linked taxonomy of generally applicable behavior change techniques (BCTs). **Design:** Twenty-six BCTs were defined. Two psychologists used a 5-page coding manual to independently judge the presence or absence of each technique in published intervention descriptions and in intervention manuals. **Results:** Three systematic reviews yielded 195 published descriptions. Across 78 reliability tests (i.e., 26 techniques applied to 3 reviews), the average kappa per technique was 0.79, with 93% of judgments being agreements. Interventions were found to vary widely in the range and type of techniques used, even when targeting the same behavior among similar participants. The average agreement for intervention manuals was 85%, and a comparison of BCTs identified in 13 manuals and 13 published articles describing the same interventions generated a technique correspondence rate of 74%, with most mismatches (73%) arising from identification of a technique in the manual but not in the article. **Conclusions:** These findings demonstrate the feasibility of developing standardized definitions of BCTs included in behavioral interventions and highlight problematic variability in the reporting of intervention content.

**Keywords:** behavior change, intervention, content, techniques, taxonomy, CONSORT

Do differences in the content of behavior change interventions have an impact on effectiveness? If so, which techniques or combinations of techniques enhance effectiveness? Answers to these questions are crucial to designers of behavior change interventions. Researching these questions depends on identification of common and distinctive techniques across evaluated interventions. For example, a reviewer might observe that some interventions use goal

Durantini, & Ho, 2005; Webb & Sheeran, 2006). This may mean that particular techniques or content characteristics that distinguish between interventions remain unidentified. If such “unseen” content differences are associated with effectiveness, then researchers will remain unaware of how intervention content determines effectiveness, thereby impeding the design of optimally effective interventions.

Meta-analysis has demonstrated that inclusion of particular inter-

Table 1

*Definitions of 26 Behavior Change Techniques and Illustrative Theoretical Frameworks*

Technique (theoretical framework)	Definition
1. Provide information about behavior-health link. (IMB)	General information about behavioral risk, for example, susceptibility to poor health outcomes or mortality risk in relation to the behavior
2. Provide information on consequences. (TRA, TPB, SCogT, IMB)	Information about the benefits and costs of action or inaction, focusing on what will happen if the person does or does not perform the behavior
3. Provide information about others' approval. (TRA, TPB, IMB)	Information about what others think about the person's behavior and whether others will approve or disapprove of any proposed behavior change
4. Prompt intention formation. (TRA, TPB, SCogT, IMB)	Encouraging the person to decide to act or set a general goal, for example, to make a behavioral resolution such as "I will take more exercise next week"
5. Prompt barrier identification. (SCogT)	Identify barriers to performing the behavior and plan ways of overcoming them
6. Provide general encouragement. (SCogT)	Praising or rewarding the person for effort or performance without this being contingent on specified behaviors or standards of performance
7. Set graded tasks. (SCogT)	Set easy tasks, and increase difficulty until target behavior is performed.
8. Provide instruction. (SCogT)	Telling the person how to perform a behavior and/or preparatory behaviors
9. Model or demonstrate the behavior. (SCogT)	An expert shows the person how to correctly perform a behavior, for example, in class or on video
10. Prompt specific goal setting. (CT)	Involves detailed planning of what the person will do, including a definition of the behavior specifying frequency, intensity, or duration and specification of at least one context, that is, where, when, how, or with whom
11. Prompt review of behavioral goals. (CT)	Review and/or reconsideration of previously set goals or intentions
12. Prompt self-monitoring of behavior. (CT)	The person is asked to keep a record of specified behavior(s) (e.g., in a diary)
13. Provide feedback on performance. (CT)	Providing data about recorded behavior or evaluating performance in relation to a set standard or others' performance, i.e., the person received feedback on their behavior.
14. Provide contingent rewards. (OC)	Praise, encouragement, or material rewards that are explicitly linked to the achievement of specified behaviors
15. Teach to use prompts or cues. (OC)	Teach the person to identify environmental cues that can be used to remind them to perform a behavior, including times of day or elements of contexts.
16. Agree on behavioral contract. (OC)	Agreement (e.g., signing) of a contract specifying behavior to be performed so that there is a written record of the person's resolution witnessed by another
17. Prompt practice. (OC)	Prompt the person to rehearse and repeat the behavior or preparatory behaviors
18. Use follow-up prompts.	Contacting the person again after the main part of the intervention is complete
19. Provide opportunities for social comparison. (SCompT)	Facilitate observation of nonexpert others' performance for example, in a group class or using video or case study
20. Plan social support or social change. (social support theories)	Prompting consideration of how others could change their behavior to offer the person help or (instrumental) social support, including "buddy"systems and/or providing social support

**HCI focus:** Translation of theoretical constructs into novel and compelling BC systems



**Self-monitoring:** observation and recording of one's own activities, thoughts, and feelings

# Uses of self-monitoring

- Assessment
  - Establish a baseline for a behavior one is trying to change
  - As data input for other types of interventions: goal-setting, reinforcement, social influence...
  - Understand influences on behaviors of interest
- Changing behavior—*reactivity*
  - Reduce undesirable/excessive behaviors
  - Increase desirable behaviors

**Reactivity of Self-monitoring:** change in frequency of the monitored behavior that is the result of self-monitoring

# Two aspects of self-monitoring

- Recording
  - Capturing information about behaviors of interest
- Feedback
  - Providing users with feedback on their behaviors and their effects

# Design considerations for recording

- Why self-monitor? What will the data be used for?
- What exactly should be tracked?
  - At what granularity?
  - In what units?
- What is the design space of options for monitoring target behavior(s)?
- For how long will monitoring need to be done?
  - What is the level of burden involved in self-monitoring?
  - Who is getting value from collected data?
- How often will monitoring need to be done?



# Why self-monitor food?

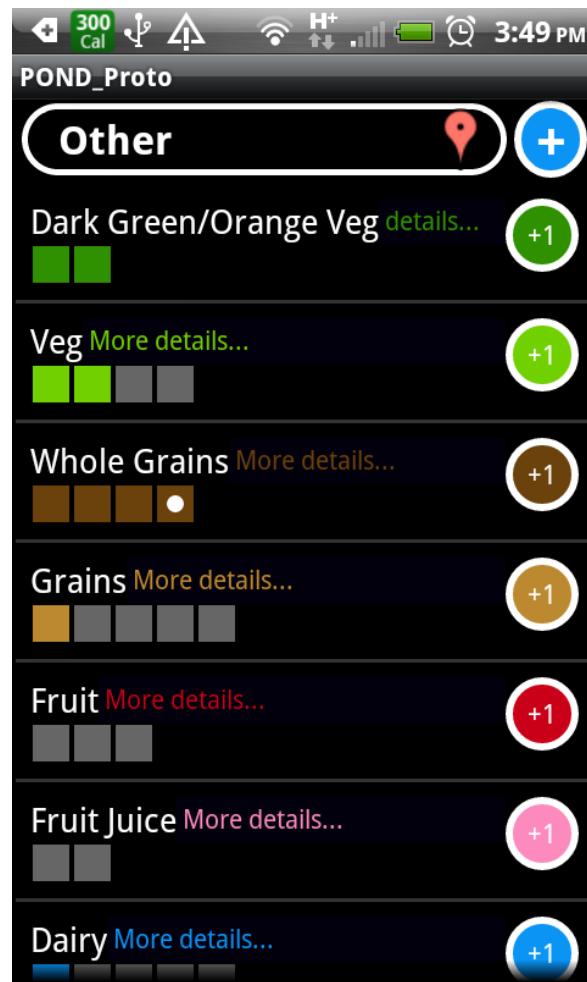
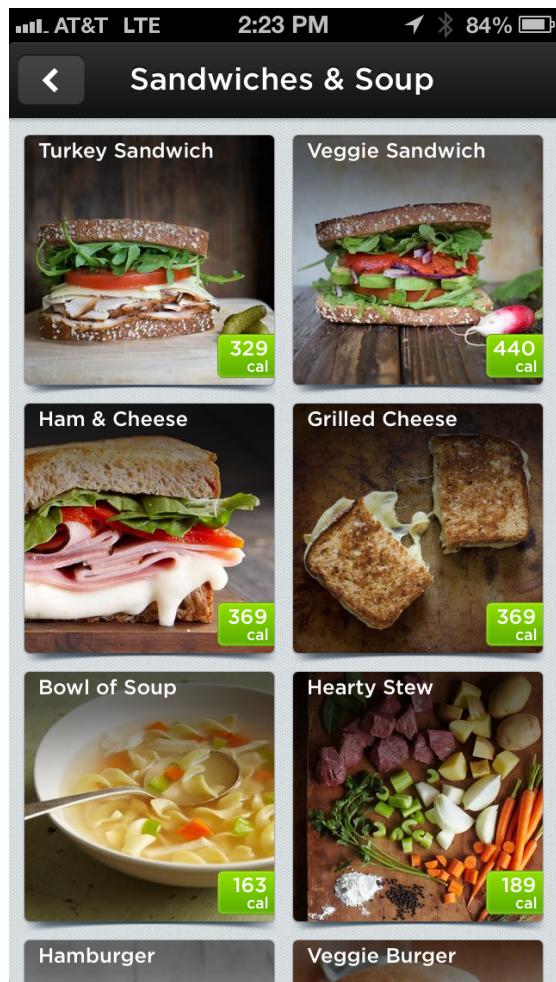
- To change eating patterns
  - Eat less/more
  - Change what one is eating
- To calculate daily energy expenditure
- To set and track consumption goals
- To share what one is eating
  - For feedback
  - For learning
- To understand effects of food on blood glucose, mood, allergies, etc.
- ...

# What should be tracked?

- Everything
- Carb-rich foods
- Fruit and vegetables
- Sugary foods
- Sugary and fatty foods
- Water
- Fast food
- Packaged/processed food
- Interesting food
- ...

# How granularly can we track?

- Exact calories
- Servings of individual ingredient types (carbs, potassium...)
- Servings of courser food groups (grains, milk products...)
- Course amount ratings (a little, a lot)
- We don't care about the amount



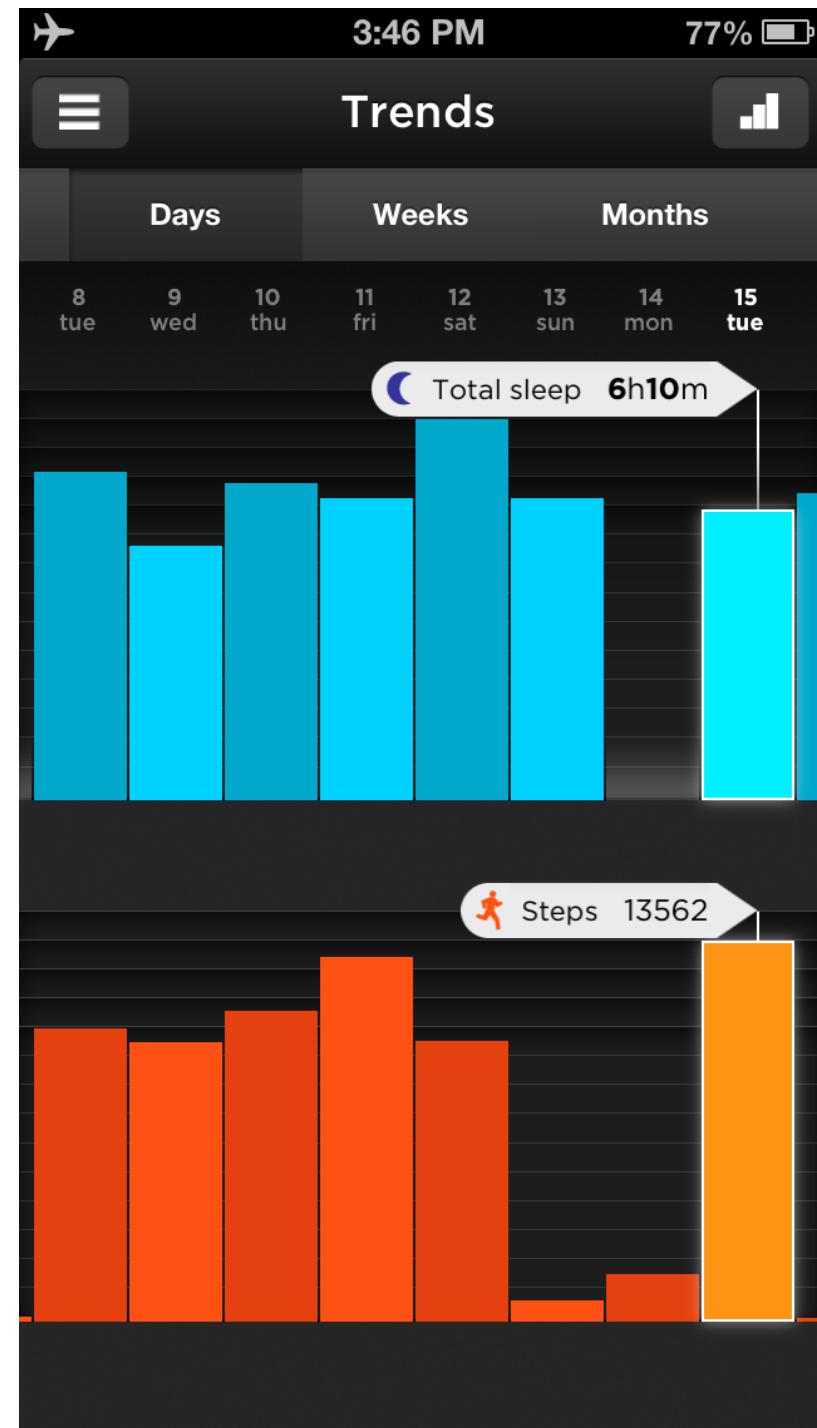
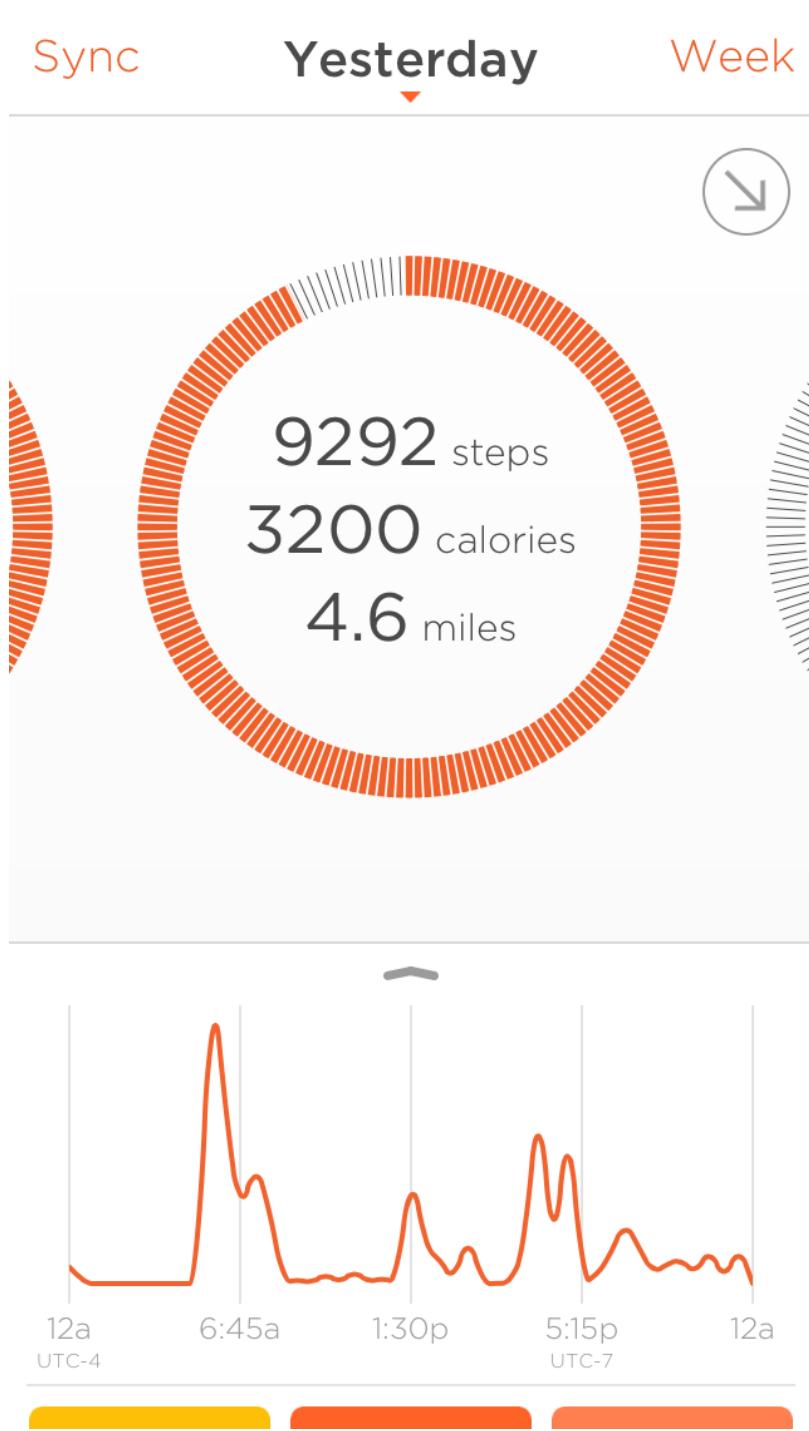
Very little      A lot

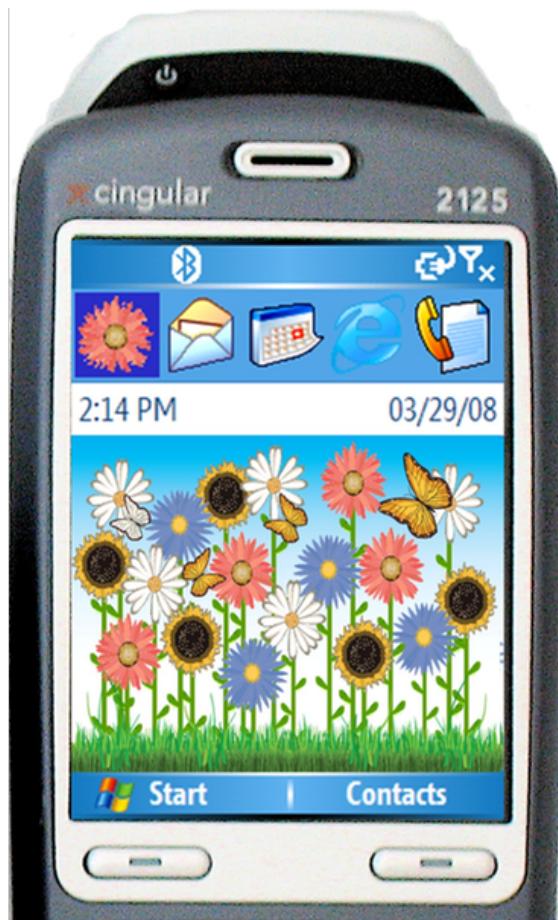
# Trade-offs of tracking options

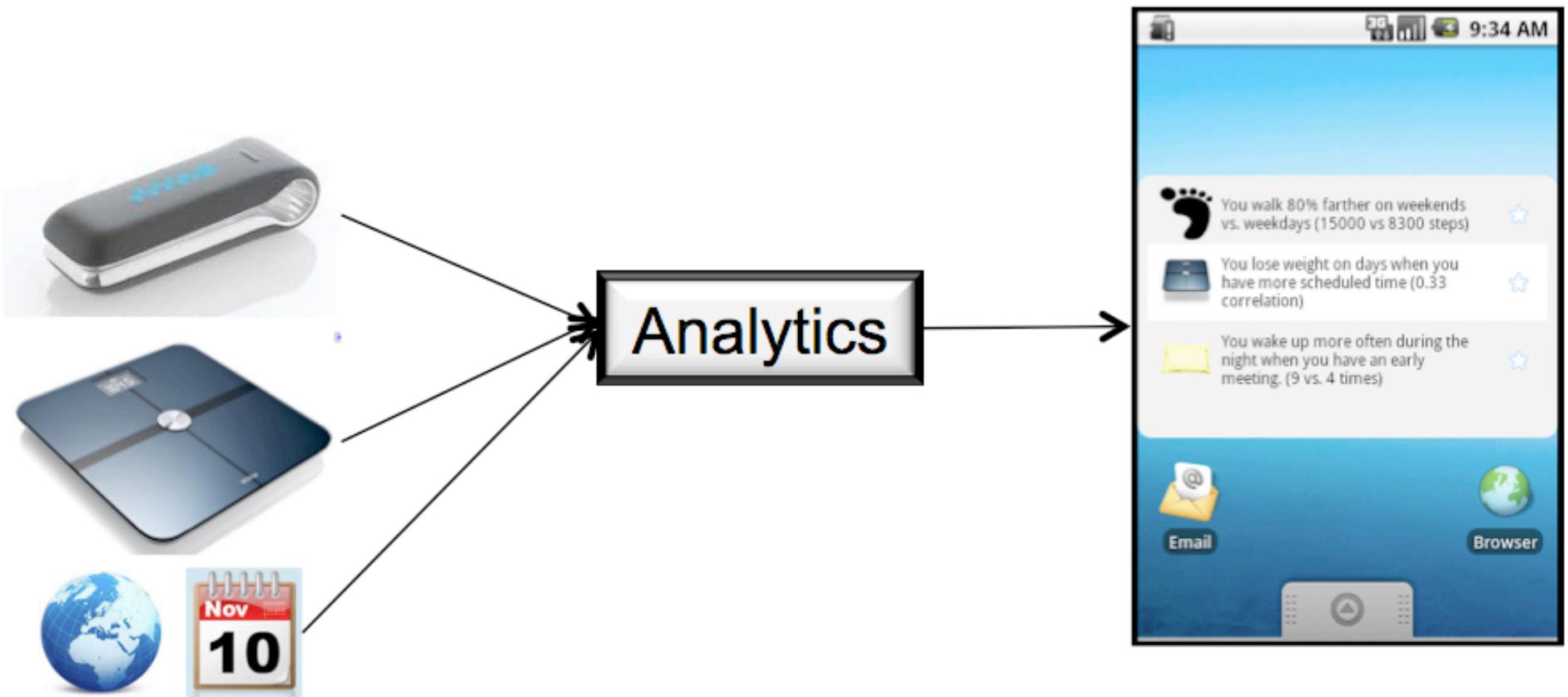
- How much work/burden it is to use them
- For what data can be used
  - What kind of feedback can be created from the data
  - What kinds of patterns of interaction can be established in the data
- Who has access to the data
- How potentially sensitive the data is
- How usable the system is
  - does it require another device, how socially acceptable tracking is...

# Forms of Feedback

- Counts
- Graphs
- Stylized representations
- Narrative feedback







# Question for Feedback Design

- Why: What purpose is the feedback serving?
- Where: Where should the feedback be shown?
- How: In what form should the feedback be presented?
- When: When and how often should the feedback be displayed?
- Who? Who is feedback aimed at?

# UbiFit



Consolvo et al. 2008. Flowers or a robot army?: Encouraging awareness & activity with personal, mobile displays . Proc UbiComp 2008., p. 54–63.

# ubifit



## garden design



# Health behavior and behavioral economics

# Behavioral economics conception of self-control

- Focus: Process of choosing among behavioral alternatives at a given moment
- Self-control conflict
  - smaller-soon reward vs. larger-later reward
  - smaller-sooner cost vs. larger-later cost
- Self-control is choosing the former
- Impulsiveness is choosing the latter

# Self-control problem in a nutshell

While in the abstract we prefer behaviors that lead to larger-later rewards, our preference often shifts as the moment of choice approaches.

This is “simple ambivalence” (Rachlin, 2000)



“the trouble with an alarm clock is that what seems sensible when you set it seems absurd when it goes off.”

# Some strategies for facilitating self-control

- Commitment: Adding substantial cost to behaviors with smaller-sooner rewards

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The smartest way to set and achieve your goals

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I commit to

(Select your Goal)

start  
Now!

Be on time, study hard, lose weight, no more debt, more time with family, better sleep schedule, eat better, go back to the gym, help others, go jogging, learn something new...

1 Select your goal



2 Set the stakes  
money is optional



3 Get a referee



4 Add

## Who's stickKing?



Nicx0r

Work 35 billable hours each week

## In the news

TIME

BBC

CBS

## The num



\$17  
dollar

# Some strategies for facilitating self-control

- Adding value to desired alternatives

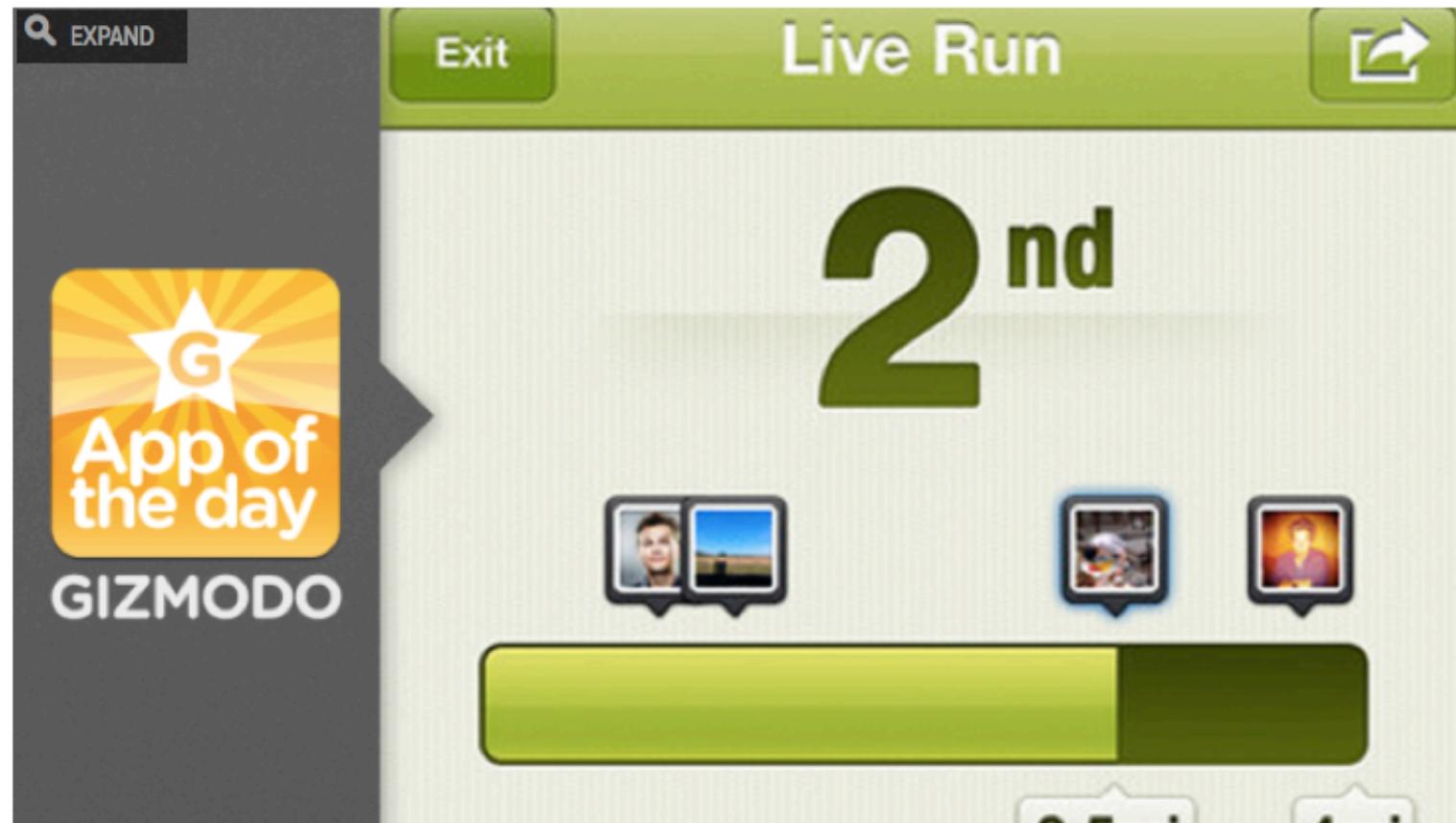
# Yog: Find New Running Buddies



Leslie Horn

Filed to: APP OF THE DAY 12/18/12 6:00pm

5,517



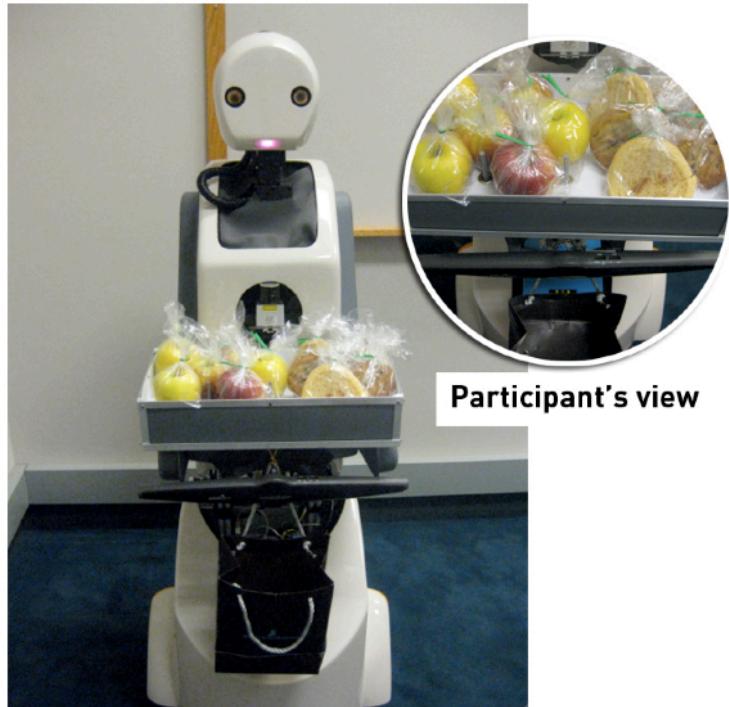
Running is a lot easier when you have someone to help you keep pace. Don't know any runners? [Yog](#) is an easy way to find them.

# Other strategies for facilitating self-control

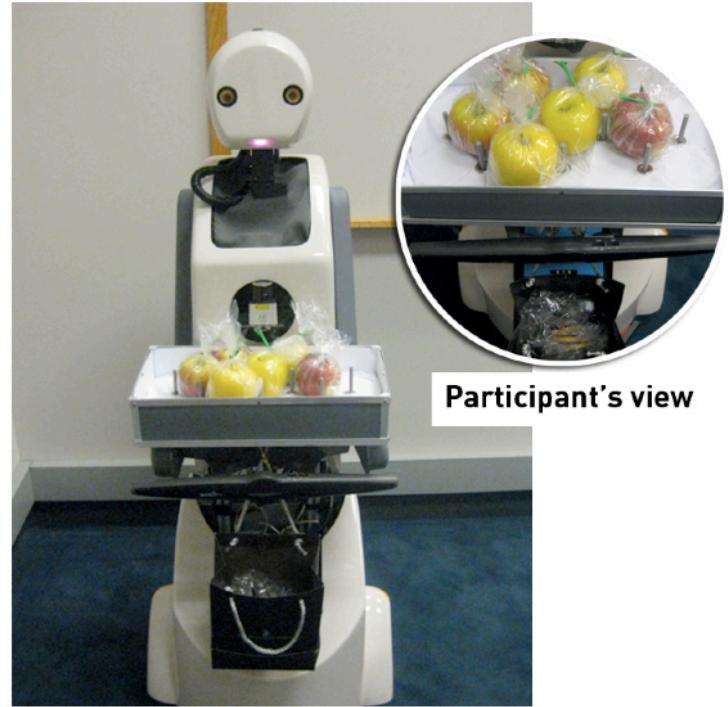
- Make healthy options the default (default bias)
- Make health goals and benefits more cognitively accessible (the availability bias)
- Increase perceived value of healthy options by contrasting them with clearly inferior choices (asymmetric dominated choice)
- Frame choices in terms of patterns, not acts.



**Control Condition**



**Default Condition**



# Some questions

- What are the differences in how theory was used in Ubifit vs. Snackbot?
- What are the tradeoffs of the evaluation strategies that were used for the two systems?

# Evaluation in BCT design

# Roles of Evaluation

- Help determine how to implement a particular feature
- Test whether the system is doing what it is supposed to be doing (theoretical fidelity)
- Gain insights about users' experience of using the system
- Test if the system is affecting distal health outcomes in ideal conditions (efficacy)
- Test if the system is affecting distal health outcomes in real-world conditions (effectiveness)

# Roles of Evaluation in HCI

- Help determine how to implement a particular feature
- Test whether the system is doing what it is supposed to be doing (theoretical fidelity)
- Gain insights about users' experience of using the system
- Test if the system is affecting intended distal health outcomes in ideal conditions (efficacy)
- Test if the system is affecting distal health outcomes in real-world conditions (effectiveness)

# Evaluation for feature design

- Goal: select among several different ways a feature can be implemented
- Criteria:
  - user preference and/or experience
  - efficacy for proximal outcomes
- Methods
  - Surveys
  - Single-case studies
  - Randomized between-subject studies (when possible)

# Theoretical fidelity

- Goal: Determine if a feature is doing what and how it is intended to do it.
- Key question: are intervention components having intended *proximal main effects*?
- Methods:
  - A priori examples for coding interview data from formative evaluations
  - Micro-randomized trials

# Proximal outcomes

Proximal outcomes: mediators of the behavior-change process

- Daily steps
  - Craving intensity
  - Cognitive accessibility of health goals
  - Goal commitment
  - Knowledge
- ...

# Qualitative analysis for theoretical-fidelity testing



UbiFit participants' statements about:

- being reminded about their goals
- noticing opportunities to be active

A priori code book of statements  
that would count as evidence of  
effects of an intervention component

# Micro-randomized trials

# Primary Goal of MRTs

Most BCTs are multi-component interventions

First question to answer: Do intervention components have the intended proximal effects?

We want to test for proximal *main effects* of intervention components

# MRTs in a Nutshell

1. Randomize delivery of a push intervention component each time that component may be delivered
2. Capture at each randomization...
  - Proximal outcome for randomized component
  - Contextual factors that may influence response
3. Model
  - Component's time-varying causal effects
  - Time-varying contextual moderation of effects

# Why Micro-Randomization

- Factorial designs: gold standard for studying effectiveness of intervention components of a complex intervention
- Randomization (+ representative sample): gold standard for establishing causal effects
- Sequential randomization: enables estimation of time-varying effects

# What We Learn From MRTs

- Does a component have a proximal main effect and how does that effect change over time?
- Does a component have unintended effects and how they change over time?
- How is a component's effect moderated by time-varying contextual factors (e.g., location, weather, level of busyness)?
- Does a component have a lagged effect?