Social Applications for *Inbodied Interaction*: Improving Health Outcomes by Integrating Personal Knowledge, Community, and Data

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ABSTRACT

People develop intuitions about their health and performance from lived experiences. However, they lack a conceptual framework to understand the interactions between different components of health. Additionally, devices and apps track data about some activities but provide limited support towards setting and achieving important health goals. Combining people's talents (curiosity, motivation, and intuitions) with appropriate data tracking can help promote general wellbeing, especially when used with a holistic framework like *inbodied interaction*. However, reasoning in a new framework can add to the difficulty and burden of making lifestyle changes. Drawing on lessons from *Gut Instinct* (gutinstinct.ucsd.edu)—a microbiome citizen science platform used by 600 voluntary participants from 30 countries—this submission proposes an architecture integrating just-in-time learning resources, hands-on doing, and social computing for people to understand and test ideas about their health. Collaboration between social computing and inbodied interaction researchers can help scale the reach and impact of this research towards holistic health outcomes.

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KEYWORDS
Social computing systems; citizen science; crowdsourcing; online learning.

INTRODUCTION: THE PROMISE OF PEOPLE UNDERSTANDING AND IMPROVING THEIR HEALTH

People have incomplete/incorrect mental models of how their activities affect their health. For example, many believe 8 hours of sleep implies good rest without considering the effect of circadian rhythm. Furthermore, digital tools encourage tracking and interacting with data in ways that do not enable answering complex, useful questions. For example, "how much did I sleep last night" provides a specific value while "which factors affected my sleep over the last month" creates actionable knowledge. The combination of poor mental models and reliance on data causes two issues.

1. **People focus on narrow health goals**—e.g. weight loss—rather than framing a higher-order question that builds on the interactions among multiple dimensions of wellbeing—e.g. improved dietary practices as a function of sleep, physical activity, and social eating.
2. **People create incorrect or incomplete "intuitive" causal relations** between activities and health outcomes. *E.g.*, Eating cookies and gaining weight can lead to the inference that weight loss *requires* not eating cookies when there might be multiple hidden variables (e.g. poor sleep) driving both these activities.

This paper suggests that a **limited understanding of 'under the hood' working of the human body** is the primary reason people and digital tools are limited in making meaningful changes to their health outcomes. This submission proposes improving popular understanding of the body's processes works by integrating conceptual knowledge and hands-on doing. Specifically, this submission proposes directly tackling these two problems by enabling people to:

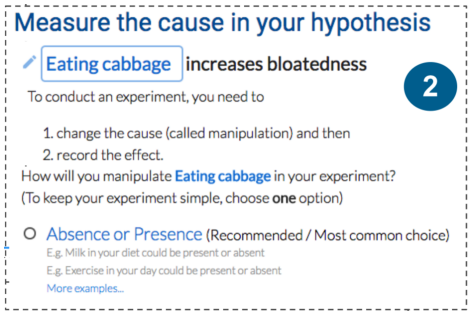
1. build conceptual models of the human body and health processes using just-in-time learning resources
2. develop an improved "intuitive" understanding of causality between activities and health outcomes by performing hands-on interventions and learning from the results

These ideas can be embedded in a social computing platform for people to brainstorm and share their interventions, outcomes, and lessons.

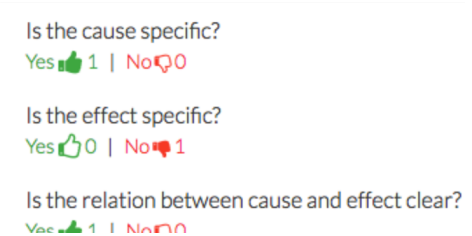
AN ANALOGOUS PROBLEM: COMMUNITY-DRIVEN SCIENTIFIC WORK

The challenges with narrow focus and intuitive beliefs show up in another setting: discussions on online health fora. Community-driven approaches to understand personal health and wellbeing largely reside outside the realm of institutional science and medicine. While some fads and beliefs are questionable at best, on occasion these communities' focus on specific questions breaks new ground that may provide widespread value, such as fecal transplants to alleviate Clostridium difficile infection symptoms. However, for every intuition proven right, many more may be closer to snake oil — e.g., the widespread belief in the utility of probiotics despite limited evidence [1].

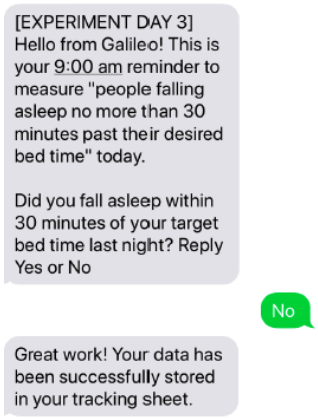
The Design-Review-Run workflow to test hypotheses



Design experiments using scaffolded procedural learning



Review: Community members improve the design



Run the experiment

People develop intuitions of cause and effect that may or may not be correct. These concerns—narrow focus on some topics and beliefs of causality despite limited evidence—parallel the challenges with enabling holistic health outcomes. Might communities' focus and efforts be guided towards useful results? Can people crystallize intuitions to create personally meaningful knowledge in a relevant scientific discipline?

Microbiome research provides a petri dish for personally meaningful efforts towards understanding and improving health. The human microbiome is the collection of all microbes and their genetic components in and on our bodies. It is highly personal: each of us hosts a different collection of microbes, and this collection is influenced by our environment, diet, health, lifestyle, and genetics. Surveys by the American Gut Project has revealed lifestyle-microbiome correlations of dog ownership and beer or vegetable consumption, among others [2]. However, few people have up-to-date and accurate knowledge about the microbiome, even to the extent that it exists.

My dissertation research with *Gut Instinct* (gutinstinct.ucsd.edu) has enabled online communities to contribute to microbiome research. In the process, this research has tackled problems in public participation that are similar to those underpinning holistic health efforts: 1) narrow focus, 2) flawed causality ideas, and 3) limited knowledge of biological systems.

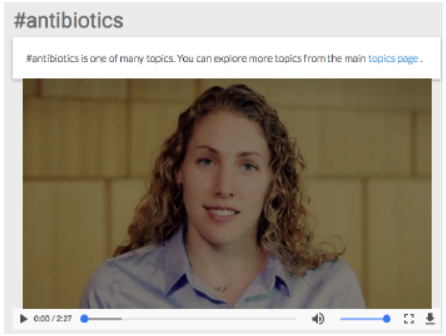
CASE STUDY: GUT INSTINCT SUPPORTS KNOWING AND DOING BY INTEGRATING CONCEPTUAL LEARNING AND PROCEDURAL TRAINING

Gut Instinct platform enables anyone to transform their intuitions to hypotheses and then design and run experiments to test them [3–5]. Gut Instinct integrates conceptual learning embedded via short lectures and software-guided procedural learning to enable designing and reviewing experiments. Participants from around the world collaboratively create hypotheses, join experiments, follow instructions, and provide data in response to automated data collection reminders. Gut Instinct operationalizes one central insight: **integrating conceptual learning with task-specific scaffolding enables personally meaningful & useful scientific work**.

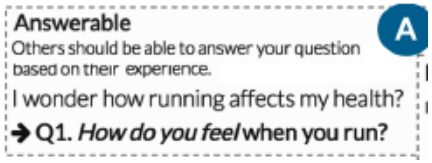
Example of a Social Workflow: Design-Review-Run: From Hypotheses to Investigations

To test their theories, end users design structurally-sound experiments, improve them via community reviews, and run them with other participants. Creating multiple roles (like experimenter, reviewer, participant) to organize multi-party collaboration into complementary tasks provides people with the flexibility to choose how much they'd like to contribute. Once underway, Gut Instinct sends condition-specific text messages to all participants: a beginning and end of experiment message, a daily reminder, and daily data collection messages.

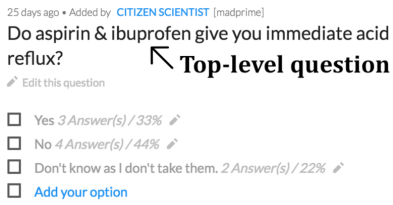
The Learn-Train-Do workflow integrates conceptual learning and procedural training



Learn: **Conceptual understanding via lectures**



Train: **"How to" instructions using procedural training**



Do: Perform **the activity in a social setting**

Results from experimentation: An online community of 37 volunteers ran the world's first citizen-led experiment about the effect of kombucha on stool consistency. Bowel movement is an important predictor of our health. Apart from data about kombucha consumption and stool consistency, participants shared and learnt about their health and provided ideas for further investigations.
P17: "..recording bowel movements makes me self-conscious of the frequency of my bowel movements. It is to be studied whether this self-awareness affects bowel movement frequency."

Learning and Training Improve Quality of Work: Controlled experiments show that participants create better hypotheses and experimental designs when they have access to procedural training. 344 voluntary participants from 27 countries created 399 hypotheses, 75 (19%) of which microbiome experts found potentially scientifically novel. A 2x2 between-subjects study tested the effect of conceptual knowledge and procedural training on participants' question quality. Training improved overall question quality (M= 0.31, vs. M= 0.47); Learning improved question content (M= 0.06, vs. M= 0.11). Different roles emerged, from leaders who perform all the activities to lurkers who may watch but not actively engage in the question-asking activity.

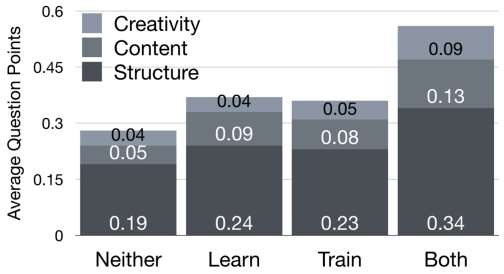
EXPECTED CONTRIBUTIONS AT THE WORKSHOP

Drawing from Gut Instinct's lessons, this submission proposes designing social applications for interventions built on inbodied interactions. Adding the social lens brings in unique challenges and opportunities.

1) *Improved understanding via learning and ideation*: Updating people's models of the human body using byte-sized learning resources and discussions can help them make meaningful contributions and reduce wasted efforts. Following this with basic daily tracking can help people see the interaction between different bodily processes and generate more realistic hypotheses.
2) *Experiential learning via social experimentation:* Enabling people to think in terms of interventions to test their intuitions can help foster scientific thinking & evidence-based reasoning. Building social architectures to enable complex tasks (like experimentation) can help improve motivation, provide peer support to debug issues, and improve task completion rates [6]. However, social settings also enforce patterns of contributions and progress rates that some might find irritable. Enabling personalization of a social experiment can tackle this. For instance, apart from the effect variable of an experiment, people can decide to track measures of their own interest as well, creating of stack of experiments

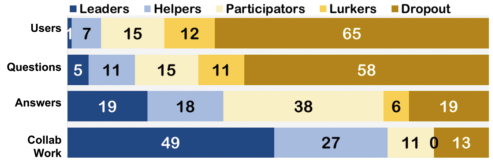
Sharing personal lessons: People's insights towards solving their problems shape the design of social HCI systems. Workshop attendees' experiences making holistic health changes will help inform design of social applications for inbodied interactions. I look forward to sharing lessons from my

Some Results from Gut Instinct



Learning and Training improve quality of questions (N=344); 75/399 hypotheses were rated novel

Role	Actions
Leader	Add questions, answer & edit others' questions, add follow-ups, discuss
Helper	Add & answer questions, add follow-ups
Participator	Answer questions
Lurker	Add questions but no collaborative work
Dropout	Add a question; never return



People take different roles online

A citizen-led kombucha experiment found evidence for the hypothesis "drinking kombucha improves stool consistency" and created ideas for new experiments

efforts modifying my digital habits, aligning my activities with the circadian rhythm, and changing diet based on (still nascent) microbiome science.

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