

Gut Instinct

Creating Scientific Theories with Online Learners

UC San Diego

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Citizen scientists have successfully solved expert-defined problems as “sensors” or “algorithms”



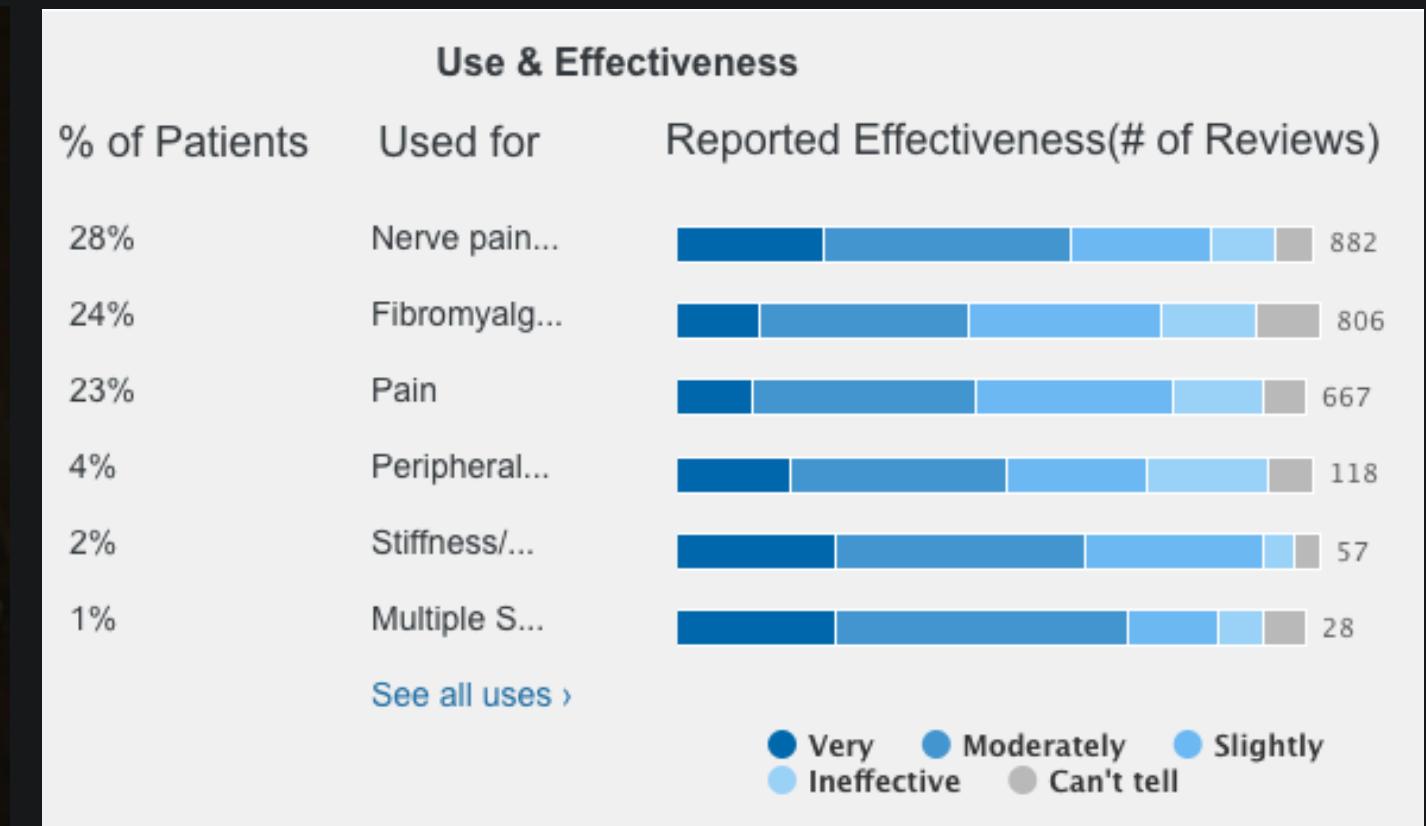
Tracking bird migration

eBird [Sullivan et al. 2009]

Folding proteins

Foldit [Cooper et al. 2010]

Powerful ideas emerge when people combine data with personal insights



Genomics
23andme

Microbiome
American Gut

Medicine effects
Patientslikeme



[A Baffling Brain Defect Is Linked to Gut Bacteria, Scientists Say](#)



VOICES
A Suicide Therapist's Secret Past

PAID POST: TROPICANA
Why Making Orange Juice Is Not as Easy as You Think



PHYS ED
Noisy Knees? Arthritis May Be in Your Future



Why Everything We Know About Salt May Be Wrong

A Baffling Brain Defect Is Linked to Gut Bacteria, Scientists Say

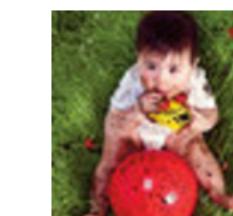
By GINA KOLATA MAY 10, 2017



RELATED COVERAGE



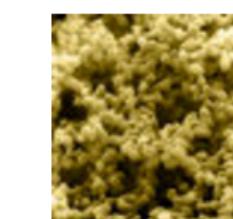
THE NEW HEALTH CARE
[Exciting Microbe Research? Temper That Giddy Feeling in Your Gut](#) MARCH 6, 2017



[Say Hello to the 100 Trillion Bacteria That Make Up Your Microbiome](#) MAY 15, 2013



[Scientists Urge National Initiative on Microbiomes](#) OCT. 28, 2015



TAKE A NUMBER
[40 Trillion Bacteria on and in Us? Fewer Than We Thought.](#) FEB. 15, 2016

Scientists' questions can miss contextual insights

Do you think you'd perform better in a sprint or in a longer distance race?

-
- Sprint race
 - Longer distance race
 - Both - I'm like the wind
 - Neither

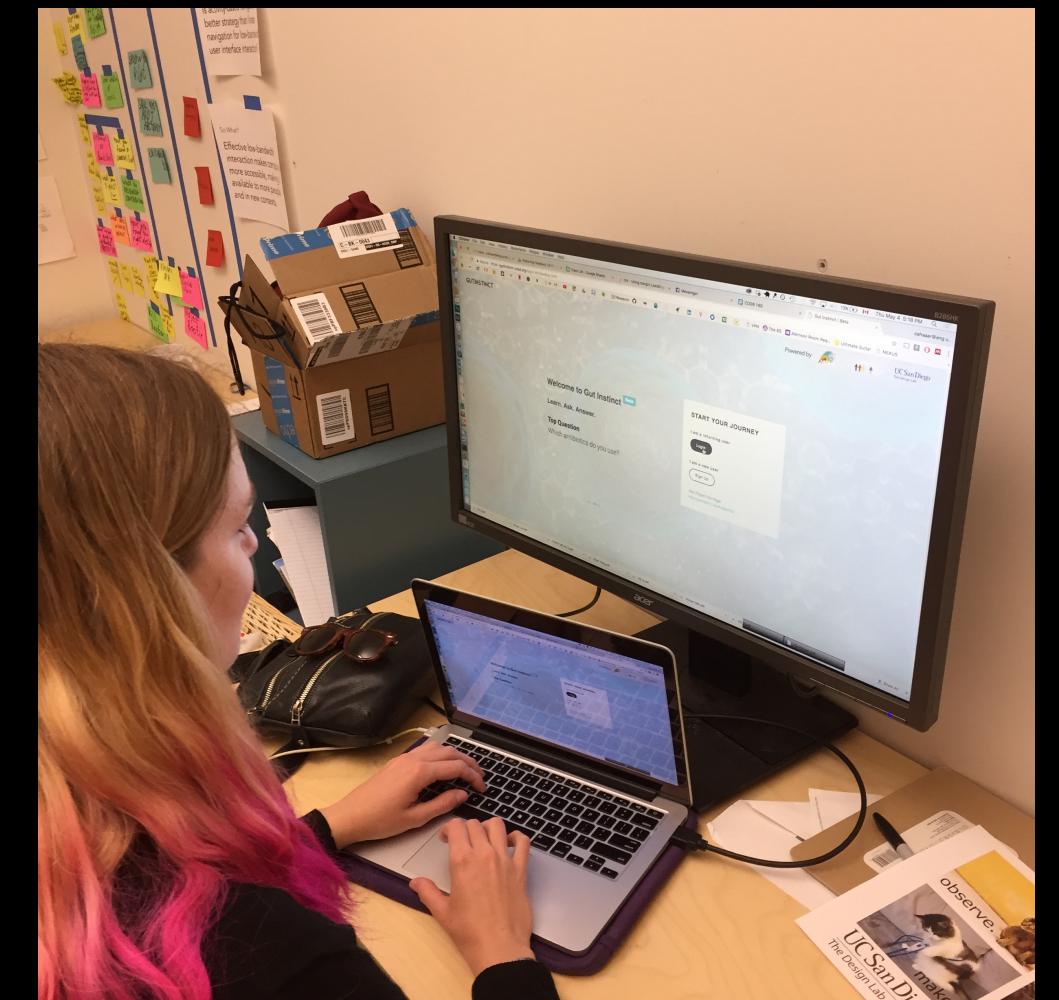
How might people's situated knowledge supplement ivory tower science?

Please chew with
your mouth shut.



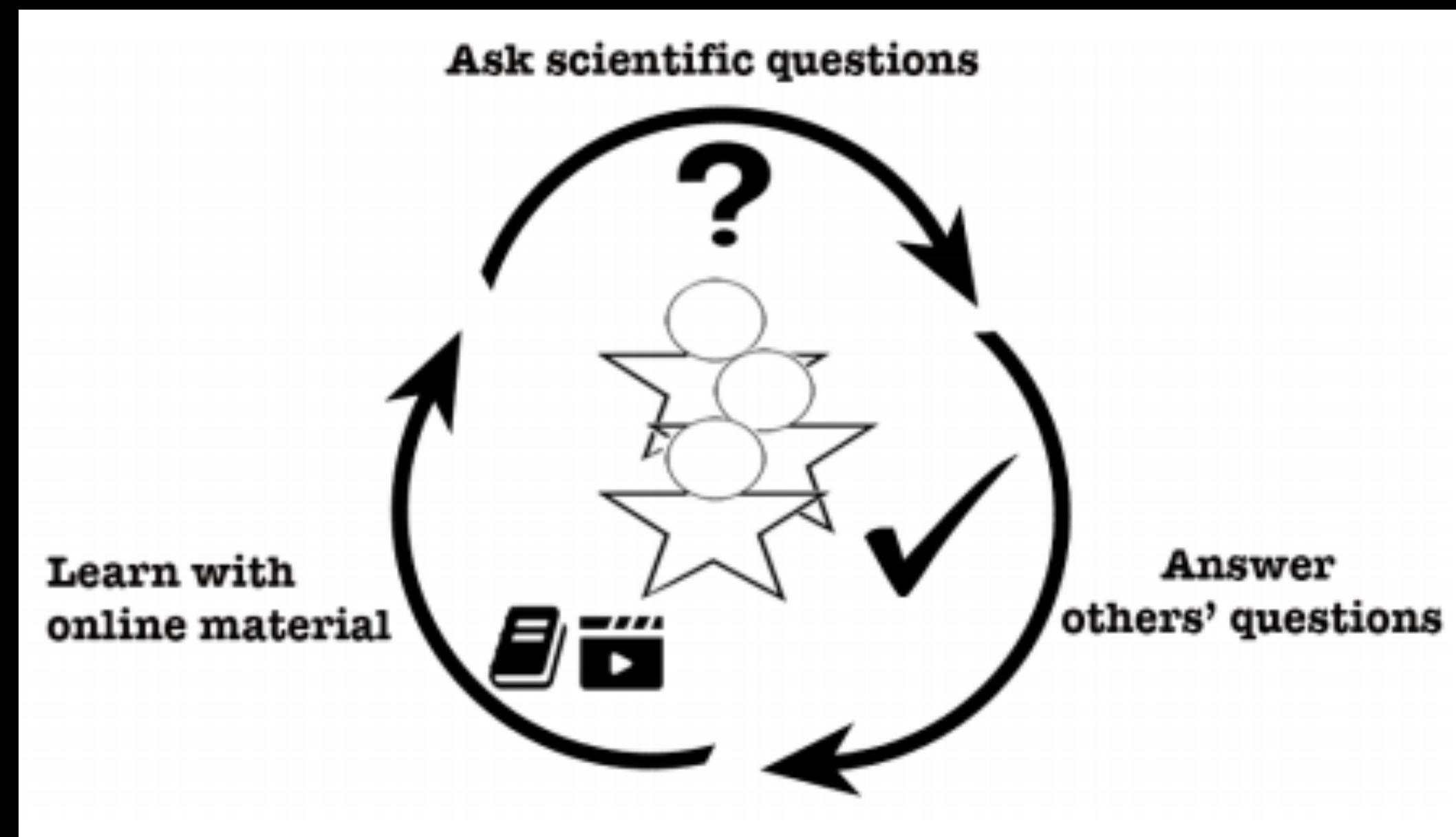
Can curious people perform scientific work while meeting their needs?

Contribute scientific hypotheses based on lifestyle



Use scientific knowledge to identify lifestyle choices

Gut Instinct integrates learning and asking questions about nascent science

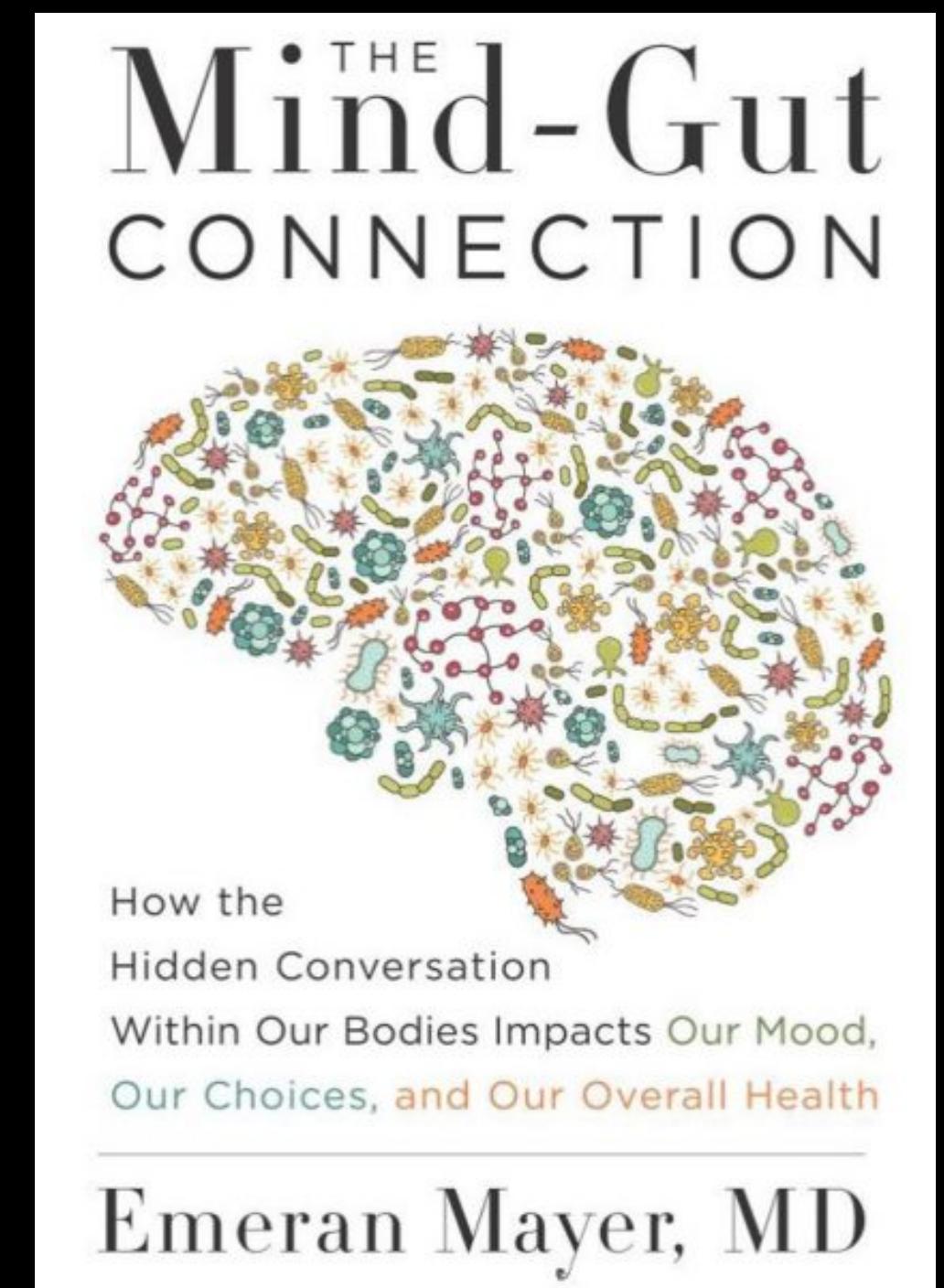


gutinstinct.ucsd.edu

Understanding the human microbiome requires insights into people's lifestyles

- Microbiome = Collection of all microbes and their genes in our body
- Extremely personal; shows drastic effects on health

Men infected with Toxoplasma gondii tend to be rule-breakers, while infected women are more sociable [Flegr et al. 1996]



Results: 10 of 29

participants'

questions matched

researchers' questions

(we think this is good)

- Do you drink soylent regularly?**
- Do you eat red meat so often?**
- Do you use the treadmill at the gym?**
- Do you take any meal replacements such as protein powders?**
- Do you smoke?**
- Do you poop regularly?**
- Were you not breast fed as a child?**
- Are you regular got drunk?**
- Do you exercise regularly or have enough physical activities?**
- Do you sleep at least 7-8 hours a night?**
- Have you quit smoking in the past?
- Do you eat hot (spicy) food often?
- Did you ever switch from a meat based diet to a vegan diet or vice versa?
- Do you eat meals while working?
- Do you eat raw meat?
- Do you smoke weed ?
- Do you just eat 1-2 meals a day ?
- Do you eat probiotic yogurt?
- Do you think you have a belly?
- Do you eat probiotic yogurt?
- Do you have really bad smelling poop?
- Do you eat blueberries regularly?
- Do you drink coffee?
- Do you often feel fatigued?
- Are you a morning person ?
- Do you follow a sleep cycle?
- Do you use antibacterial soap?
- Do you wash your hands everytime you use the bathroom?
- Do you follow a specific diet?

Step 1: Answer questions created by other participants

The screenshot shows a web browser window with the URL <https://hde.gutinstinct-ucsd.org...>. The page title is "GutBoard Straight from the Gut" with the subtitle "How do your Gut Instincts compare to others?". It features a blue speech bubble icon. Below the title are three buttons: "ALL QUESTIONS! 21", "BOOKMARKED 0", and "WRITTEN 0". A question is listed: "Does consuming alcohol affect your bowel movements?". It was posted 10 days ago by "CITIZEN SCIENTISTS". The question has four options: "Yes 1 Answer(s) / 50%", "No 0 Answer(s) / 0%", "Does consume more than 3 beers to day affect your bowel movements? 1 Answer(s) / 50%", and "Add my option". There is a red star icon next to the last option. Below the options are buttons for "Save my choice(s)" and a list of tags: beer, wine, liquor, alcohol, poop, bowelmovements. At the bottom is a comment section with a speech bubble icon and "(1 comment)".

Step 1a:

Answer follow-up questions created by other participants

Dive deeper with these follow-up questions!

What type of alcoholic drinks (ex wine, beer, liquor, mixed with sugar) affect your bowel movements?

- wine
- beer
- liquor
- sugary mixed drinks
- Add my option

[Save my choice\(s\)](#)

[Skip](#)

How many drinks does it take to notice a difference in your bowel movements?

- 1-2
- 3-4
- 5+
- Add my option

[Save my choice\(s\)](#)

[Skip](#)

Step 2: Ask questions

The screenshot shows a web browser window with a blue header bar. The address bar displays a secure connection to <https://gutinstinct-ucsd.org/>. Below the header is a dark blue navigation bar with a small white icon. The main content area features a logo with a speech bubble icon followed by the text "GutBoard" and "Straight from the Gut". A large light blue callout box contains the text "Add your Gut Instinct here!" and a vertical list of seven steps:

- Step 1: Add top-level question and options
- Step 2: Add follow-up question and options
- Step 3: Add more follow up questions
- Step 4: Start a discussion
- Step 5: Add tags
- Step 6: Add a URL/ Attach a file!
- Step 7: Review and submit

Step 2a: Ask questions

Add your Gut Instinct here!

Step 1: Add top-level question and options

Think of interesting questions that are personally relevant to you! Many crazy ideas have led to amazing discoveries, esp for gut microbiome - so don't shy away!

sample: How frequently do you eat probiotic yogurt?

Option 1:

enter your option here

[ADD MORE OPTIONS](#) [SAVE&NEXT](#)

Step 3: Learn about the scientific domain

Secure | <https://hde.gutinstinct-ucsd.org/topics>

Confused? Add your question! Topics Guide GutBoard Notifications

Follow Your Gut

Choose among following topics to understand your gut!



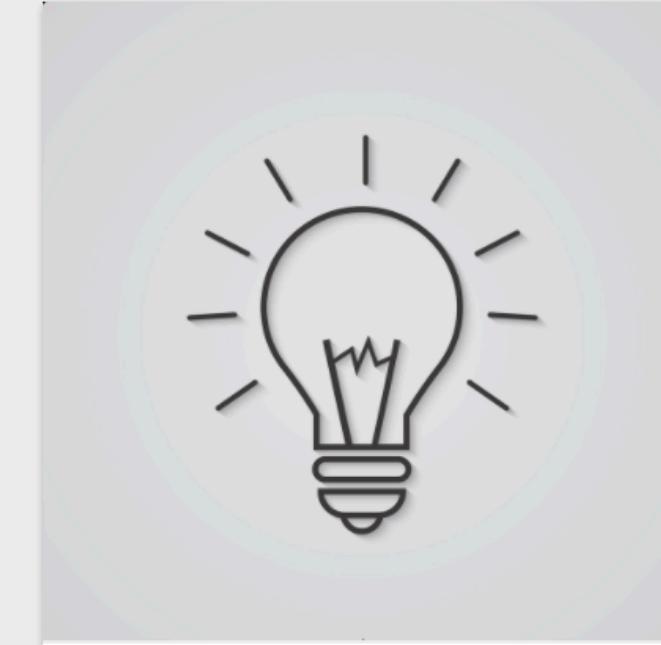
Genetics



Physiology



Probiotics

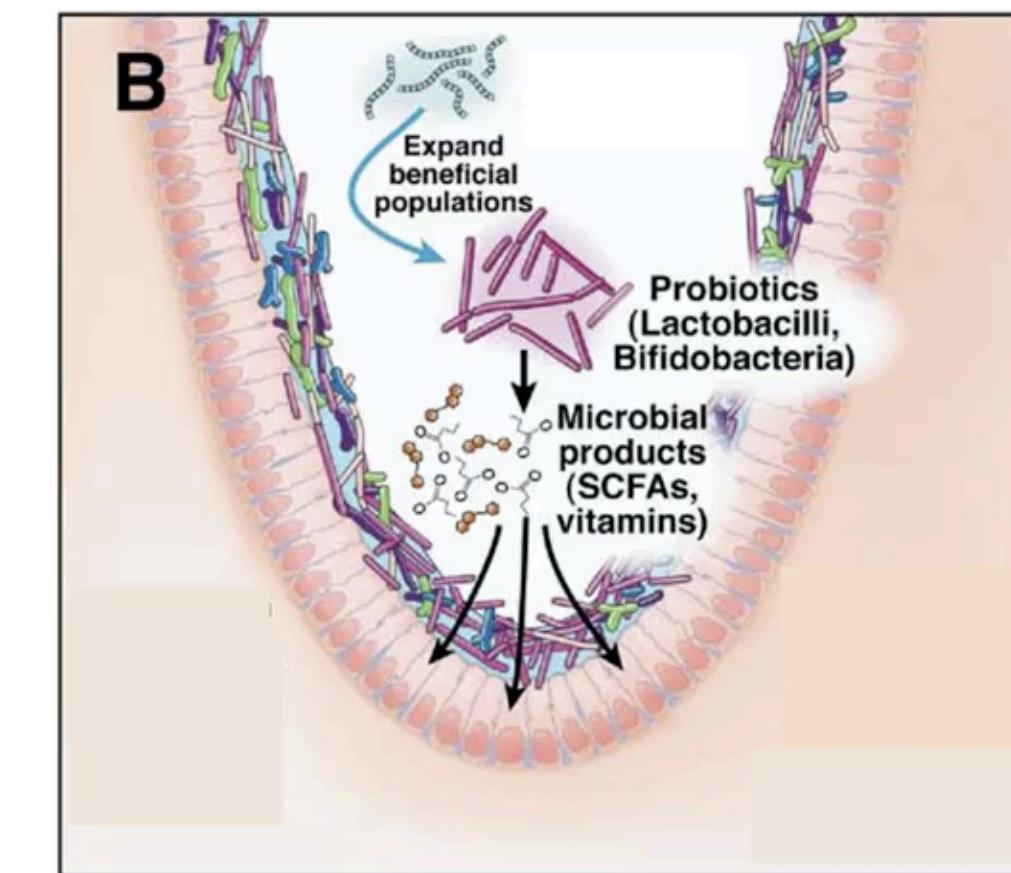


Introduction

Step 3a: Learn about #antibiotics



Photo credit: Creative Commons License



Preidis and Versalovic 2009, Gastroenterology

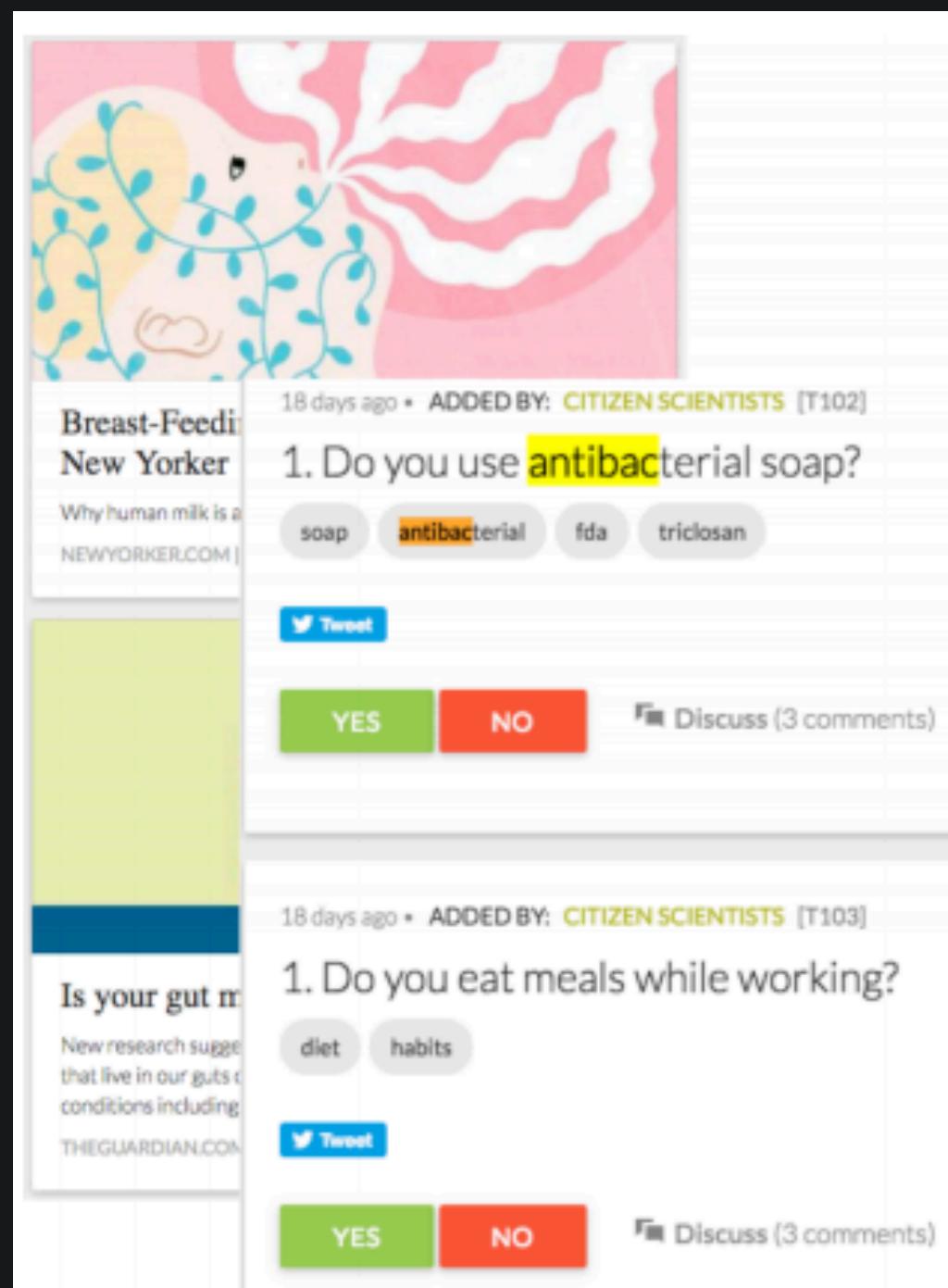
Hypotheses for Dual-objective online learning systems

H1 Learning improves quality of work
on relevant problems.

H2 Working on relevant real-world
problems improves learning.

Between-subjects experiment (N=44) w/ 3 conditions; Lab study followed by 3-day use

Between-subjects experiment (N=44) w/ 3 conditions: *Contribute, Learn, & Combined*



(1) Contribute

Between-subjects experiment (N=44) w/ 3 conditions: *Contribute, Learn, & Combined*

The screenshot shows a mobile application interface with two main sections:

- Post 1:** Title: "Breast-Feeding New Yorker". Content: "1. Do you use antibacterial soap?". Options: "YES" (green button) and "NO" (red button). Below the question: "18 days ago • ADDED BY: CITIZEN SCIENTISTS [T102]". Tags: "soap", "antibacterial", "fda", "triclosan". Buttons: "Tweet" (blue), "Discuss (3 comments)" (grey).
- Post 2:** Title: "Is your gut microbiome healthy?". Content: "1. Do you eat meals while working?". Options: "YES" (green button) and "NO" (red button). Below the question: "18 days ago • ADDED BY: CITIZEN SCIENTISTS [T103]". Tags: "diet", "habits". Buttons: "Tweet" (blue), "Discuss (3 comments)" (grey).

(1) Contribute

The screenshot shows a mobile application interface titled "#diet". It includes a scatter plot and the following content:

- Scatter Plot:** A PCA plot showing gut microbiome samples from US, Malawians, and Amerindians.
- Question 1:** "Which of these is not true? Germ-free mice have: Incorrect. Attempted 4 times." Options:
 - Similar immune activity to normal mice
 - Reduced immune activity
 - Fewer immune cells
 - Increased rates of infection
- Question 2:** "Does short-term diet... Correct! Rapid changes in short microbiome. Consuming only fat the video for more." Options:
 - Yes, but it cannot cause diarrhea
 - Yes, it can cause huge swings
 - No, it does not have influence
 - Researchers just don't know
- Question 3:** "Leaky gut refers to: Correct. Attempted 3 times." Options:
 - Diarrhea after consumption of certain synthetic fats, such as olestra
 - Short-chain fatty acids getting into the gut epithelium
 - Bacteria passing across the gut epithelial membrane
 - Food passing across the gut into the bloodstream more than it should

(2) Learn

Between-subjects experiment (N=44) w/ 3 conditions: *Contribute, Learn, & Combined*

Breast-Feeding New Yorker
Why human milk is a
NEWYORKER.COM |

Is your gut microbiome
New research suggests that live in our guts can affect our health and conditions including
THEGUARDIAN.COM

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T102]

1. Do you use antibacterial soap?

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T103]

1. Do you eat meals while working?

#diet

#diet is one of many topics. You can explore more topics from the main [topics page](#).

c
US Malawians Amerindians

PC2 (6.6%) from UniFrac distance

Which of these is not true? Germ-free mice have:
Incorrect. Attempted 4 times.

- Similar immune activity to normal mice
- Reduced immune activity
- Fewer immune cells
- Increased rates of infection

SUBMIT

Click here to discuss about this question

Does short-term diet

Correct! Rapid changes in short microbiome. Consuming only fast food can lead to a leaky gut. Watch the video for more.

Leaky gut refers to:

Correct. Attempted 3 times.

- Yes, but it cannot cause diarrhea
- Yes, it can cause huge swings in blood sugar levels
- No, it does not have influence on health
- Researchers just don't know

SUBMIT

Click here to discuss about this question

#diet

#diet is one of many topics. You can explore more topics from the main [topics page](#).

c
US Malawians Amerindians

PC2 (6.6%) from UniFrac distance

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T102]

1. Do you use antibacterial soap?

18 days ago • ADDED BY: CITIZEN SCIENTISTS [T103]

1. Do you eat meals while working?

(1) Contribute

(2) Learn

(3) Combined

Measures

- Questions: Novelty and usefulness
(measured by blind, independent raters)
- Learning: Score on summative test

Results: 10 of 29
participants'
questions match official
American Gut survey
(we think this is good)

- Do you drink soylent regularly?**
- Do you eat red meat so often?**
- Do you use the treadmill at the gym?**
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- Do you follow a sleep cycle?
- Do you use antibacterial soap?
- Do you wash your hands everytime you use the bathroom?
- Do you follow a specific diet?

Challenge: Gut Instinct questions are not framed as hypotheses

1. Do you drink soylent regularly?

diet soylent

[Tweet](#)

[YES](#) [NO](#) [Discuss \(1 comment\)](#)

12% said "Yes" and 88% said "No"

2. If so, have you noticed any specific changes in your lifestyle? For example, do you get hungry more often or do you feel more energetic?

Score: 5/6

(Novelty: 2, Usefulness: 3)

1. Do you think you have a belly?

exercise

[Tweet](#)

[YES](#) [NO](#) [Discuss \(2 comments\)](#)

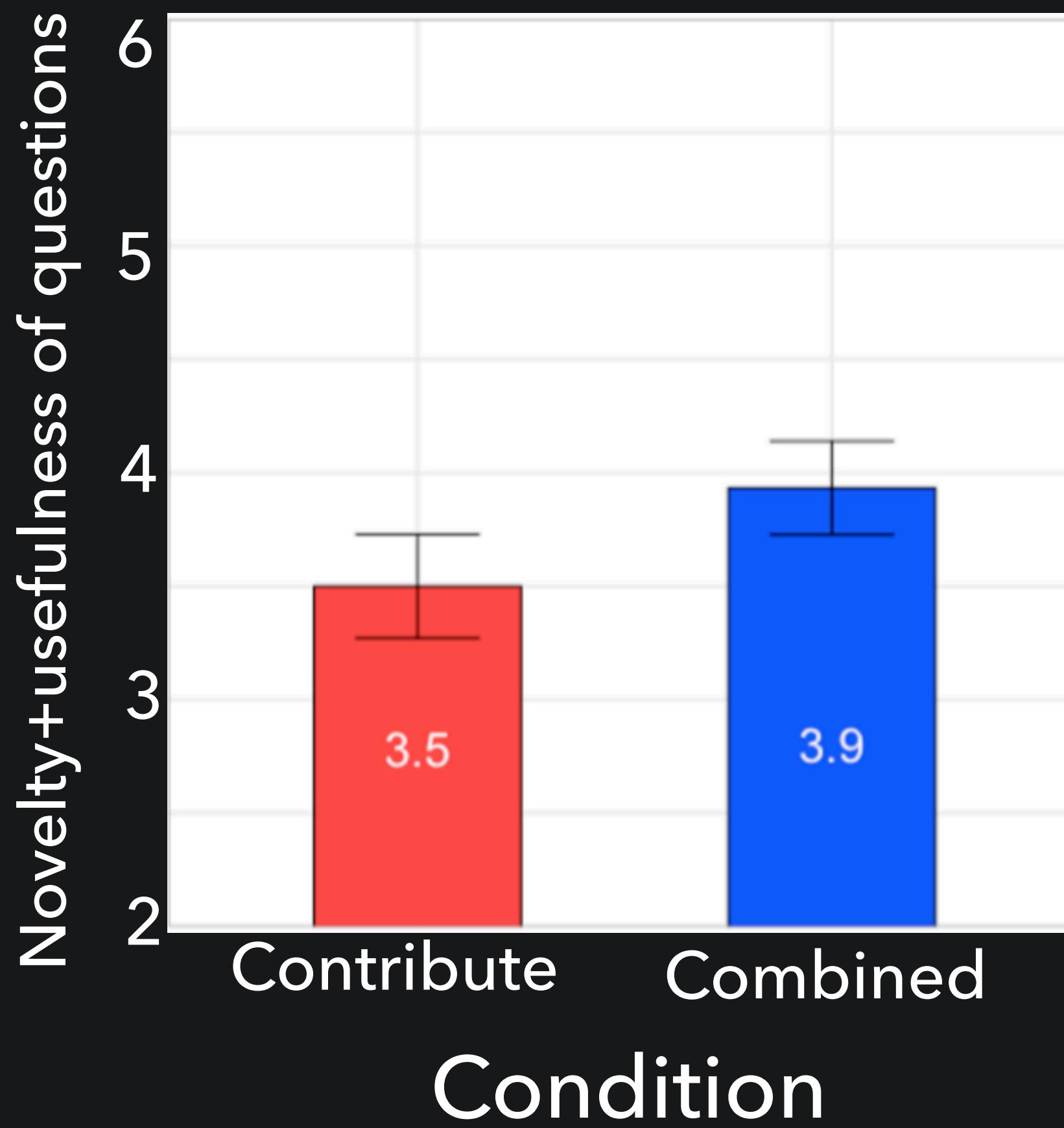
64% said "Yes" and 36% said "No"

2. What steps do you take to get a flatter stomach?

Score: 2/6

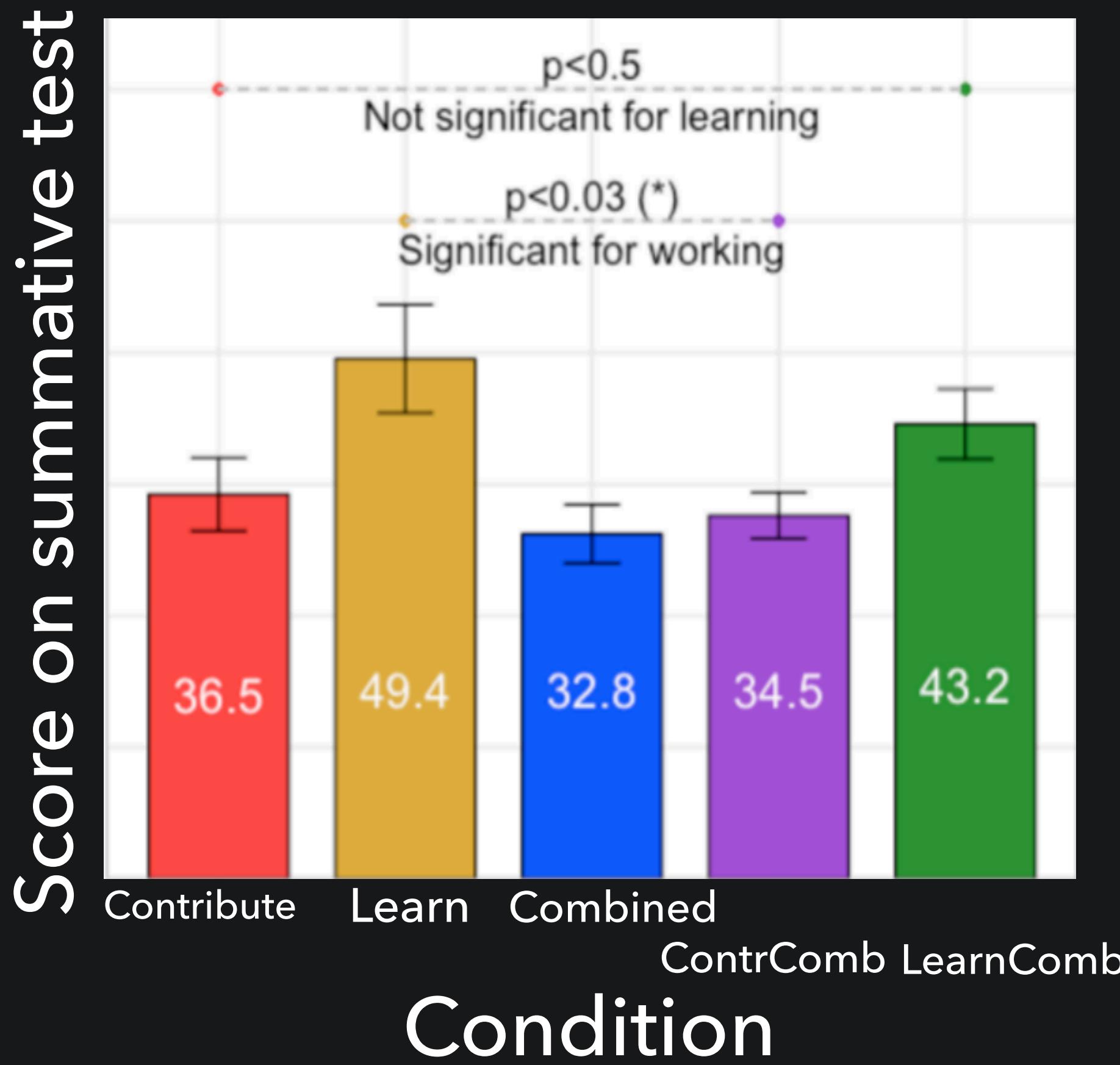
(Novelty: 1, Usefulness: 1)

Results: H1. Did learning improve quality of questions? No.



Participants in Contribute and Combined conditions created questions of similar quality

Results: H2. Did asking questions improve learning scores? No.



Participants in Learn condition performed the best on a summative test.

Learning did not show a significant effect on score but working did.

Combined condition did not perform better because..

- Multiple criteria of success
- Cognitive overload of multiple tasks
- Short "incubation" time for "scientists"
- Personalized learning and need for feedback
- ...

Systems with two objectives often achieve one but not the other



Duolingo
Language learning +
translation
[Hacker 2014]



Have your cake
Language learning +
translation
[Culbertson et al. 2017]



Is this galaxy likely to have T
high rates of star formation? F

Crowdclass
Decision-trees + galaxy
classification
[Lee et al. 2016]

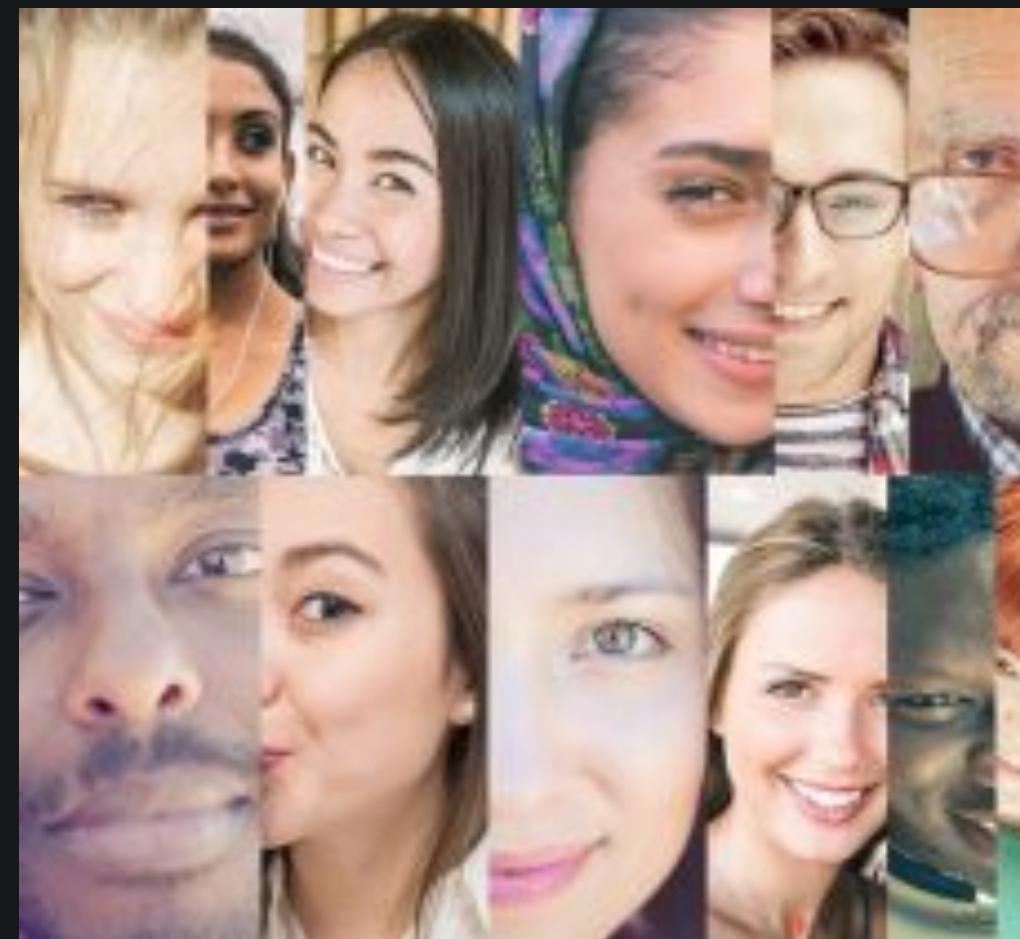
Dual-objective online learning systems: Promise and challenges

- Learning & working
 - Integrate objectives and provide clear criteria of success
 - Task-specific scaffolding (aka how to generate good hypotheses)
- Make learning & work personally relevant
 - Working with intrinsically motivated participants



From the gut microbiome... to where?

Calling out to potential collaborators..



gutinstinct.ucsd.edu
americangut.org

Cultural
psychology

Transcranial
direct-current
stimulation

References

- [Sullivan et al. 2009] **eBird**: A citizen-based bird observation network in the biological sciences. Brian L. Sullivan *, Christopher L. Wood, Marshall J. Iliff, Rick E. Bonney, Daniel Fink, Steve Kelling.
- [Cooper et al. 2010] Predicting protein structures with a multiplayer online game.
- [Flegr et al. 1996] Induction of changes in human behaviour by the parasitic protozoan *Toxoplasma gondii*.
- [Hacker 2014] Severin Benedict Hans Hacker. 2014. Duolingo: Learning a Language while Translating the Web. Ph.D Dissertation.
- [Culbertson et al. 2017] Gabriel Culbertson, Solace Shen, Erik Andersen, Malte Jung. Have your Cake and Eat it Too: Foreign Language Learning with a Crowdsourced Video Captioning System. CSCW 2017.
- [Lee et al. 2016] Doris Lee, Joanne Lo, Moonhyok Kim, Eric Paulos. Designing classification-based citizen science learning modules. HCOMP 2016

Extra slides