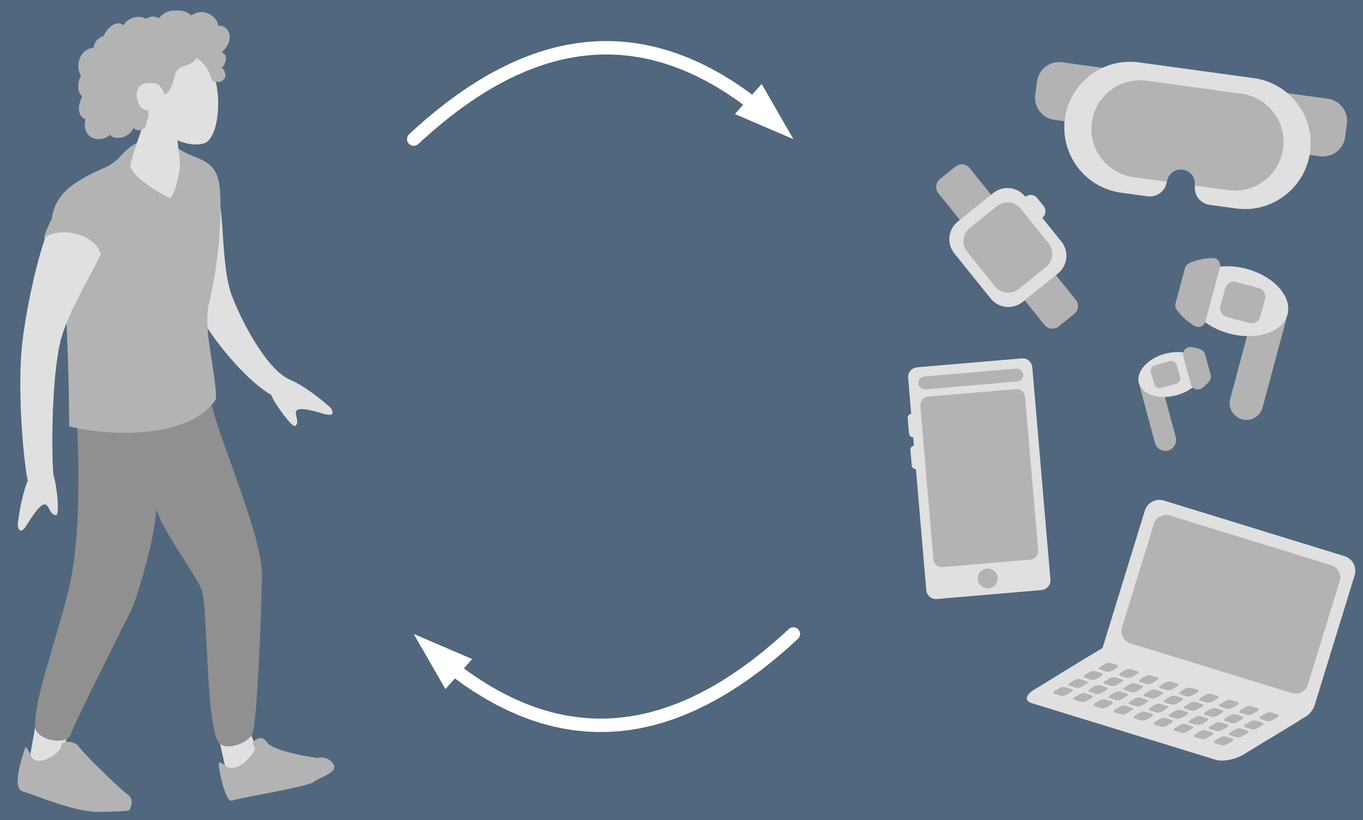
Health + HCI

CS 347

Parker Ruth

Health-computer interaction



Many health technologies tackle one of three key challenges

Diagnosis

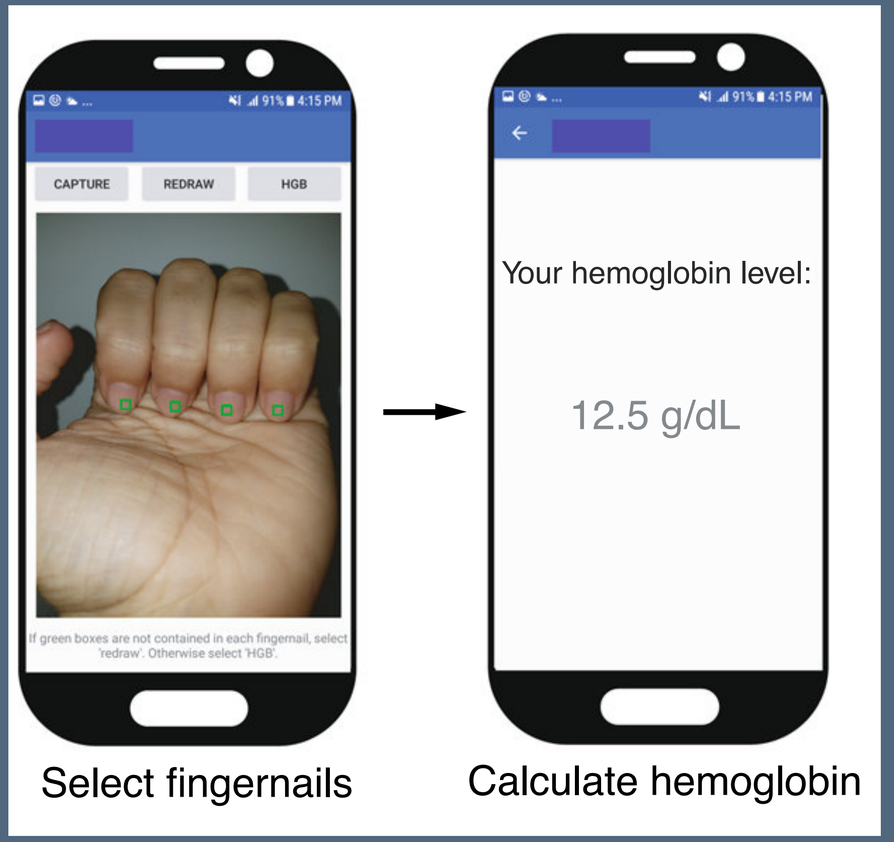
Monitoring

Intervention

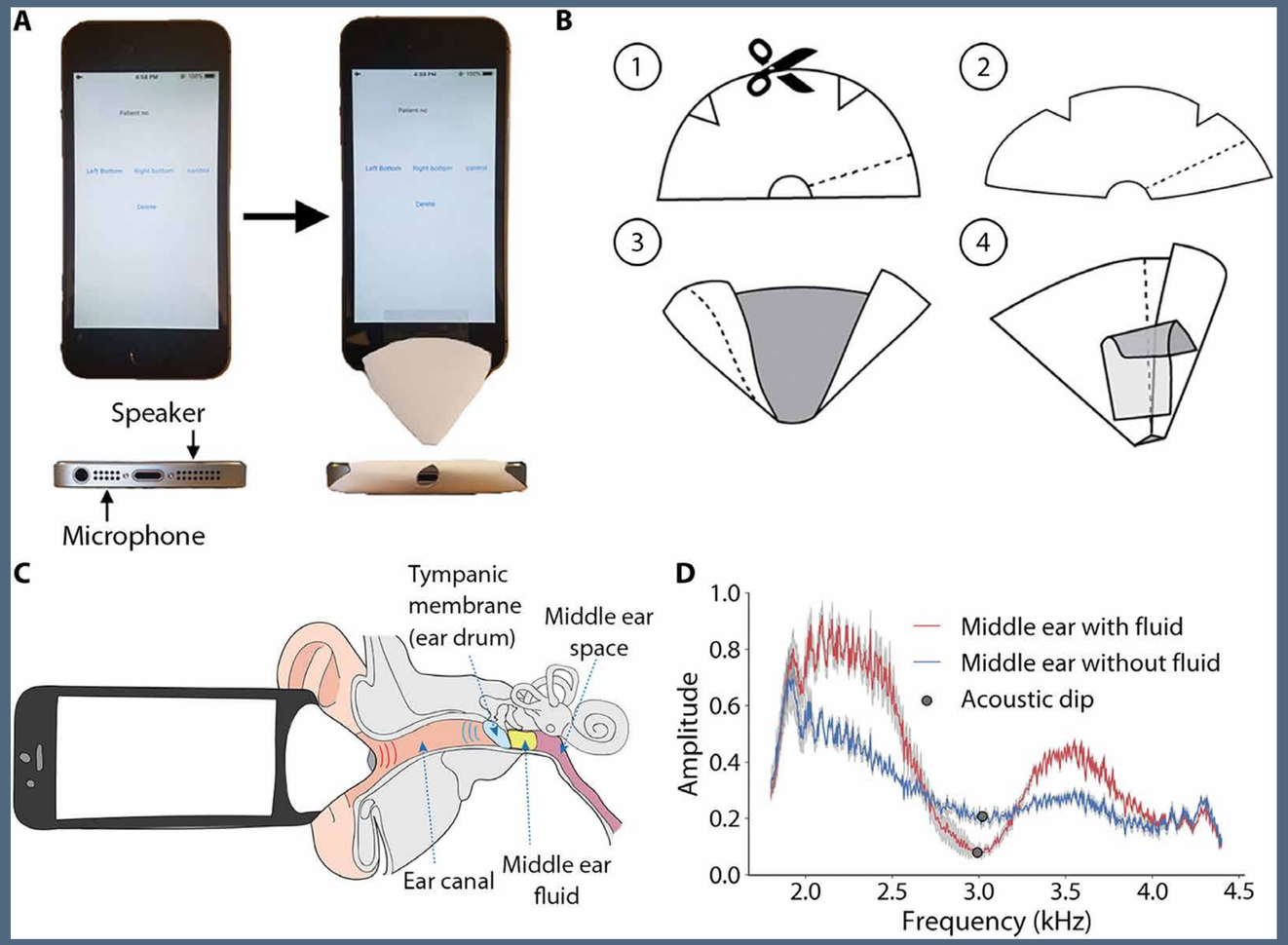
Diagnosis

Nailbed color can indicate anemia

[Mannino et al. 2017]



With low-cost accessories, smartphones can detect middle ear fluid [Chan et al. 2019]



Apple Watches can detect atrial fibrillation

[Perez et al. 2019]

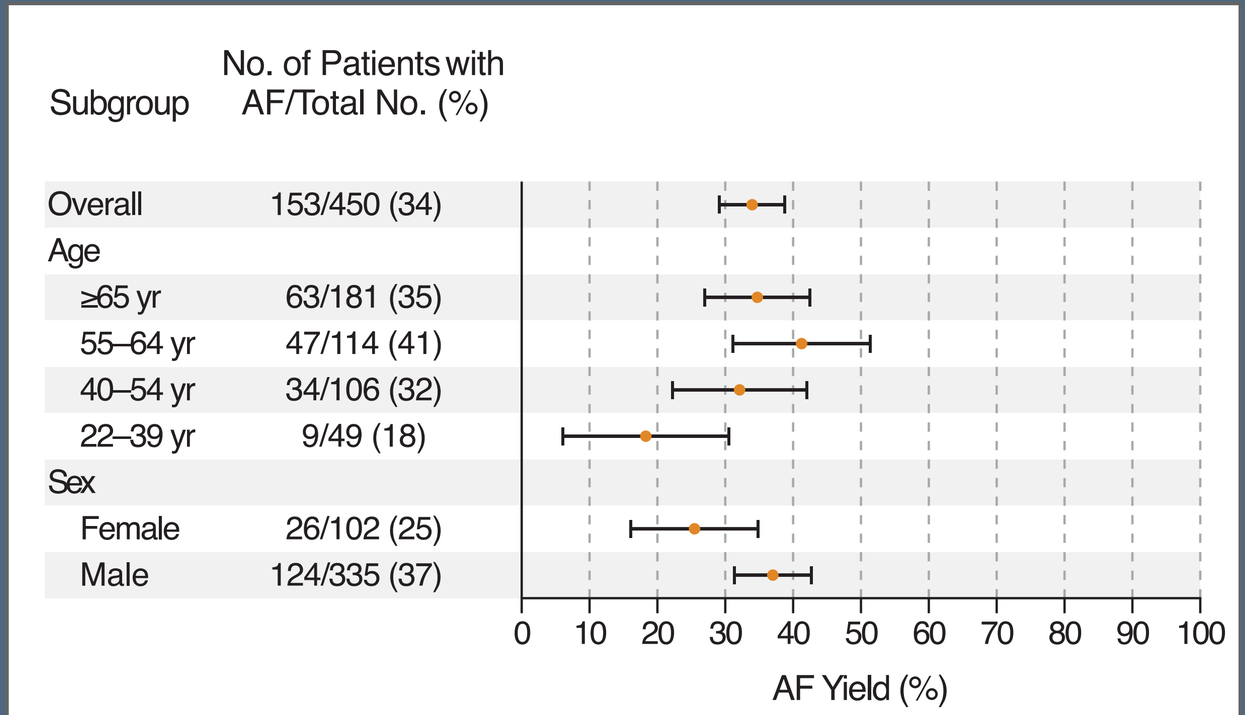
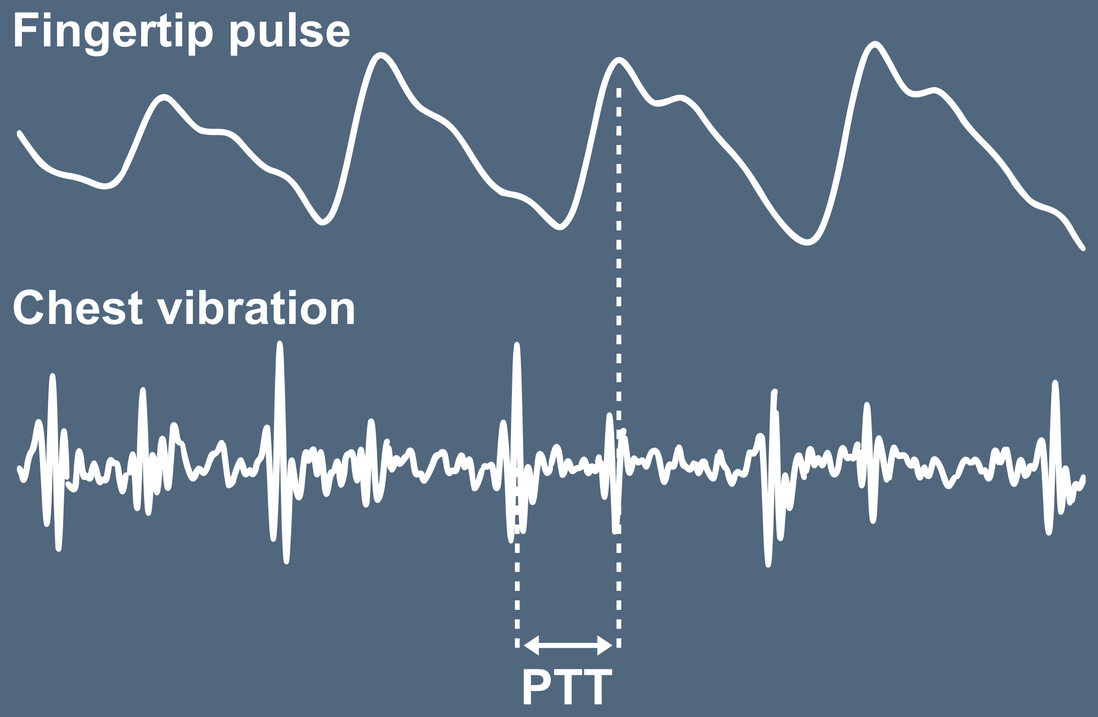


Figure 3. Yield of Atrial Fibrillation on ECG Patch Monitoring. Horizontal bars indicate 97.5% confidence intervals.

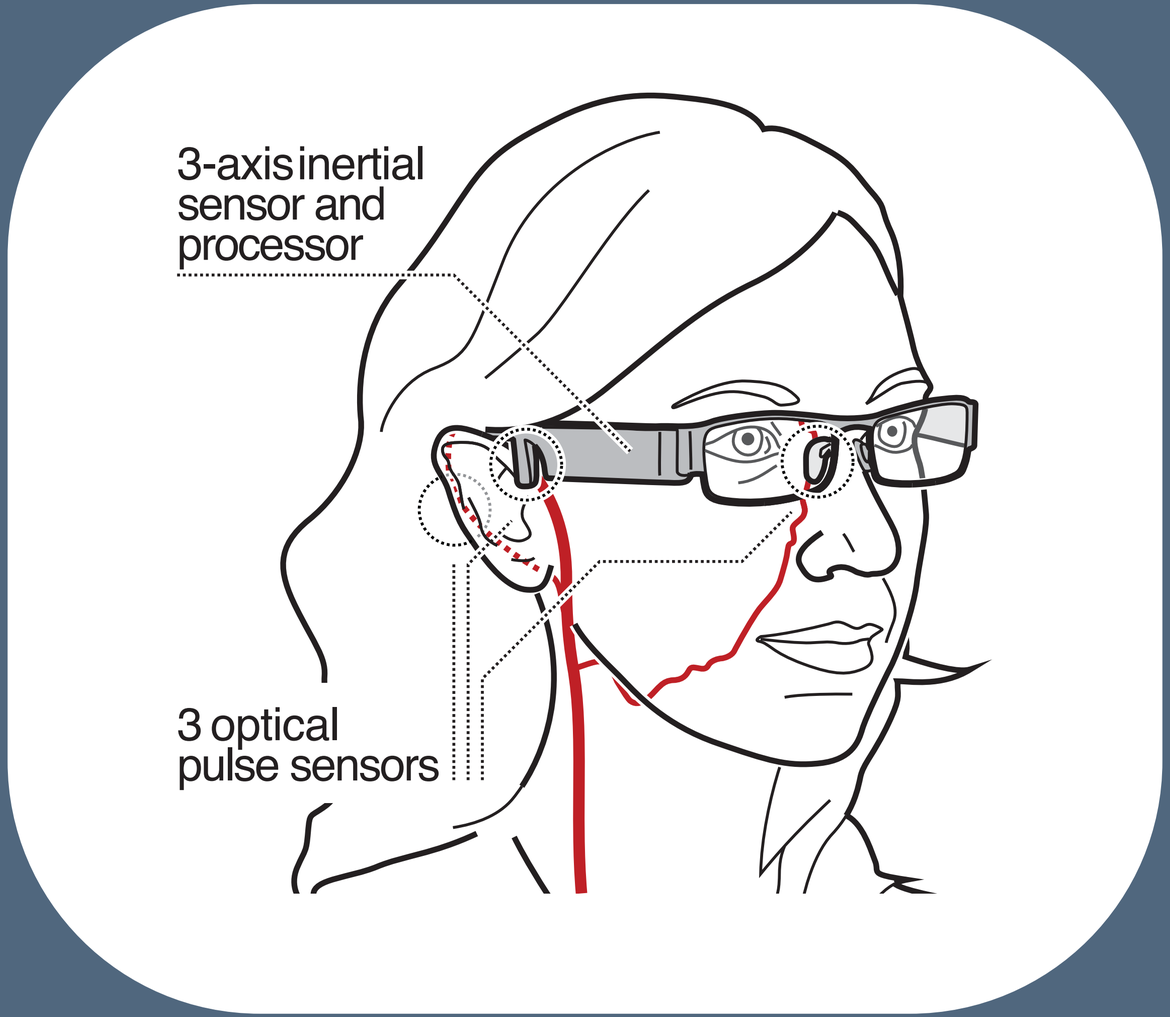
Monitoring

Unmodified commodity sensors can measure cardiovascular health metrics [Wang et al. 2018]

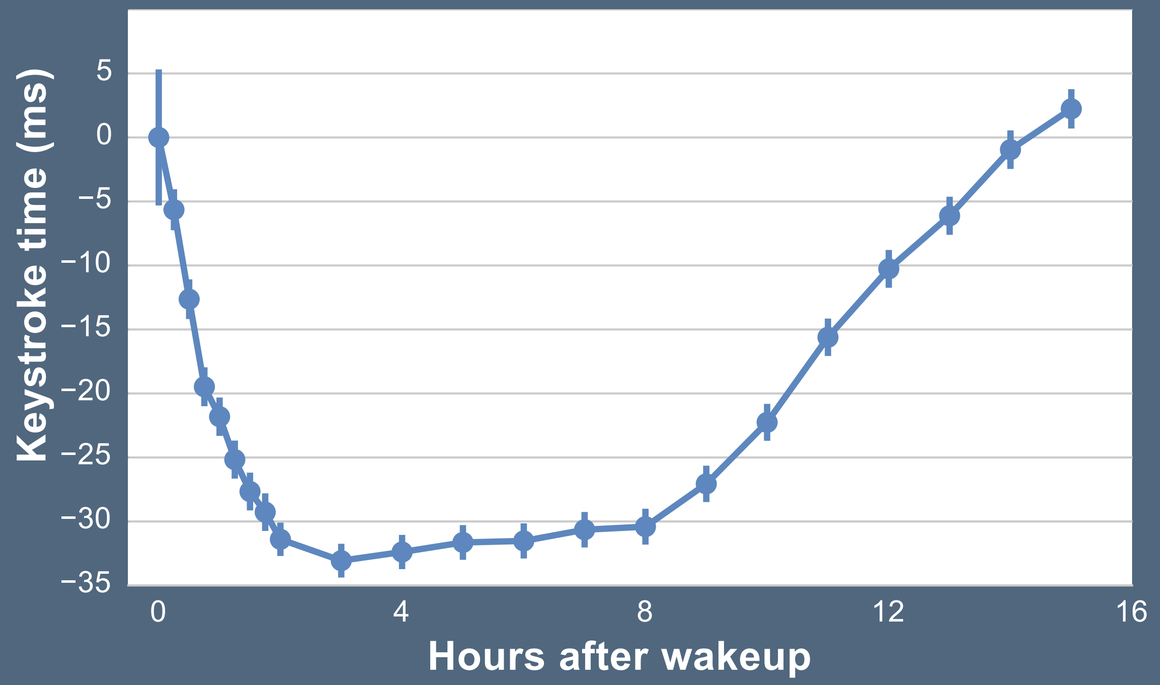


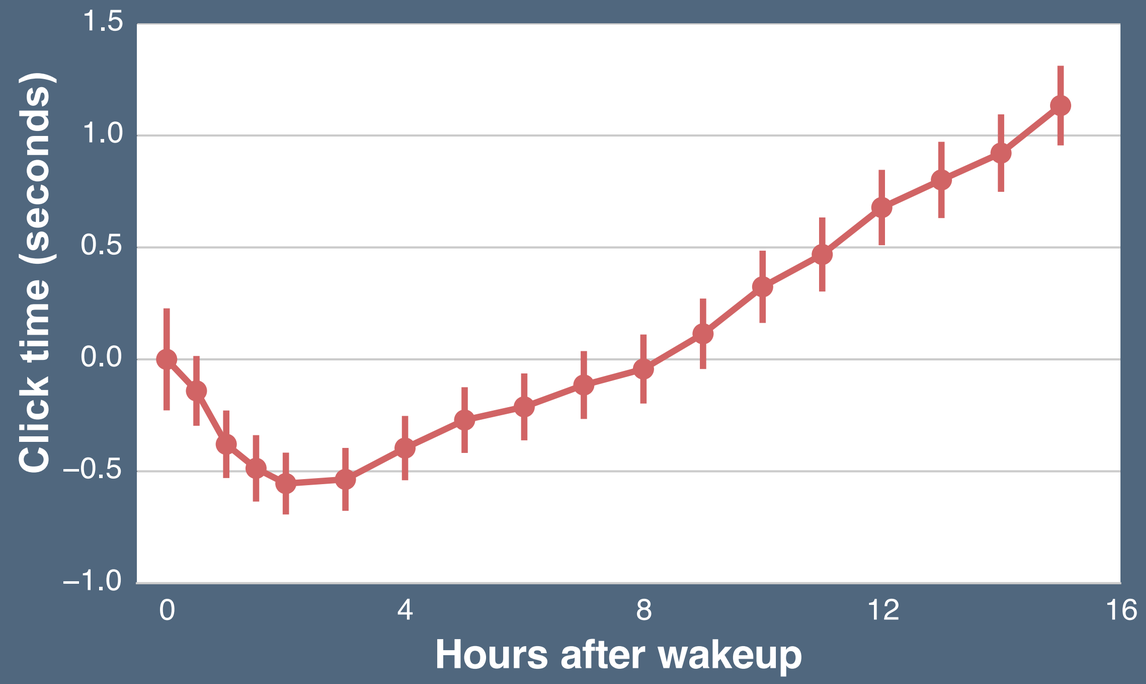
Smart glasses can track blood pressure changes

[Holz et al. 2017]

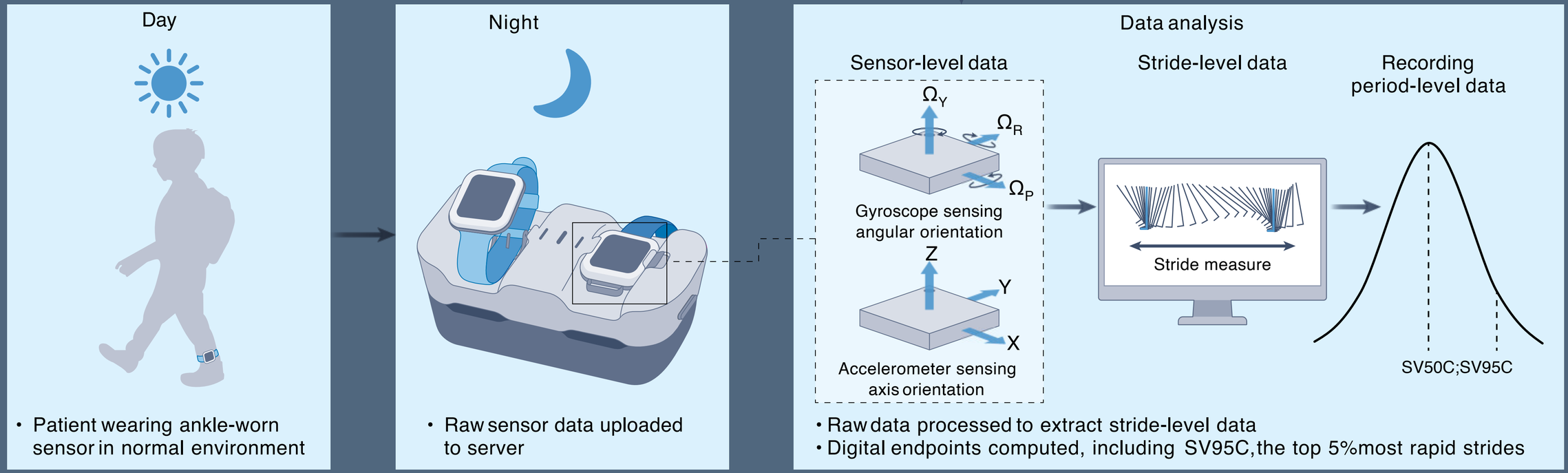


Opportunistic computer interactions can indicate sleep quality [Althoff et al. 2017]





Wearables are now used to measure primary endpoints for clinical trials [Servais et al. 2023]



Intervention

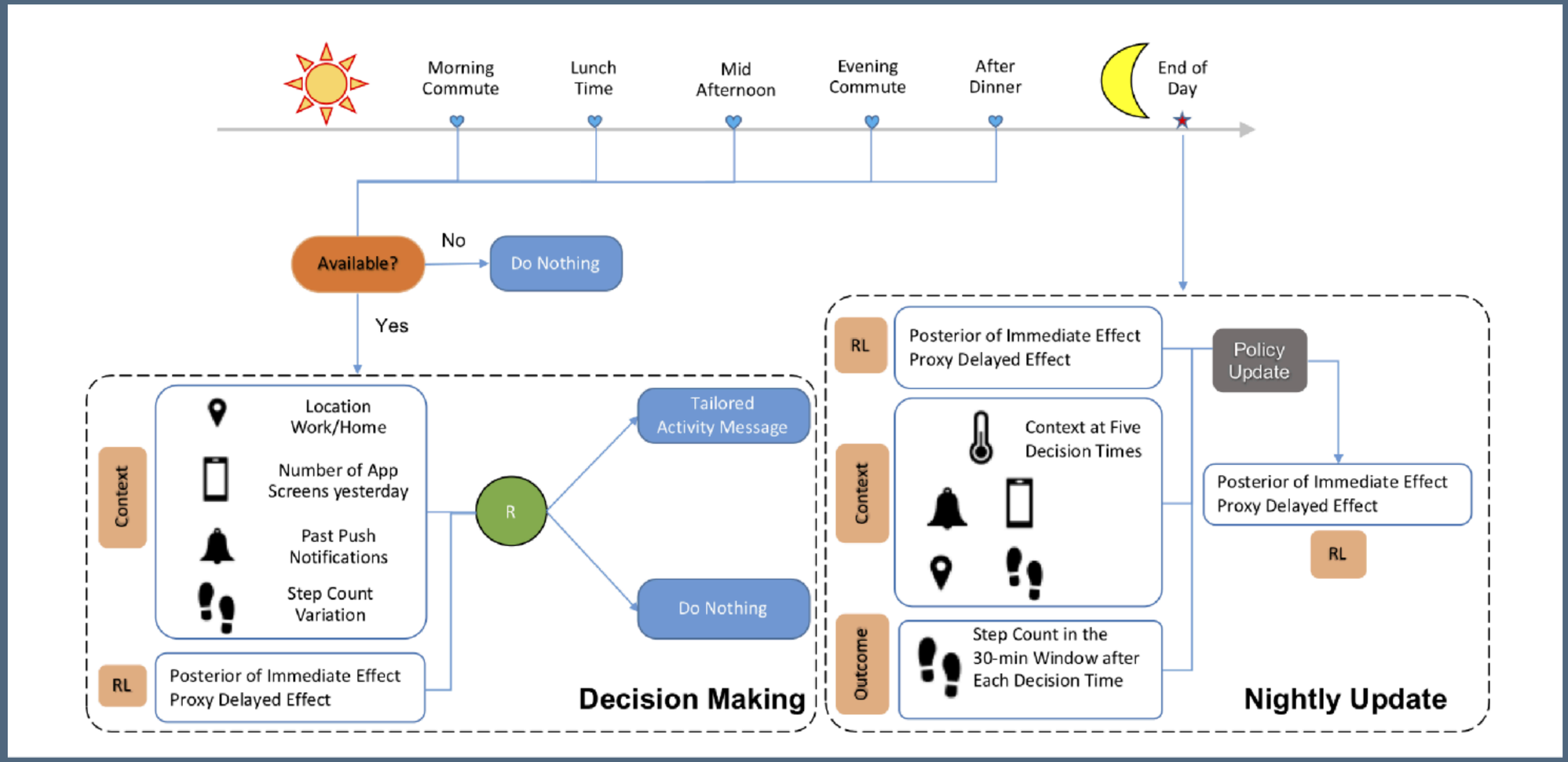
Ambient displays can promote healthy behaviors

[Consolvo et al. 2008]

[Murnane et al. 2020]

Perfecto (ongoing)

Reinforcement learning for promoting health behavior change [Liao et al. 2020]



Health+HCI is a wicked problem

Designing for health has unique challenges

Health is difficult to **define and measure**

- Who decides what "healthy" means?
- How do we measure measure health objectively

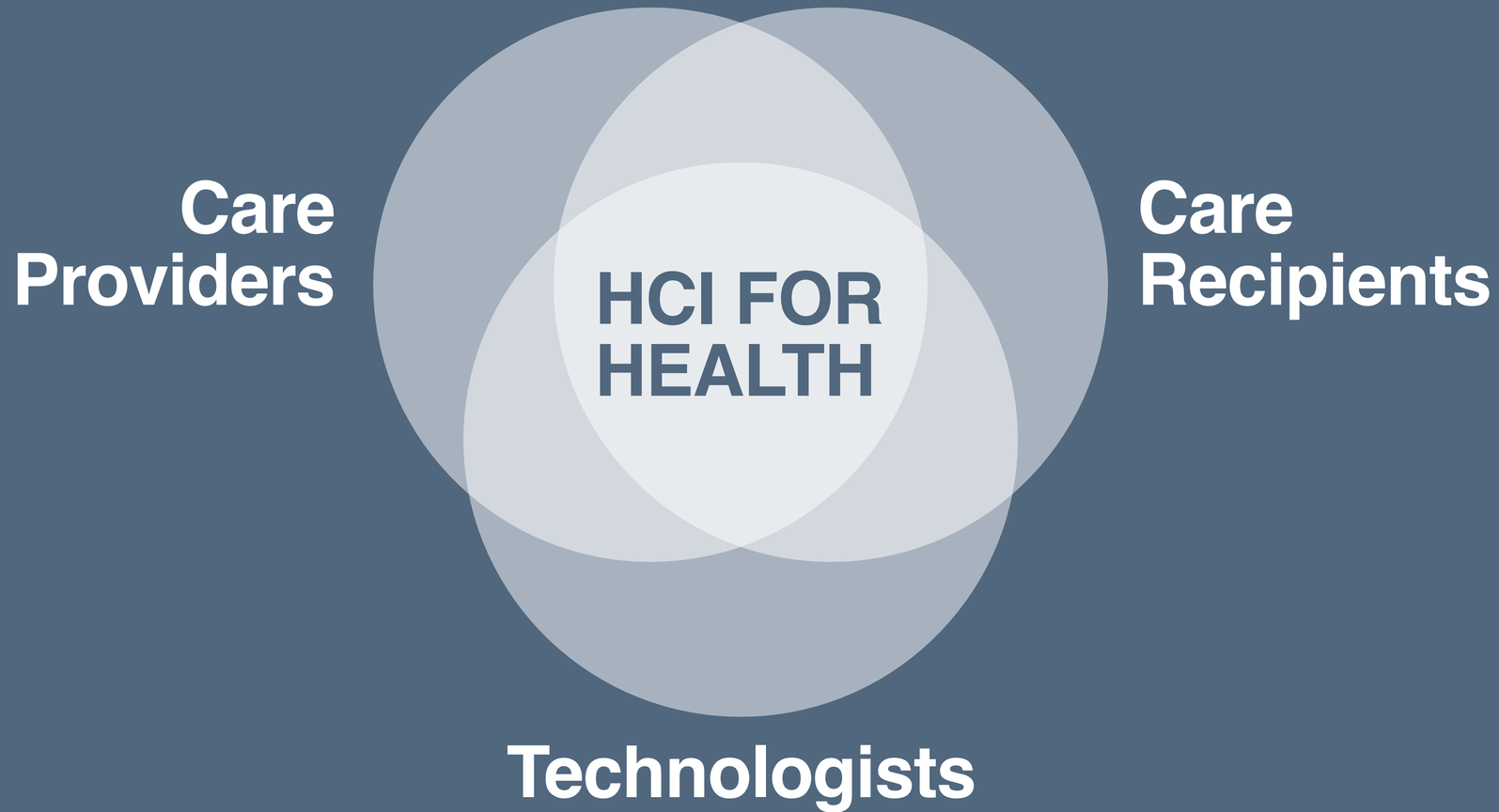
Health evolves over **short and long time scales**

- Health conditions can be acute or chronic
- Time scales range from seconds to decades

It can be hard to establish **cause and effect**

- How do we know what causes health outcomes?

Engaging stakeholders can promote ethical and effective technology design



Summary

HCI can play a role in understanding and advancing human health

Many health technologies aim to tackle **diagnosis**, **monitoring**, or **intervention**

This is a **wicked problem**

- Health can be difficult to define and measure
- Health evolves over short and long time scales
- It can be hard to establish cause and effect

Involving stakeholders (including care providers and recipients) can promote ethical and effective health technologies

References

T. Althoff, E. Horvitz, R. W. White, and J. Zeitzer, "Harnessing the Web for Population-Scale Physiological Sensing: A Case Study of Sleep and Performance," in Proceedings of the 26th International Conference on World Wide Web, Perth Australia: International World Wide Web Conferences Steering Committee, Apr. 2017, pp. 113–122.

J. Chan, S. Raju, R. Nandakumar, R. Bly, and S. Gollakota, "Detecting middle ear fluid using smartphones," Science Translational Medicine, vol. 11, no. 492, May 2019.

S. Consolvo et al., "Activity sensing in the wild: a field trial of ubifit garden," in Proceeding of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI '08, Florence, Italy: ACM Press, 2008, p. 1797.

C. Holz and E. J. Wang, "Glabella: Continuously Sensing Blood Pressure Behavior using an Unobtrusive Wearable Device," Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, vol. 1, no. 3, pp. 1–23, Sep. 2017.

P. Liao, K. Greenewald, P. Klasnja, and S. Murphy, "Personalized HeartSteps: A Reinforcement Learning Algorithm for Optimizing Physical Activity," Proc. ACM Interact. Mob. Wearable Ubiquitous Technol., vol. 4, no. 1, p. 18:1-18:22, Mar. 2020,.

R. G. Mannino et al., "Smartphone app for non-invasive detection of anemia using only patient-sourced photos," Nature Communications, vol. 9, no. 1, Art. no. 1, Dec. 2018.

E. L. Murnane et al., "Designing Ambient Narrative-Based Interfaces to Reflect and Motivate Physical Activity," in Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, in CHI '20. New York, NY, USA: Association for Computing Machinery, Apr. 2020, pp. 1–14.

M. V. Perez et al., "Large-Scale Assessment of a Smartwatch to Identify Atrial Fibrillation," New England Journal of Medicine, vol. 381, no. 20, pp. 1909–1917, Nov. 2019.

L. Servais et al., "First regulatory qualification of a digital primary endpoint to measure treatment efficacy in DMD," Nat Med, vol. 29, no. 10, pp. 2391–2392, Oct. 2023, doi: 10.1038/s41591-023-02459-5.

E. J. Wang et al., "Seismo: Blood Pressure Monitoring using Built-in Smartphone Accelerometer and Camera," in Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18, Montreal QC, Canada: ACM Press, 2018, pp. 1–9.

HCI + Education

CS 347

Miroslav Suzara

Today

Why should HCI researchers care about the learning sciences?

What is Bloom's 2 sigma problem?

What is Computer-Supported Collaborative Learning (CSCL)?

Why should HCI researchers care about the learning sciences?

Learning Sciences

Learning sciences is an interdisciplinary field is centered around understanding learning and "how to better facilitate learning in designed environments – in school, online, in the workplace, at home, and in informal environments."

It is informed by constructivist, social-constructivist, socio-cognitive, and socio-cultural theories of learning.

It draws upon diverse fields such as cognitive science, educational psychology, linguistics, computer science, and more.

Why should we care?

Education and learning is fundamentally about interaction - between students, teachers, content, and tools.

Humans are learning all the time - useful to have an understanding of how they learn when designing technologies they will learn and use

> Theories about learning, memory, attention, cognitive load can help HCI researchers design better interfaces

What is Bloom's 2 sigma problem?

Bloom's 2 sigma problem

[Bloom, 1984]

Conventional

Students learn the subject matter in a class with about **30 students per teacher**.

Tests are given periodically for marking the students.

Mastery Learning

Students learn the subject matter in a class with about **30 students per teacher**.

Tests are given periodically for marking the students.

Corrective procedures on tests and more **tests to determine extent to which students have mastered the subject matter**.

Tutoring

Students learn the subject matter with a **good tutor for each student** (or for two or three students simultaneously).

Same corrective procedures and more tests as mastery condition.

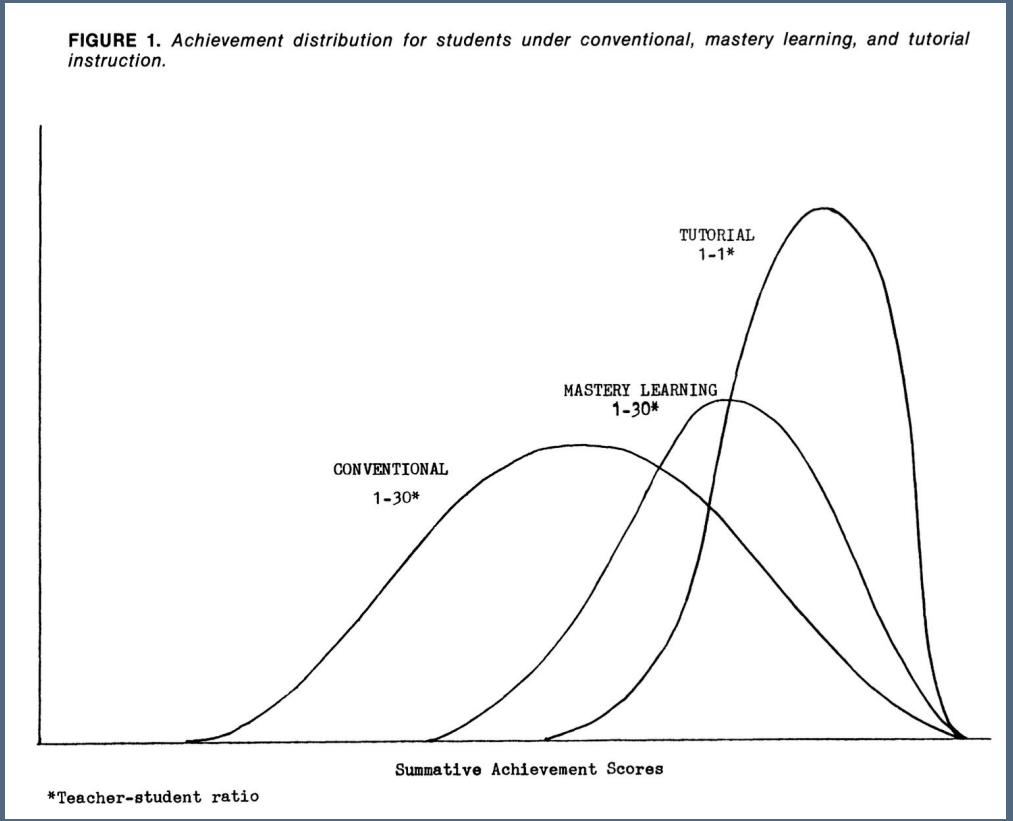
Bloom's 2 sigma problem

[Bloom, 1984]

"*The average tutored student was above 98% of the students in the control class*"

Mastery learning + one-on-one tutoring = great

- But how can this scale?
- An army of tutors?



Bloom's 2 sigma problem

[Bloom, 1984]

The "problem":

> *How can we make group classroom instruction as effective as those tutoring sessions?*

Most students, with right method, could reach what only top 2% achieve in a normal classroom.

Raising both *floor* and *ceiling?*

HCI & Bloom's 2 sigma problem

What might this look like?

History of developments

1920s: Sidney Pressey's Automatic Teaching Machine

1950s-60s: B.F. Skinner's Teaching Machine

1970: Carbonell's SCHOLAR - Computer Assisted Instruction (CAI)

1980s-1990s: Cognitive Tutors (Anderson et al., 1990)

1990s-2000s: AutoTutor (Graesser et al, 2005)

2000s-2010s: Growth of Intelligent Tutoring Systems

2020: LLM based tutors

History of developments

[Skinner, 1958;1961]

Teaching Machines

From the experimental study of learning come devices which arrange optimal conditions for self-instruction.

B. F. Skinner

Rule-based systems

…is it different this time with LLMs?

MACHINE FOR TEACHING INDUCTIVE REASONING presents a pattern at the top of a screen and below it a selection of responses on separate panels that are activated by touch. When the student responds correctly, he is "reinforced" (rewarded) by hearing a musical chime and seeing a light; part of his reward is seeing a new problem flash on the screen.

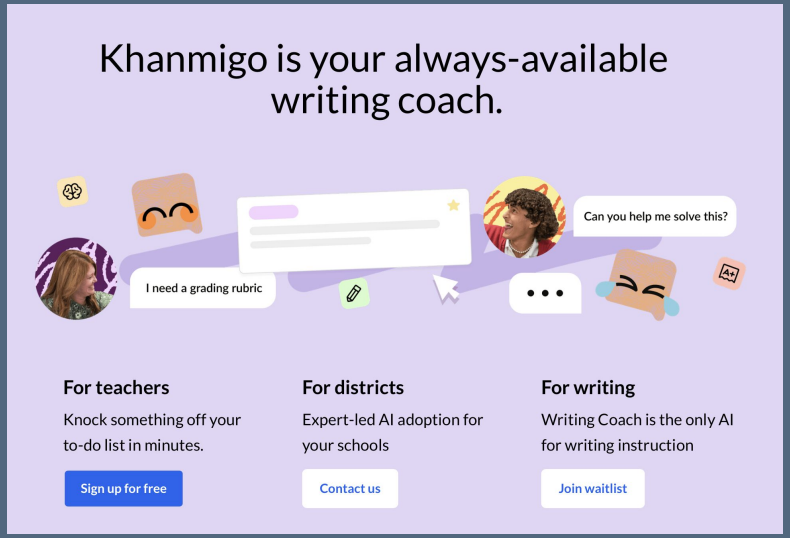
GenAI and LLMs

LLMs as AI tutors or teaching assistants

- 24/7 on demand personal tutor
- Answer questions, give explanations, guide students through process

But, supporting students is not the only problem of practice:

- 24/7 on demand personal teacher's aide
- Helping teachers teach better
- Generating educational content, grading



OpenAI and the California State University system bring AI to 500,000 students and faculty

The largest deployment of ChatGPT to date will expand the use of AI in education and help the United States build an AI-ready workforce.

Challenges

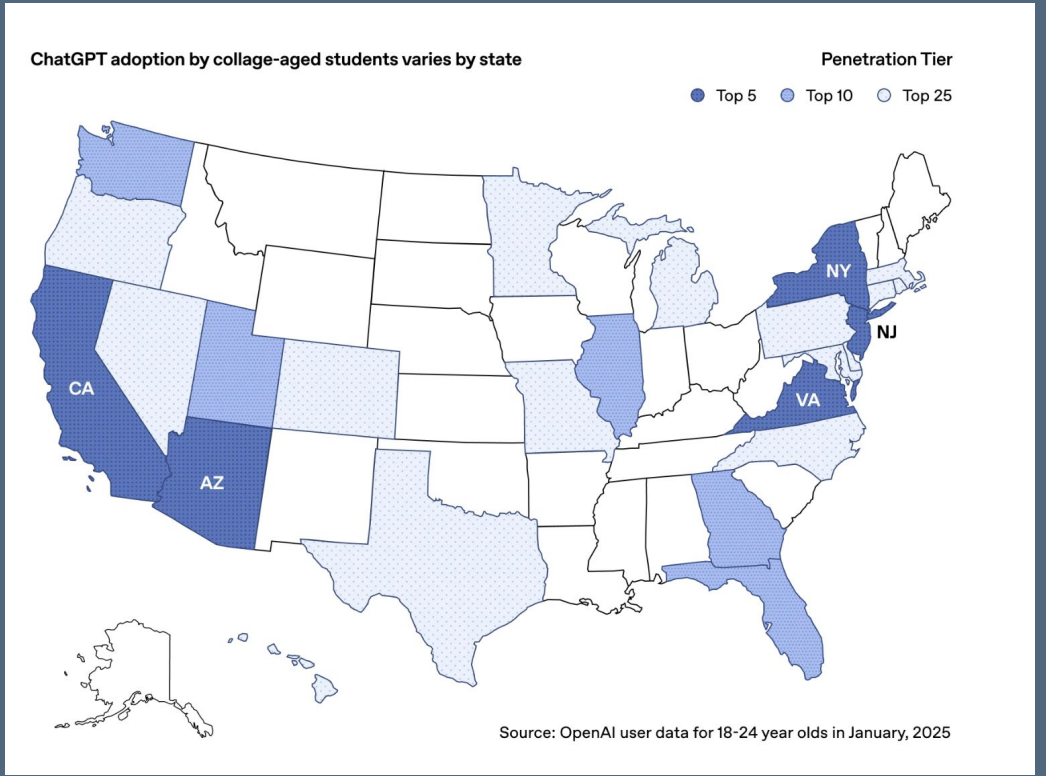
Hallucinations

Plagiarism

Ban or Embrace?

Scaffold vs Crutch?

But, but…what learning *really* matters now?



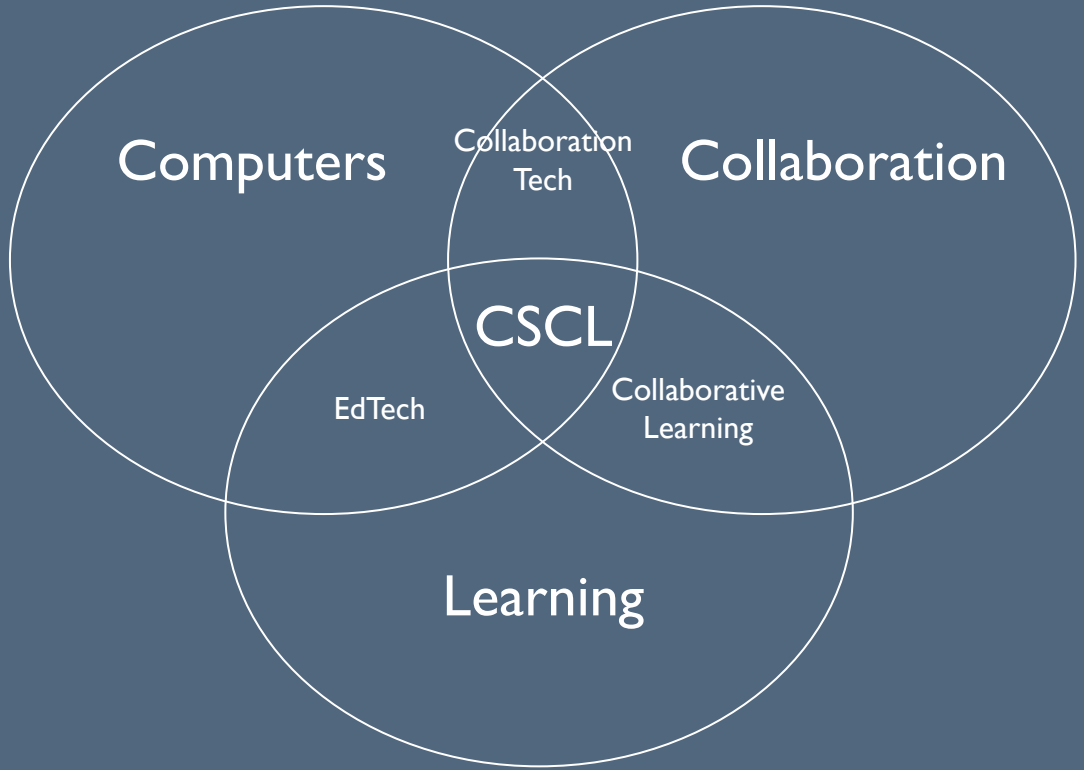
https://cdn.openai.com/global-affairs/openai-edu-ai-ready-workforce.pdf

What is Computer-Supported Collaborative Learning (CSCL)?

CSCL

Learning taking place by social interaction with help of well-designed technology

Draws on rich literature outlining benefits of collaborative learning



CSCL Scripts

[Dillenbourg, 2007]

Putting people in groups does not guarantee quality collaborative learning → we need scripts!

Collaboration script = instructions for how to form groups and how to interact with each other to solve the problem

Successful collaborative learning environments have design elements that guide students on how to work together: clear roles, specific goals, and prompts provided by the software.

"The script is reified in the interface of the learning environment"

Considerations

Can AI tutors ever fully replicate (or even surpass) the effectiveness of a human one-on-one tutor? What unique qualities might human tutors always retain, and where might AI actually be superior (e.g. endless patience, instant data-driven feedback)?

How can we ensure equity when implementing personalized AI or collaborative learning at scale? For instance, what happens if some students have access to advanced AI tutors and others do not?

What do you see as the ideal partnership between human teachers, AI systems, and students in a future classroom? In what ways should technology augment teaching, and what aspects of learning should remain decidedly human-centered?

What *really* matters now? What should be taught in schools?

Summary

Why should HCI researchers care about the learning sciences?

Humans are learning all the time – this is relevant for HCI

What is Bloom's 2 sigma problem?

Tutoring + mastery learning has 2 sigma gain over traditional learning

What is Computer-Supported Collaborative Learning (CSCL)?

Intersection of computers, collaboration, and learning

Thoughtful design of technologies that help people learn together

References

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational researcher*, *13*(6), 4-16.

Carbonell, J. R. (1970). AI in CAI: An artificial-intelligence approach to computer-assisted instruction. *IEEE transactions on man-machine systems*, *11*(4), 190-202.

Graesser, A. C., Chipman, P., Haynes, B. C., & Olney, A. (2005). AutoTutor: An intelligent tutoring system with mixed-initiative dialogue. *IEEE Transactions on Education*, *48*(4), 612-618.

Jeong, H., Hmelo-Silver, C. E., & Jo, K. (2019). Ten years of computer-supported collaborative learning: A meta-analysis of CSCL in STEM education during 2005–2014. *Educational research review*, *28*, 100284.

Pea, R. D. (2018). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. In *Scaffolding* (pp. 423-451). Psychology Press.

Skinner, B. F. (1958). Teaching Machines: From the experimental study of learning come devices which arrange optimal conditions for self-instruction. *Science*, *128*(3330), 969-977.

Skinner, B. F. (1961). Teaching machines. *Scientific American*, *205*(5), 90-106.

Anderson, J. R., Boyle, C. F., Corbett, A. T., & Lewis, M. W. (1990). Cognitive modeling and intelligent tutoring. *Artificial intelligence*, *42*(1), 7-49.

Wood, D., Bruner, J. S., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of child psychology and psychiatry*, *17*(2), 89-100

Critical Theory

CS 347
Philip Baillargeon
Credit to Alice Fox, Nava Haghighi

Last Time - Feminist HCI

- **Artifacts have politics**: the systems we create influence groups and societies, often with undesirable outcomes
- Theory gives us a lens through which we can assess dimensions of problems (f(x) → y)
- Design approaches focused on marginalized groups, such as **feminist HCI**, center these communities' needs in the design process
- Today: Critical Theory
  - How do we structure critiques of normative thinking?
  - How do we put those critiques into practice?
- Later: Accessibility and ICT4D

Critical Theory in Interaction Design

“He was a skater boy, she said see you later boy”

What is critical theory?

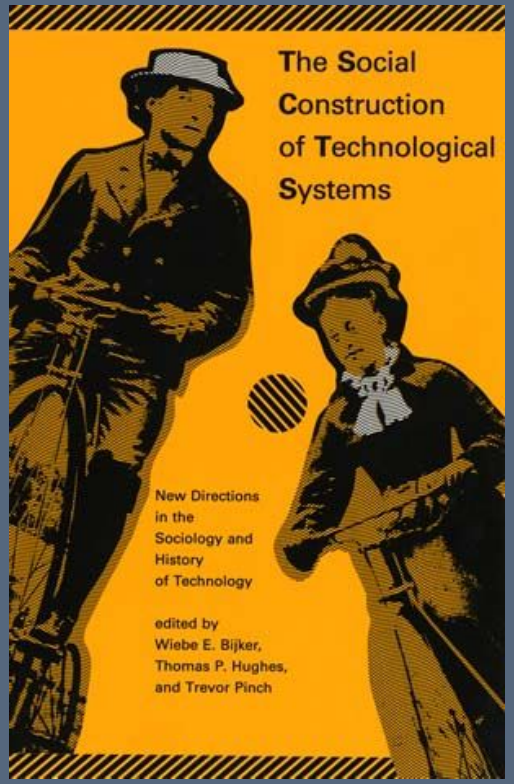
- Critical theory is inspired by the constructivist philosophy and its radical skepticism (Bardzell 2009)
- Speculative and generative, not to explain what is known but offer new ways of thinking about it (Bardzell and Bardzell 2013)
- Could involve imagining alternative futures, questioning widely-held beliefs

What is critical theory?

- Critical Race Theory (Brooks 1994)
  - "A collection of critical stances against the existing legal order from a race-based point of view"
  - Specific attention to intersectionality and implicit biases that undermine legal structures that seek to eliminate racism
- Cyborg Theory (Haraway 1991)
  - We are all assemblages of experiences, interactions with our environment, technologies we use
  - As a result, binaries are insufficient to describe life in our modern world
  - Sometimes criticized for presenting groups as monoliths, overly technophilic

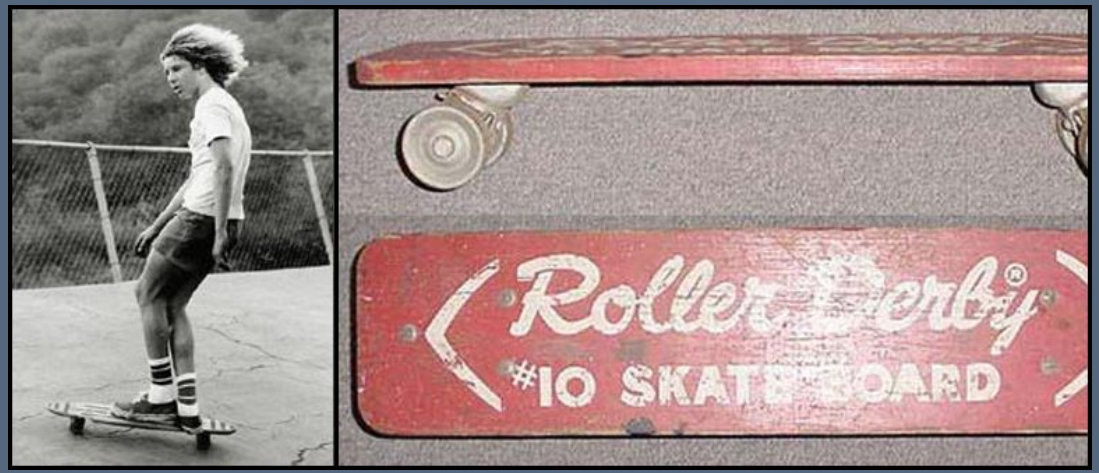
Getting Real

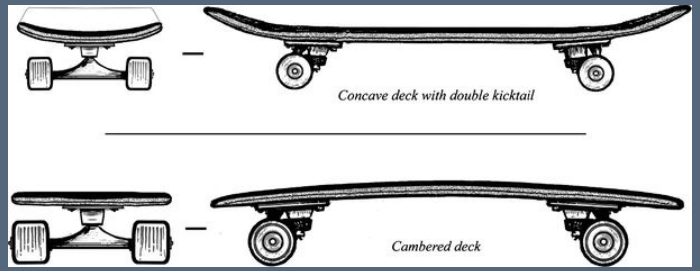
- An important theory in science and technology studies (STS): Social Construction of Technology (SCOT) (Bijker and Pinch 1987)
  - Response to technological determinism (technology defines social values)
  - Claims the reasons that technology designs succeed or fail based on social factors
  - Rigorous process for outlining important points in the evolution of a technology

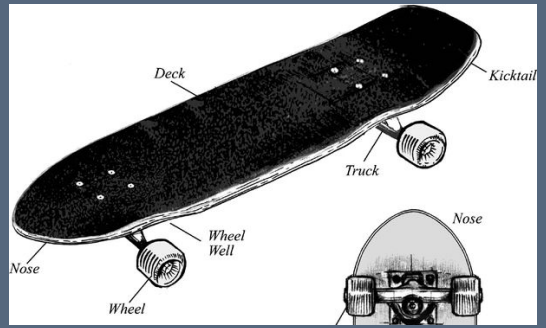


Getting Rad with SCOT

- The evolution of skateboards is all about **where skaters skate** and **who they skate with** (Prentiss et al. 2011)



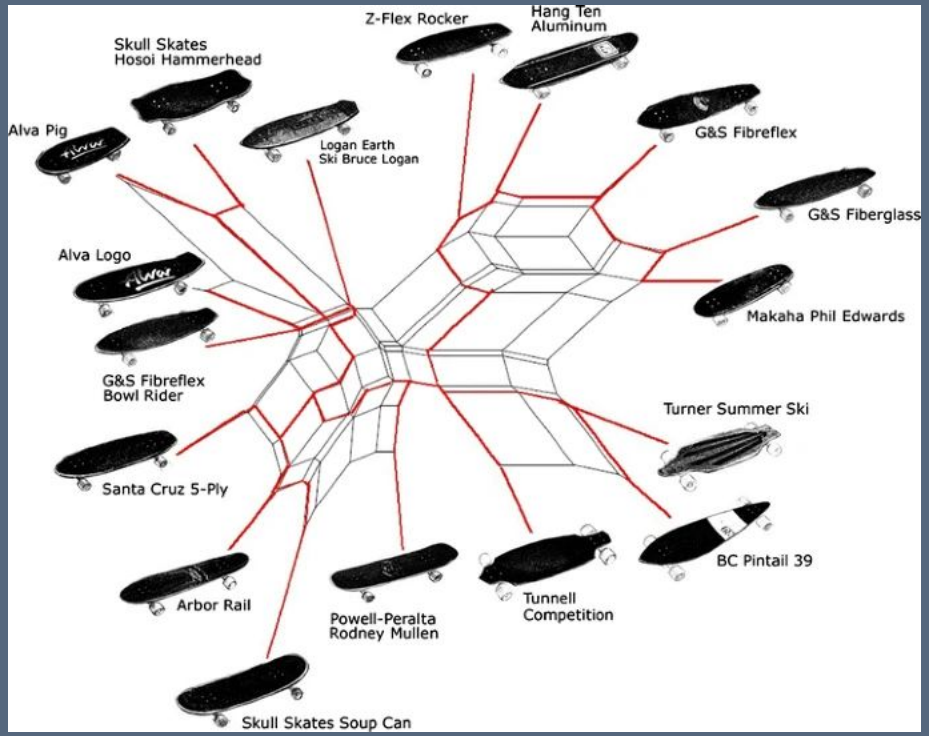




Side profiles of skateboards showing the development of the kicktail. Note the concave deck that is more compact for tricks and the cambered deck that offers more support while coasting (image from skatedeluxe).

Getting Rad with SCOT

- Skateboards evolve as skateboarders interact socially
  - Bowl skaters and freestyle skaters learn how to best support tricks
  - Skateboarders interact with surfers too!
- Technical capabilities didn't change; skateboarders and skate culture did!



The evolution of skateboards, using evolutionary biology and synthesis of different species.

Four Wheels, Two Explanations

- Technological Determinism: the skateboards are making the kids troublemakers
  - Social media is making the kids troublemakers
- SCOT: the kids want the freedom to go faster and express themselves, so they demand more dynamic skateboards
  - The kids want wild, entertaining, interruptible content while they're stuck inside, so they demand short form online content
- Not right or wrong, but we should consider both!

You Might Be Thinking

- Now I know how skateboards work
  - But what if I want to build a faster skateboard?
  - A safer skateboard?
  - A better way to learn how to skateboard?
  - A way to facilitate connection between skateboarders?
- A lens by itself doesn’t change the world...

From Interventions to Counterventions

Interventionist HCI

- Many HCI researchers try to go “out there” and make things better, but we don’t always ask the right questions (Rogers and Marsden, 2013)
  - Radio show in the UK “Does He Take Sugar”: wait staff in restaurants often ask the companions of disabled people in place of the people themselves, even when their disability is not related to speech
  - A majority of social computing papers with neurodiverse participants only involve neurodivergent people in the evaluation phase (Baillargeon et al. 2025)
- Critical theory can help us!
  - What questions are we asking?
  - Who are we looking to for the answers?

Counterventionist HCI

- What if we wanted to set the record straight?
  - Critical researchers and health technology researchers pair up to review previous work (Williams et al. 2023)
  - We need both established consensus in health practices and the perspectives of self-advocates
  - Critical Theory: Neurodiversity (differences in thinking, learning, and being should be respected)
- Countervention: a **community-informed** counterargument to normative empirical studies and interventions

Neurodiverse Social Computing

- Recall from our “Activity Sensing” lecture: Tools for practicing social skills [Escobedo et al. 2012]
  - Problem Definition: autistic children struggle socially in schools
  - From: curriculum developed by teachers and parents
  - Solution: give autistic students in the class a tablet that tells them who to interact with, what to say
- What are your counterventionist critiques?

Synergistic Critical Theories

- Why pick one lens when you could have many?
- Example: Black Cyberfeminism (Cottom 2016; Richard and Gray 2018)
  - Critical Race Theory (Brooks 1994)
  - Feminist Theory
  - Cyborg Theory (Haraway 1991)
- Neurodiverse Social Computing
  - Neurodiversity
  - Double Empathy
  - Muted Group Theory
- Assemblages help us consider intersectionality, ensure coverage of various social aspects influencing technology

Summary

- Frameworks like the Social Construction of Technology (SCOT) challenge us to consider the social factors that impact the development of technology
- Going “out there” is not enough; we need to **open ourselves up to critical perspectives** to do things right
- Counterventions operationalize critical theory by providing **alternatives to normative interventions**

References

Bardzell, J. 2009. Interaction criticism and aesthetics. In Proc. CHI'09, ACM, NY, 2357-2366

Bijker, Wiebe E., and Trevor J. Pinch. "The social construction of fact and artifacts." Philosophy of technology: the technological condition: an anthology (1987): 107-139.

Brooks, Roy (1994). "Critical Race Theory: A Proposed Structure and Application to Federal Pleading". Harvard BlackLetter Law Journal. 11: 85–.

Cottom, Tressie McMillan. "Black cyberfeminism: Ways forward for intersectionality and digital sociology." Digital sociologies (2016): 211-232.

Haraway, D. (1991) A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century. Simians, Cyborgs and Women: The Reinvention of Nature, Routledge, New York, 149-181.

Jeffrey Bardzell and Shaowen Bardzell. 2013. What is "critical" about critical design? In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13). Association for Computing Machinery, New York, NY, USA, 3297–3306. https://doi.org/10.1145/2470654.2466451

Philip Baillargeon, Jina Yoon, and Amy Zhang. 2025. Who Puts the "Social" in "Social Computing"?: Using A Neurodiversity Framing to Review Social Computing Research. Proc. ACM Hum.-Comput. Interact. 9, 2, Article CSCW208 (April 2025), 44 pages. https://doi.org/10.1145/3711106

Prentiss, A.M., Skelton, R.R., Eldredge, N. et al. Get Rad! The Evolution of the Skateboard Deck. Evo Edu Outreach 4, 379–389 (2011). https://doi.org/10.1007/s12052-011-0347-0

Richard, G. T., & Gray, K. L. (2018). Gendered play, racialized reality: Black cyberfeminism, inclusive communities of practice, and the intersections of learning, socialization, and resilience in online gaming. Frontiers: A Journal of Women Studies, 39(1), 112-148.

Rogers, Yvonne, and Gary Marsden. "Does he take sugar? Moving beyond the rhetoric of compassion." *interactions* 20.4 (2013): 48-57.

Rua Mae Williams, Louanne Boyd, and Juan E. Gilbert. 2023. Counterventions: a reparative reflection on interventionist HCI. In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems (CHI '23). Association for Computing Machinery, New York, NY, USA, Article 653, 1–11. https://doi.org/10.1145/3544548.3581480