EICS Abstract (https://eics.acm.org/2019/keynotes.html)
The computer user of today operates in situations very unlike those of the computer user from the 1980s, when PCs sat atop desks in staid office environments that provided ample lighting, comfortable seating, controlled temperatures, and minimal noise or distraction. Computer users of today, by contrast, are likely to use a touch screen device, perhaps while on-the-go, perhaps while outside, perhaps while surrounded by attention-grabbers like people, traffic lights, curbs, and signs. Users might be trying to interact while carrying luggage, wearing gloves, squinting in bright sunlight, or wiping rainwater from their screens. Unfortunately, however, today's mobile devices know almost nothing about these challenging situations, and offer even less to users by way of help or support for interaction. A useful perspective is to view these challenges through the lens of ability, disability, and accessibility, given that these notions involve the interplay of personal, environmental, and social factors. In this view, people can be "situationally impaired," as their abilities and resources for action are diminished by context. In this talk, I present the conceptual and historical foundations for situationally induced impairments and disabilities, including the rightly controversial aspects of this notion. I define a space of impairments that broadens accessibility to include everyone, not just people with disabilities. Having established the foundations for this perspective, I present four projects in which mobile devices are given enhanced situation- and user-awareness (without adding custom sensors), resulting in new capabilities and improved interactions. I demonstrate how, by increasing devices' situation awareness, interfaces can better support users in mobile contexts. By the end of my talk, I hope to have convincingly motivated the need for our mobile devices to become more situationally aware, while acknowledging the privacy and ethical challenges that such awareness raises.

3

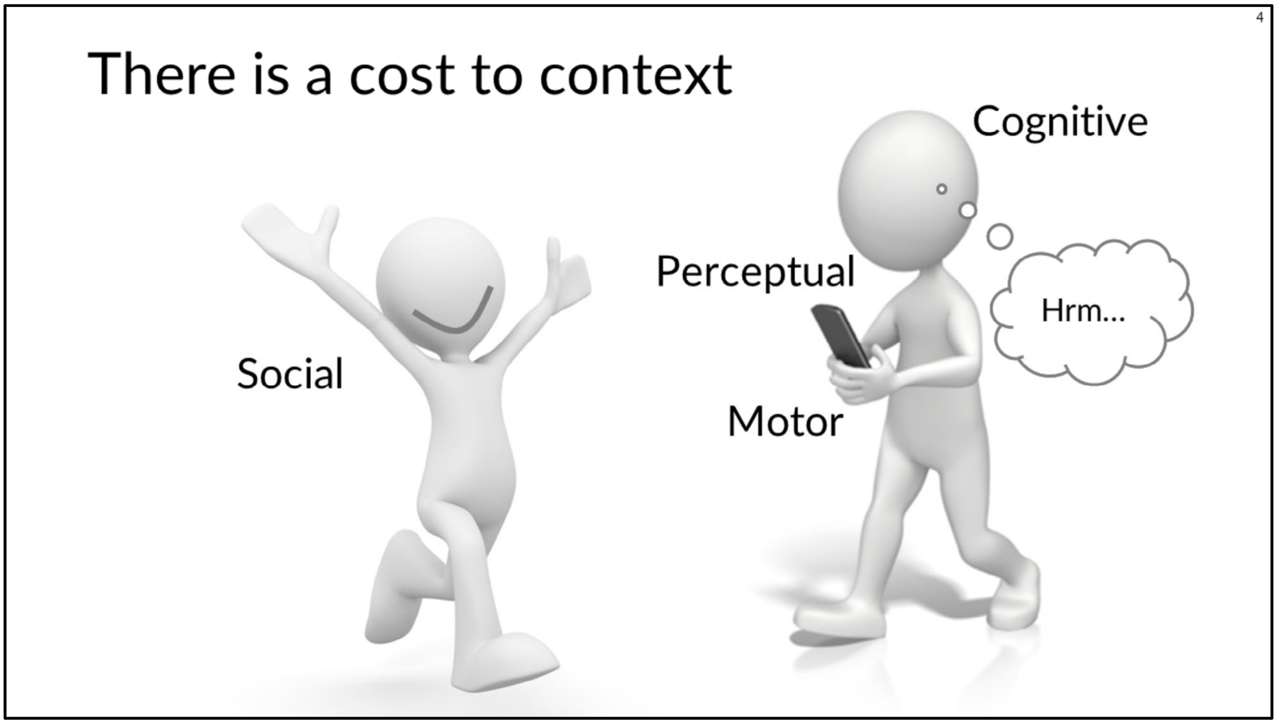
Computing environments have changed

1980s

Today

The computer user of today would be quite unrecognizable to the computer user of forty years ago. Most likely, that user sat comfortably at a desk, typed with two hands, and was not distracted by outside people, noises, forces, or situations. She would have enjoyed ample lighting, dry surroundings, moderate ambient temperatures, stable surfaces, and physical safety. Of course, these conditions describe most of today's office computing environments as well.

But the computer user of today can also be described quite differently. Today, such a user might be walking through an outdoor space, her attention repeatedly diverted to her surroundings as she navigates among people, along sidewalks, through doors, up and down stairs, and among moving vehicles. She might be in the rain, her screen getting wet. Her hands might be cold so that her fingers feel stiff and clumsy. She might only be able to hold her computer in one hand, as her other arm carries groceries, luggage, or a baby. She might be doing all of this at night, when lighting is dim, or in the blazing heat of a sunny day, with sweat and glare making it difficult to use her screen.



Today’s mobile and wearable computers, especially smartphones, tablets, and smartwatches, enable us to interact with computers in a variety of situations, contexts, and environments. But the flexibility of computing in these settings does not come for free—it comes at a cost to our cognitive, perceptual, motor, and social abilities. These abilities are taxed all the more in mobile, dynamic settings, where we must attend to more than just a computer on our desk.

Interacting while walking

Reduces reading speed
(Mustonen et al. 2004)

Reduces motor accuracy
(Lin et al. 2005, 2007; Schedlbauer & Heines 2007)

Divides attention; 4 second "bursts" of interaction
(Oulasvirta et al. 2005; Bragdon et al. 2011)

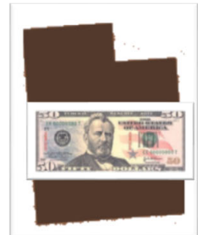
Reduces ability to maneuver and avoid obstacles
(Vadas et al. 2006)

As an example, consider walking while interacting with a smartphone. Studies have shown numerous ways in which our abilities are situationally impaired.

How are we coping?

Given instructions

Shown warnings



Issued fines

Changed environments

As a society, to cope with these challenges, we have given instructions, shown warnings, issued fines, or changed environments.

But we haven’t yet put the burden on *smart devices themselves* to help with this problem.

Here is a sign in the town of Hayward, California. It says, “Heads up! Cross the street and *then* update Facebook.”

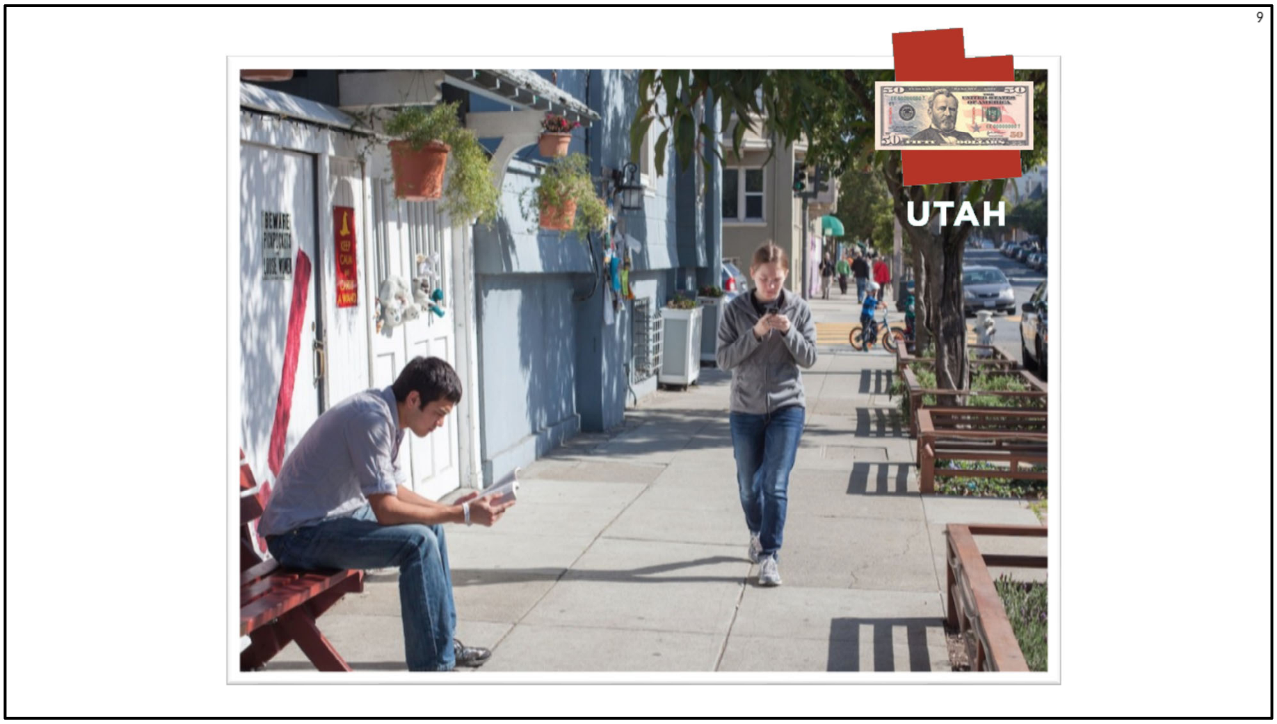
http://www.businessinsider.com/apps-and-street-signs-to-get-people-to-stop-texting-and-walking-2016-2/#signs-that-warn-drivers-of-texting-pedestrians-1

https://www.sfgate.com/bayarea/article/Heads-up-Hayward-debuts-snarky-traffic-signs-6079819.php#photo-7522859

Stockholm, Sweden

In Stockholm, they gave up on getting walkers to stop texting; instead, they're trying to alert drivers not to run over the walkers who are texting.

Notes:
(Street sign designed by Jacob Sempler and Emil Tiismann.)
https://www.telegraph.co.uk/news/worldnews/europe/sweden/12139462/Road-signs-warn-pedestrians-not-to-use-smartphones.html



In 2012, in the U.S. state of Utah, the Utah Transit Authority imposed a $50 fine for "distracted walking“ near light rail tracks.

https://www.motherjones.com/environment/2014/12/texting-walking-injuries-deaths/
http://www.businessinsider.com/apps-and-street-signs-to-get-people-to-stop-texting-and-walking-2016-2/#a-fine-for-distracted-walkers-5

In Honolulu, you can be fined on-the-spot if you're caught texting in a crosswalk.

Headline from: https://www.npr.org/2017/10/25/560089121/distracted-walking-law-bans-texting-while-crossing-streets-in-Honolulu

Photo from: https://www.nytimes.com/2017/10/23/business/honolulu-walking-and-texting-fine.html

People are looking down at their phones and stepping into traffic, so near Amsterdam they projected the crosswalk indicator down on the ground.

https://www.nytimes.com/2017/10/23/business/honolulu-walking-and-texting-fine.html

The same was done in Augsburg, Germany near the rail tracks.

https://www.washingtonpost.com/news/worldviews/wp/2016/04/25/this-city-embedded-traffic-lights-in-the-sidewalks-so-that-smartphone-users-dont-have-to-look-up/

13

Chongqing, China

In Chongqing, China, they’ve tried to provide two separate walking lanes, one for walking while texting and one for walking without using your phone.

https://www.newsweek.com/chinese-city-creates-cell-phone-lane-walkers-271102

London experimented with padded lamp posts in Brick Lane's 'Safe Text' street *Getty*

In an area of London, they put pads on the lamp posts… [advance slide]

“More than 11,000 injuries resulted from phone-related distraction while walking in the US between 2000 and 2011, according to a University of Maryland study published in 2015.”

https://www.independent.co.uk/news/world/americas/honolulu-texting-walking-hawaii-city-distracted-pedestrian-law-a8018686.html

15

…because *this* kept happening.

481,000

16

The U.S. Federal Communications Commission says, “At any given daylight moment across America, approximately 481,000 drivers are using cell phones or manipulating electronic devices while driving.”

https://www.fcc.gov/consumers/guides/dangers-texting-while-driving

17

And it isn’t just driving automobiles. Local ordinances against texting while biking have appeared in some towns.

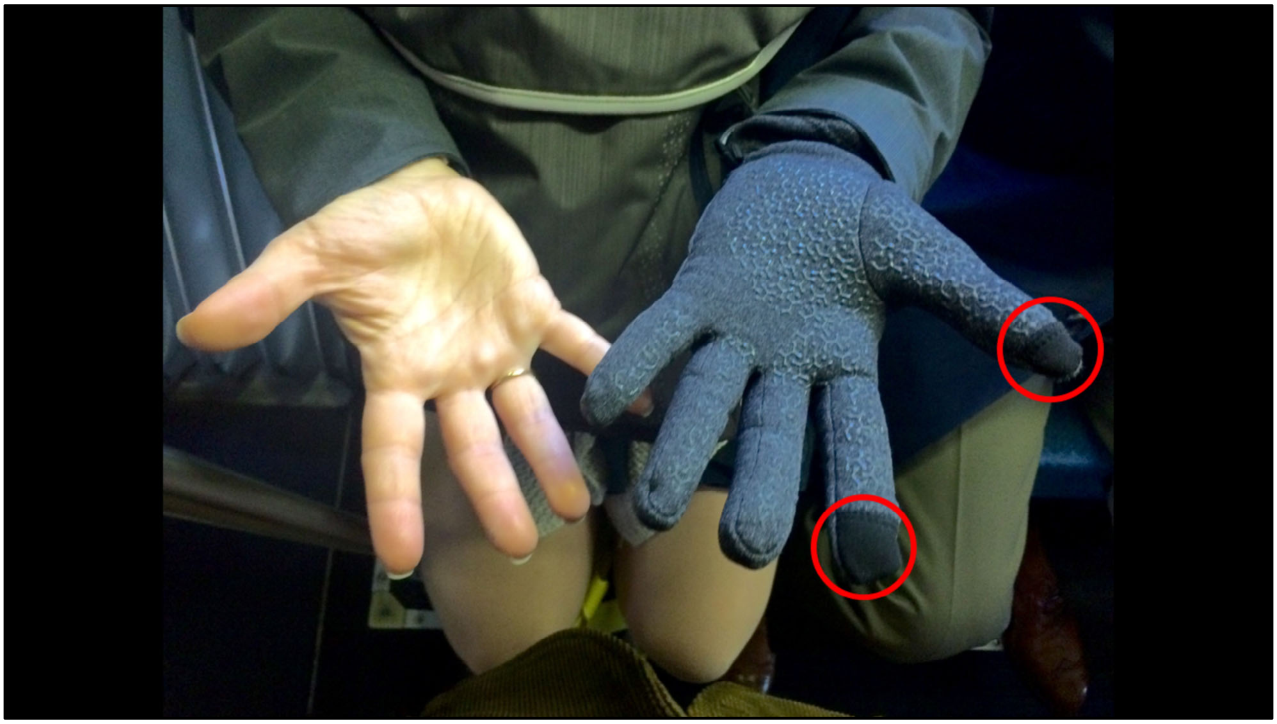
Some people will interact with their devices in the most extreme situations…

Even more extreme, these folks built the world's first website on a tablet entirely while skydiving before they reached the ground.

We have come a long way from the desktop, haven't we?

Notes:
http://www.scoop.co.nz/stories/CU1310/S00052/kiwis-claim-world-first-for-webpage-built-in-mid-air.htm

Watch the video here: http://www.youtube.com/v/A7_jXvWkFHo



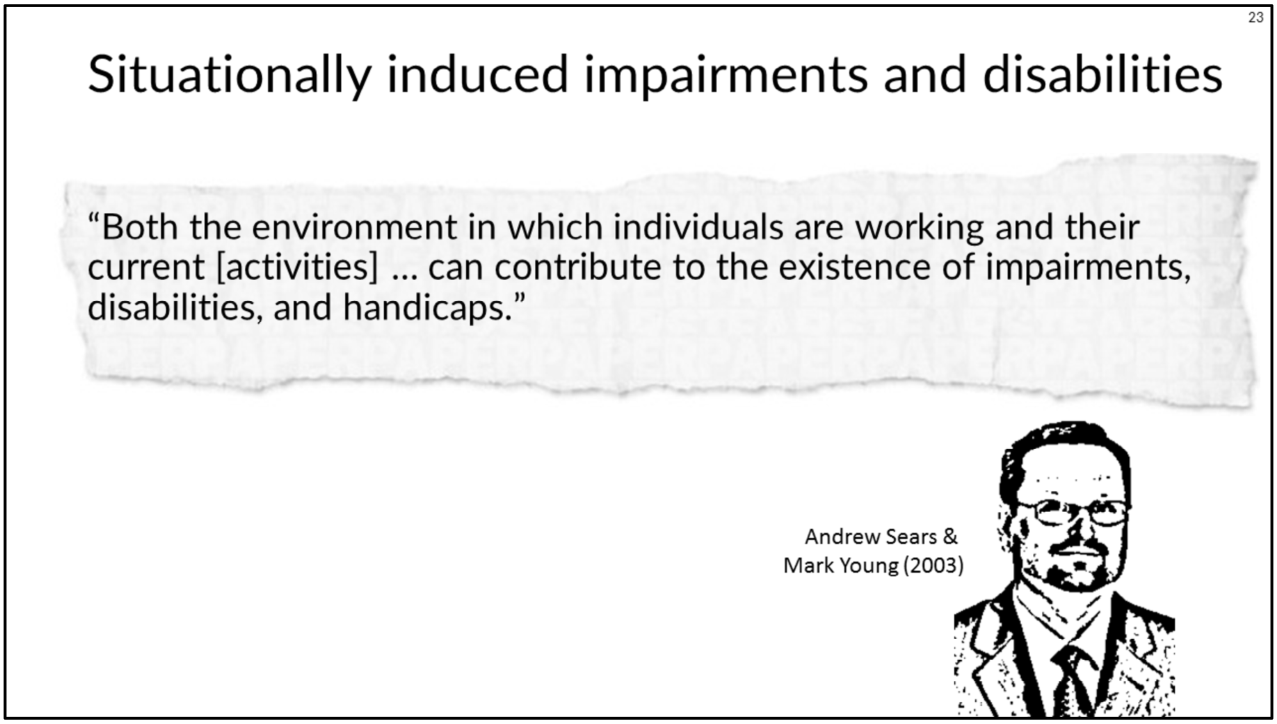
I saw a woman on the bus who had one glove on and one glove off, so I asked her about this, and she said she had to take off one glove to operate her phone. This was despite her gloves having capacitive sensing fingertips on the thumbs and index fingers.

So even the things we design to *overcome* these challenges can actually cause them.

21

The point is, there are *many* varied situations in which we interact with computers and computing devices today.

Situations affect our abilities
to interact with technologies,
our surroundings, and other people.



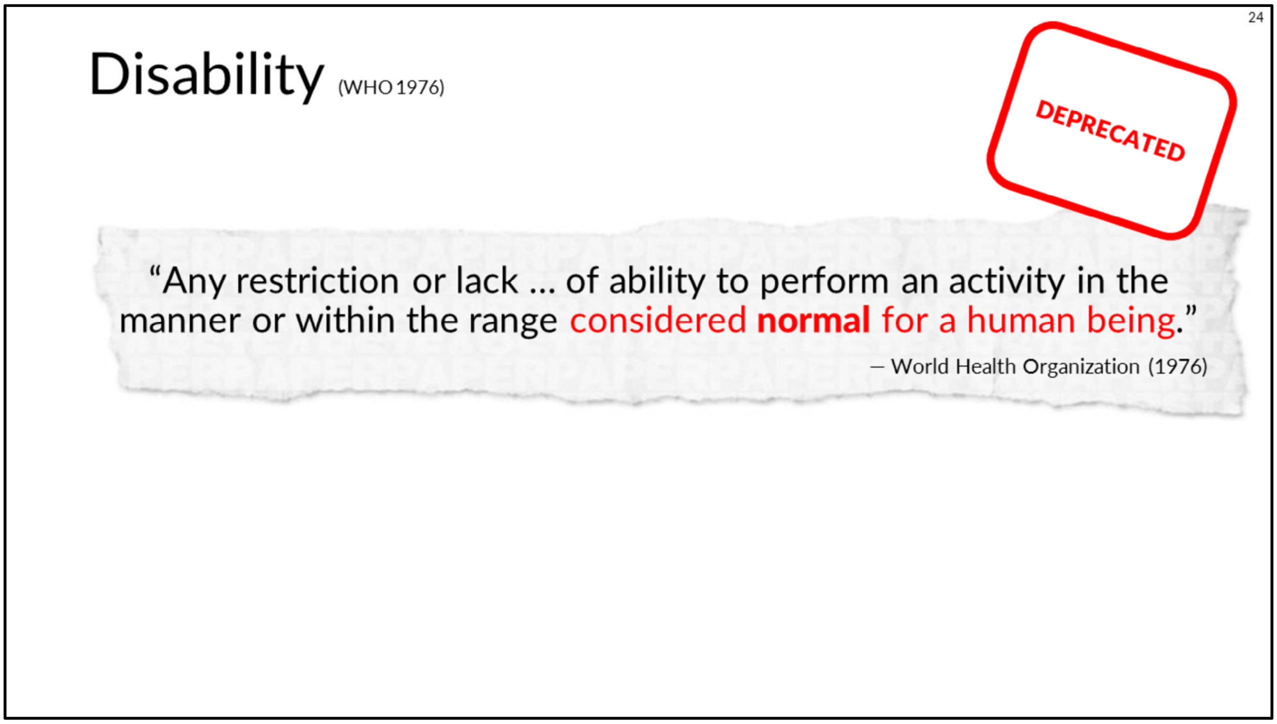
I'm not the first to make this observation.

The way situations affect our abilities has become known in the accessibility community as "situationally induced impairments and disabilities," or "SIIDs."

Andrew Sears and Mark Young were the first to coin this term, saying, "Both the environment…"

Notes:

A. Sears and Mark Young. 2003. Physical disabilities and computing technologies: An analysis of impairments. In *The Human-Computer Interaction Handbook* (1st ed.), Julie A. Jacko and A. Sears (eds.). Lawrence Erlbaum Associates, Hillsdale, New Jersey, 482-503. Retrieved February 28, 2017 from http://dl.acm.org/citation.cfm?id=772105



To understand SIIDs, we need to talk a bit about *disability*.

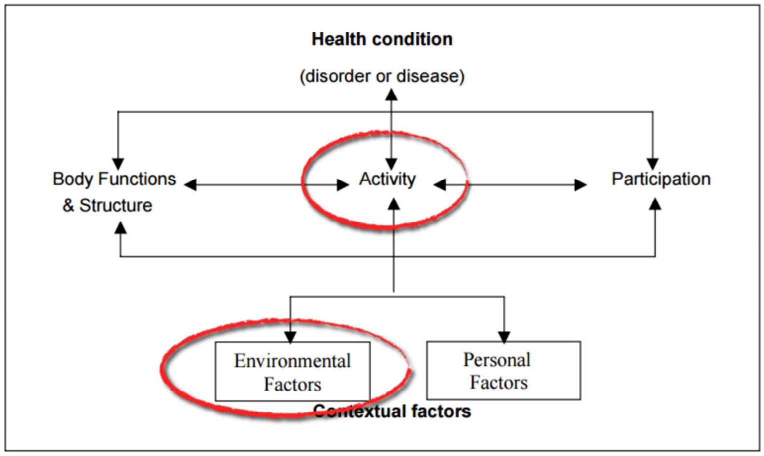
In 1976, the World Health Organization put forth the following definition of "disability."

The important thing to note about this definition is that it places disability entirely *within* the person.

Fortunately, this has become deprecated.

http://hcdg.org/definition.htm

Disability (WHO ICF 2001)



In 2001, a new definition recognized the interplay among multiple factors like health conditions, activities, and the environment. I want to highlight activities and environmental factors because we'll come back to those as being very consequential when thinking about abilities.

Notes:

- Impairment is a loss of function;
- Disability is an activity limitation; and a
- Handicap is a participation restriction.

Example: a loss of motor function in the arms and hands (impairment) might lead to the inability to use a mouse and keyboard (disability), which prevents a person from applying for jobs online (handicap).

"Among contextual factors are external environmental factors (for example, social attitudes, architectural characteristics, legal and social structures, as well as climate, terrain and so forth); and internal personal factors, which include gender, age, coping styles, social background, education, profession, past and current experience, overall behavior pattern, character and other factors that influence how disability is experienced by the individual."

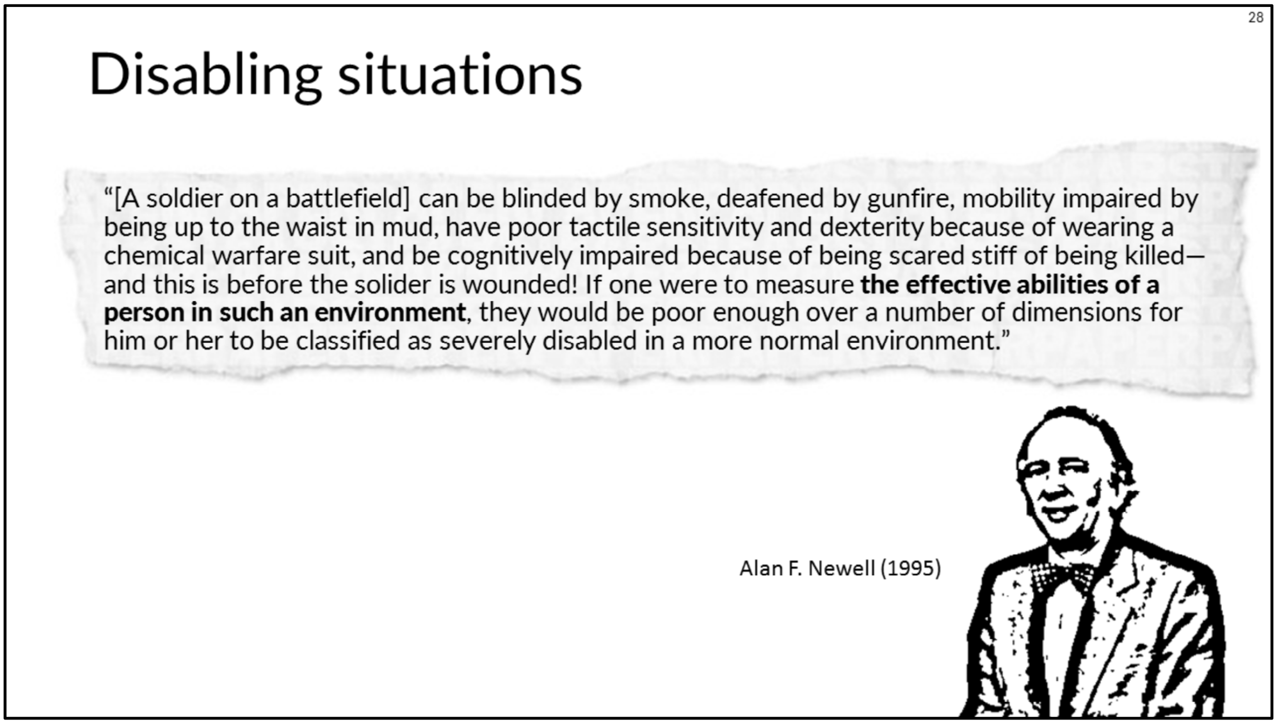
http://www.who.int/classifications/icf/icfbeginnersguide.pdf?ua=1

http://www.rollingrains.com/2007/10/the-world-health-organizations-new-definition-of-disability.html

Disability due to the **environment** has been recognized for some time in the accessibility community.

When a person in a wheelchair encounters a flight of stairs, the disability they experience is a product of the fact that they cannot walk *and that the stairs require that they do*.

This perspective is called the social model of disability, as opposed to the medical model.



Environments disable all of us, not just people with disabilities.

Alan F. Newell, the accessible computing pioneer, wrote about disabling environments back in 1995.

He said, “[A solider on a battlefield] can be…”

29

Alan F. Newell (1995)

Here's the illustration he had accompanying that description from Newell's 1995 book.

<u>Source:</u>

Alan F. Newell. 1995. Extra-ordinary human-computer interaction. In *Extra-Ordinary Human-Computer Interaction: Interfaces for Users with Disabilities*, Alistair D. N. Edwards (ed.). Cambridge University Press, Cambridge, England, pp. 3-18.

You don’t have to be in the soldier’s extreme situation to experience an SIID.

Here’s a woman trying to operate her smartphone while carrying a baby.

Think about all the ways her abilities could be affected by being in this situation.

Environments affect our ability to interact.
We **adapt ourselves** to compensate.

Assistive technology

People with disabilities have been adapting themselves to environments, whether physical or social, for a long time.

In the post-WW2 era, if you were missing a leg, we gave you a leg. If you were missing an arm, we gave you an arm.

The expectation was that *you* would conform to the environment as it was. There was no expectation for the environment to change.

37

Our computing devices remain **oblivious** to the many ways we adapt ourselves to suit them.

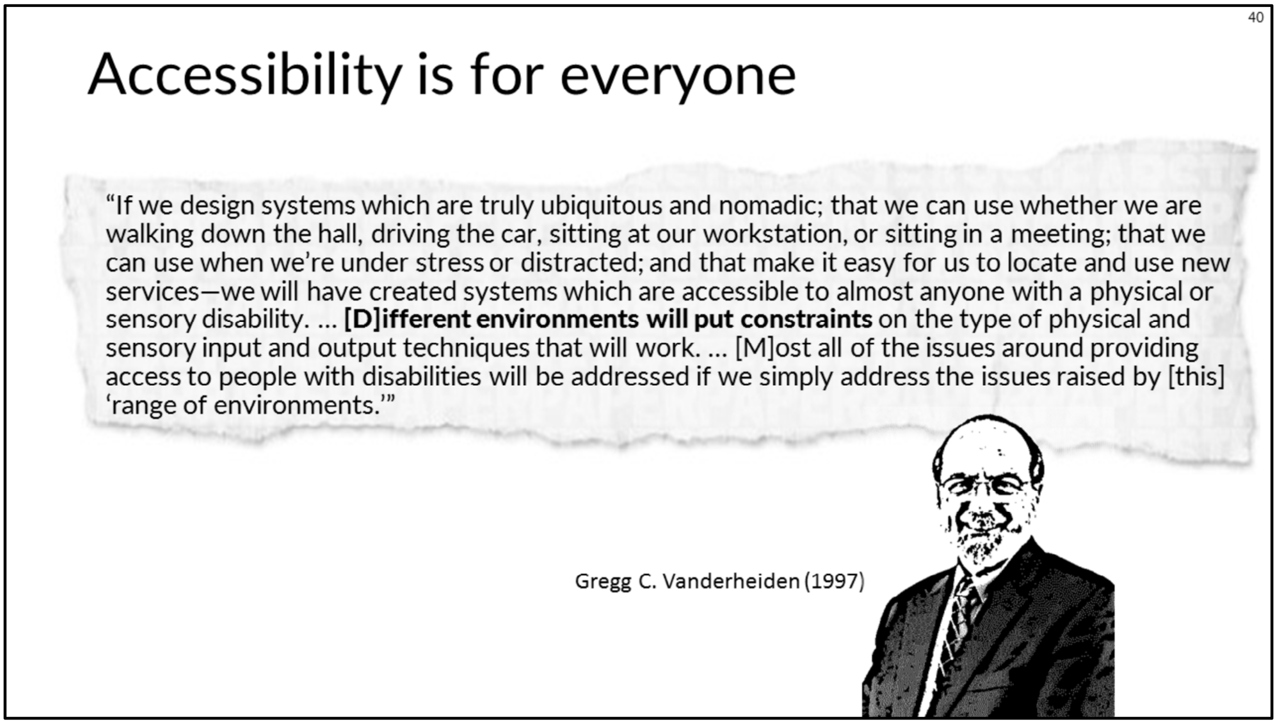
But computers are not concrete stairs. They *are* capable of sensing and changing, and yet "our computing devices remain oblivious to the many ways we adapt ourselves to suit them."

Accessible computing?

People with disabilities today *still* often have to adapt themselves to their technologies, which have no idea that they are doing so.

The keyboard has no idea that the person is using a pointing stick.
The laptop has no idea that the woman is typing with her feet.
The smartphone has no idea that it is being used by a stylus instead of a finger.
The trackball has no idea that it is being operated by the person’s chin.

Since environments affect all of us,
we *all* might benefit from more
situationally aware devices.



Accessibility is for everyone.

As Gregg Vanderheiden, another pioneer in accessible computing wrote in 1997, “If we design systems…”

Not “the same!”

- Different lived experience
- No stigma with SIIDs
- No disability culture
- No need for legal protections or policy considerations

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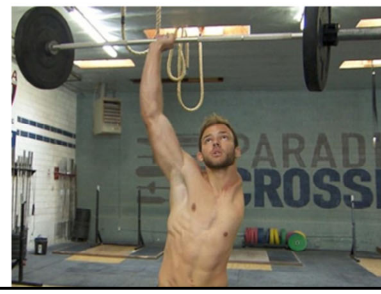


And yet…

- The impairing effects of SIIDs are real
- Designs that can benefit people with disabilities can also benefit people experiencing SIIDs

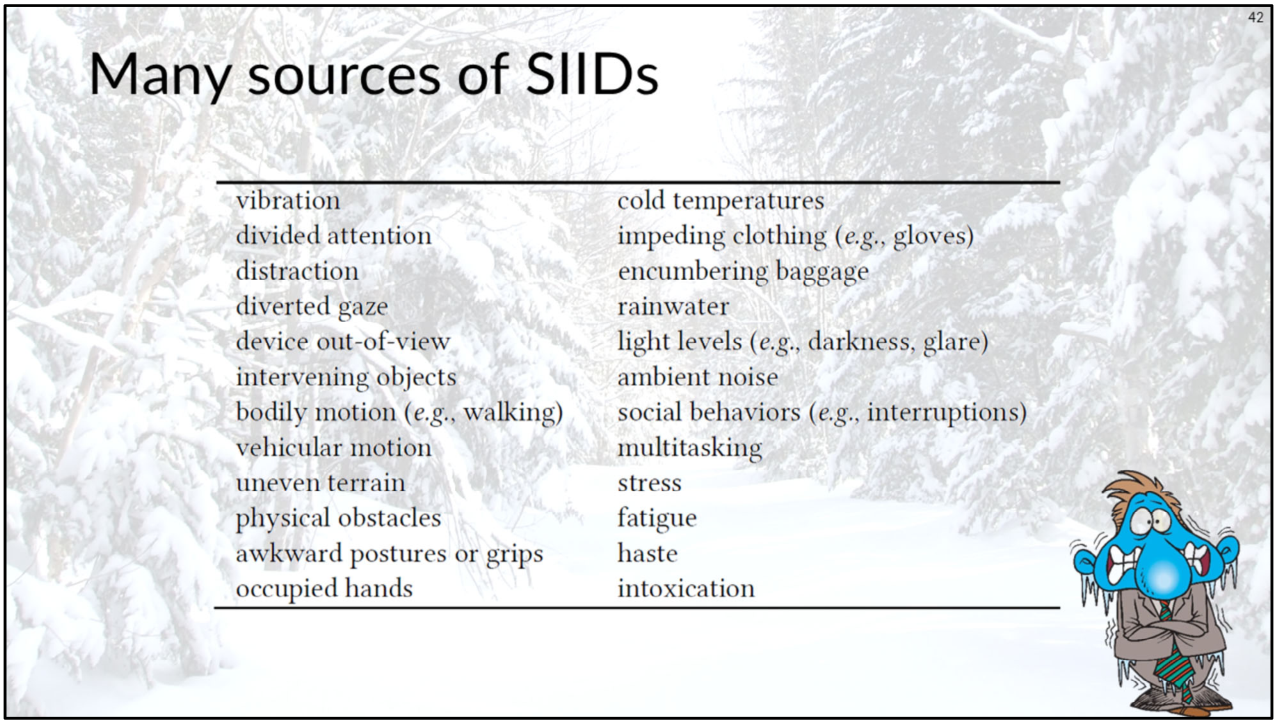
41

Now, to be clear, these authors and I are not making the claim that being situationally impaired is like living with a disability.

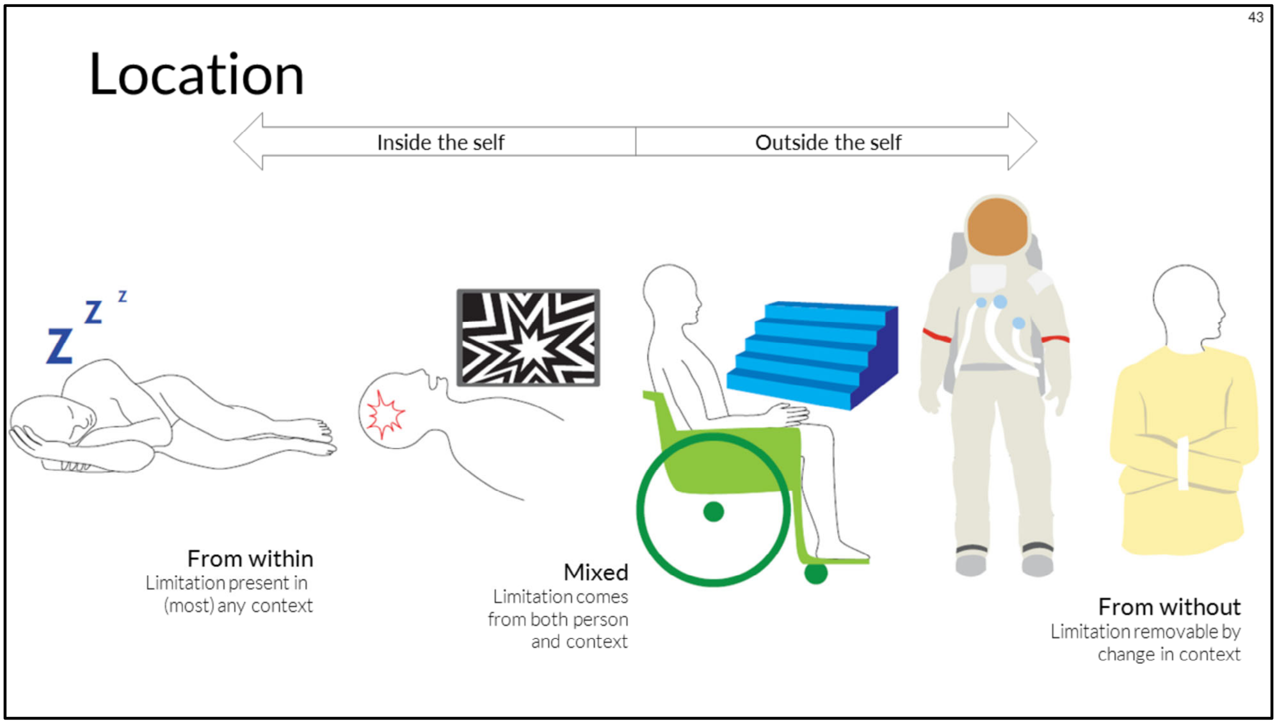
The lived experience of having a disability is unique to that person and their life story. Experiencing a situational impairment has little to do with the lived experience of disability.

But what I *am* claiming is that a design approach focused on *situation and ability* can address both SIIDs and disabilities. Although a person carrying an infant while typing *is not the same as* a person with one arm, both might benefit from technology designs for one-handed use.

By focusing on *ability* in design, we unify our approach towards everyone, rather than treating design for people with disabilities as design for “those people.”



In my work, I have tried to surface a number of SIIDs and then find ways to address them.



As we think about context, we can consider a whole space of ability limitations.

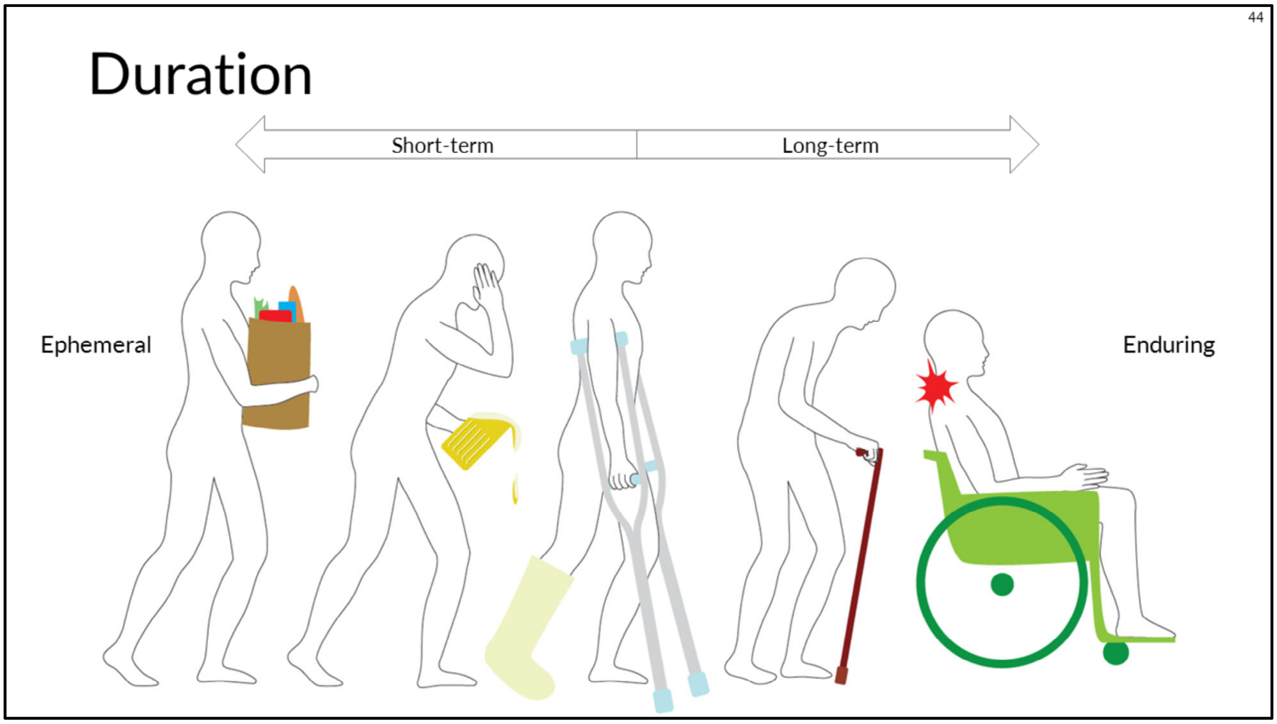
We can consider the *Location* of an ability limitation.

Some ability limitations come mostly from "within the self," where it matters very little what environment the person is in.

Other ability limitations come mostly from "outside the self," where a change in the environment immediately changes or removes the ability limitation.

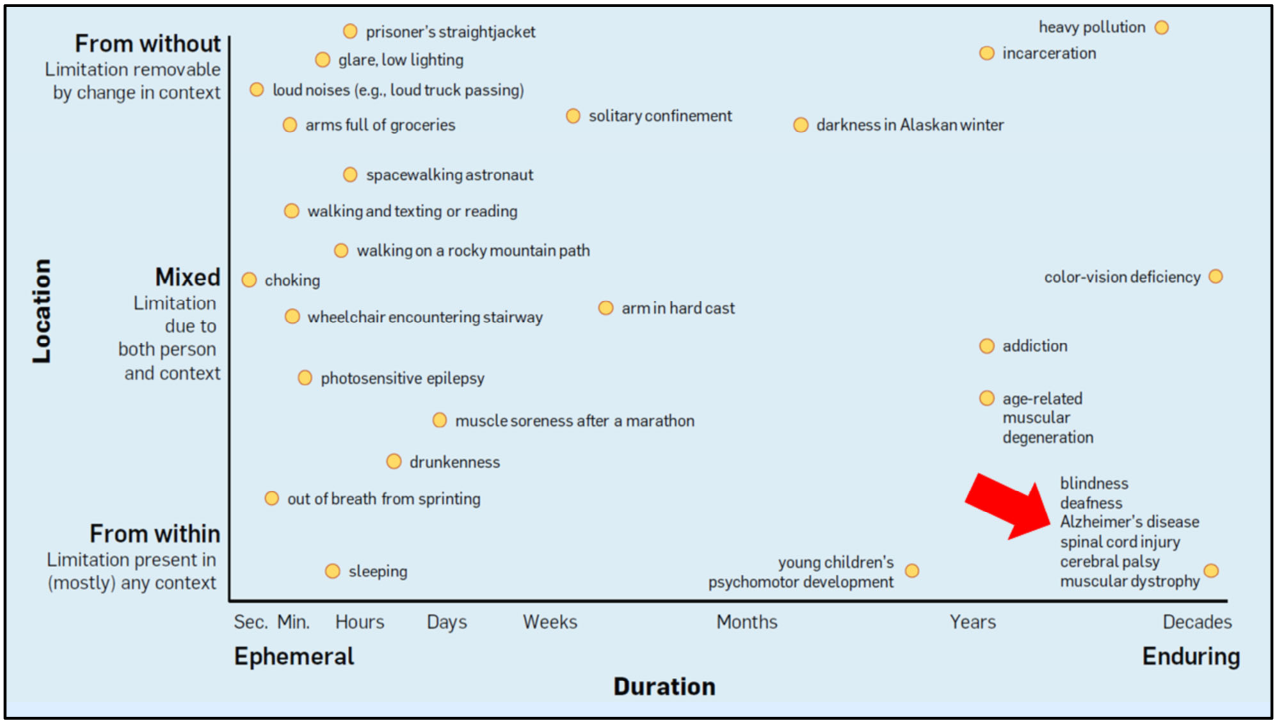
If I put the world's greatest athlete in a prisoner's straightjacket, they can do very little because of the external constraints on their abilities.

On the other hand, if you are sleeping or otherwise unconscious, it doesn't matter what environment you are in, you can't do very much.



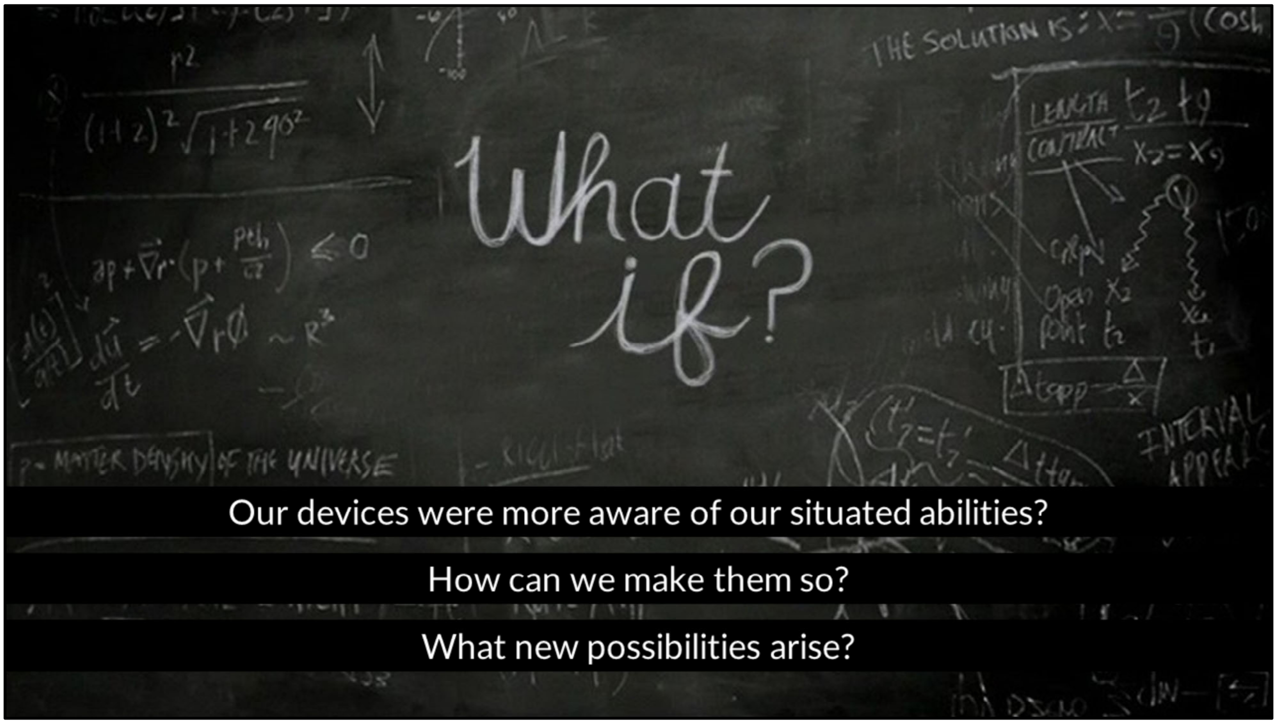
We can also consider the duration of limitations to our abilities.

The *Duration* of ability limitations can be quite different. Some are short-lived and others are permanent.



Together, *Location* and *Duration* can define a space of ability limitations.

Traditional accessible computing and assistive technology have focused on the bottom-right corner. But there is a much bigger space of possibilities here, a space that can affect anyone.

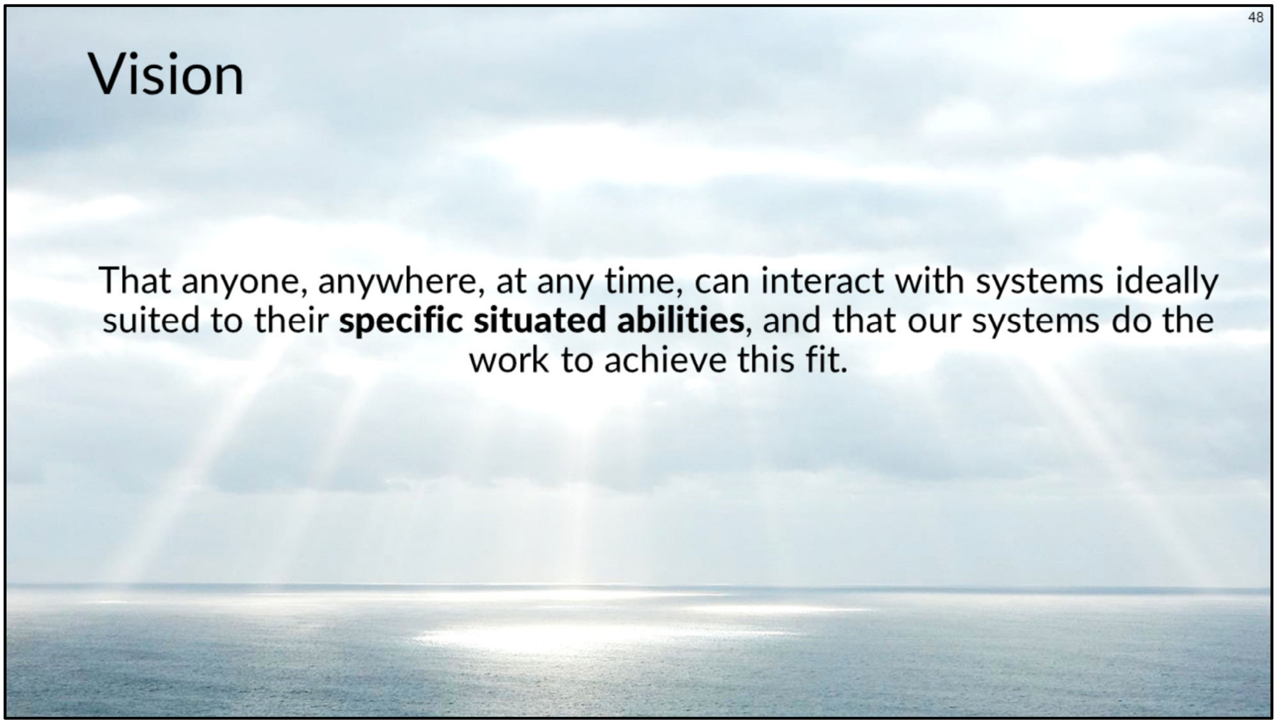


This framing brings us to some research questions.

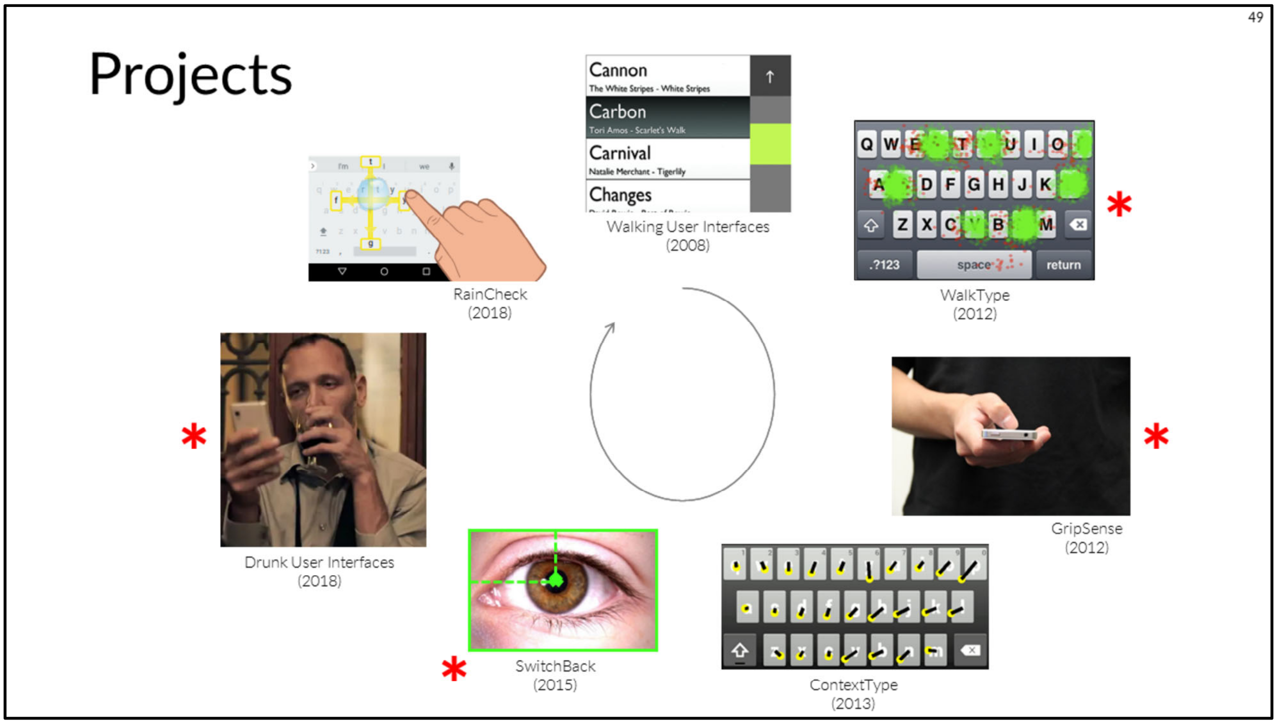
“What if our devices were more aware of our *situated abilities*?”

“How could we make our devices more aware?”

“If we could do this, what new possibilities for interactive systems might arise?”



These questions point towards a vision. “That anyone, anywhere, at any time…”



Over the last decade, my research group and I have done multiple projects related to situationally induced impairments and disabilities.

These projects have made mobile devices more aware of our situated abilities, and have allowed us to explore ways of improving interaction when users are experiencing SIIDs.

Rather than go into any one project too deeply, I'm going to give an overview of four of these projects.

All seven of these projects are described in my EICS paper accompanying this talk.

And for even more detail, you can find the original published papers about each of the projects.

50

Main collaborators

Mayank Goel

Alex Mariakakis

Shwetak N. Patel

I want to acknowledge my main collaborators on the four projects you're about to see.

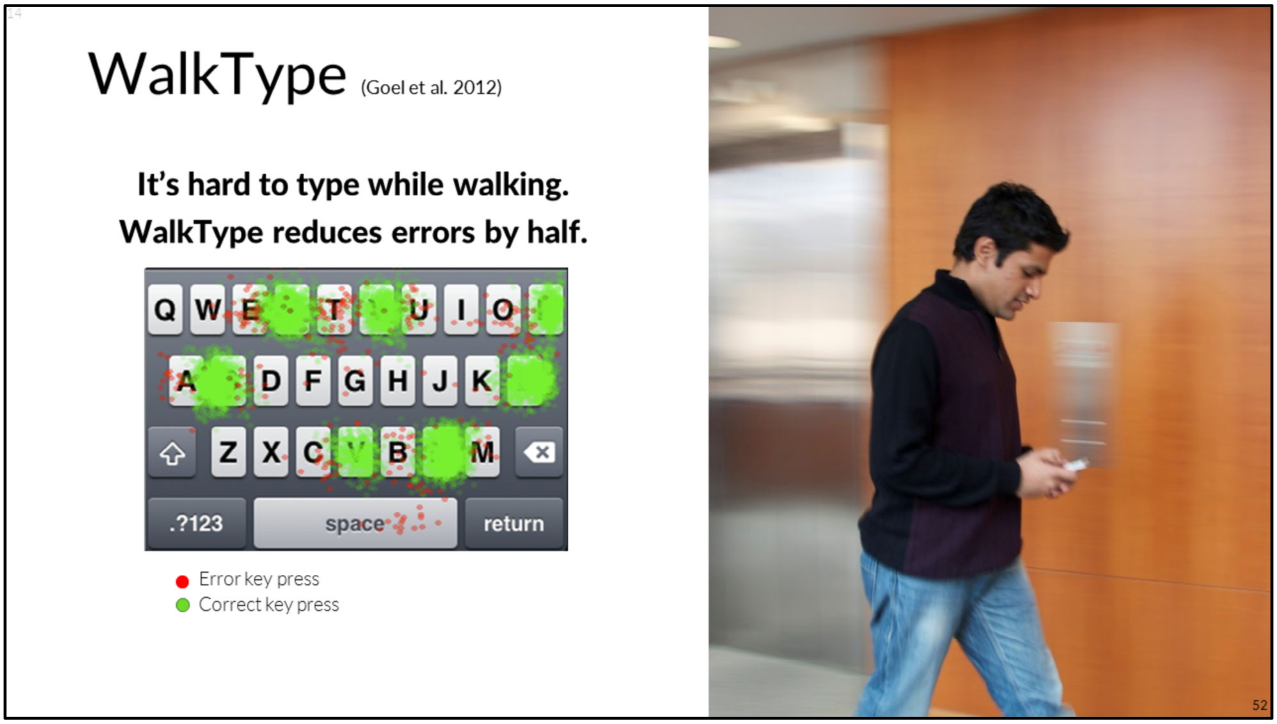
Mayank Goel is now a professor at Carnegie Mellon.

Alex Mariakakis just graduated with his Ph.D. in computer science from the University of Washington in Seattle.

Shwetak Patel is a colleague of mine at the University of Washington.

WalkType

Goel, M., Findlater, L. and Wobbrock, J.O. (2012). **WalkType: Using accelerometer data to accommodate situational impairments in mobile touch screen text entry.** Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '12). Austin, Texas (May 5-10, 2012). New York: ACM Press, pp. 2687-2696. Honorable Mention Paper.



WalkType was a project that attempted to improve key-press accuracy on smartphone keyboards while the user was walking.

"It's hard to type while walking. WalkType reduced key-press errors by almost *half*."

So how did it do this?

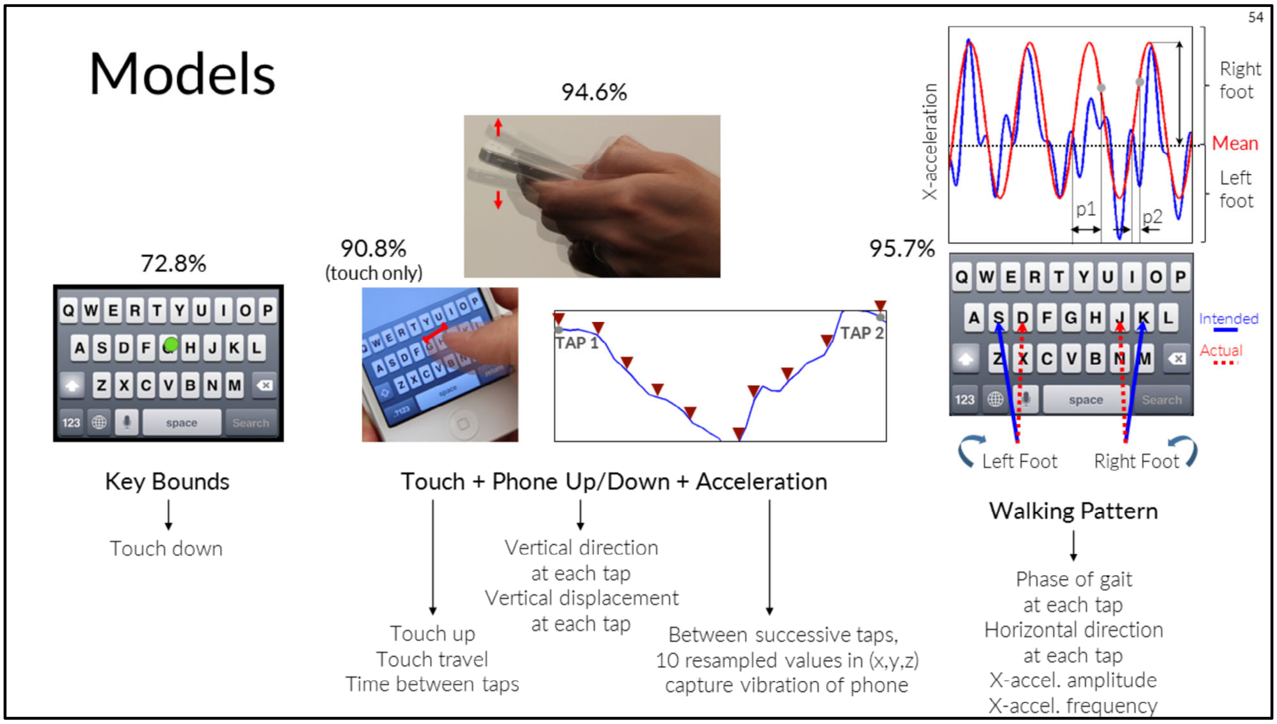
Training data

- 16 participants
- Sitting, and walking with a human pacesetter
- 50 phrases each
- Two-thumb typing
- 47,647 key-presses

- 3-axis accelerometer @ 100 Hz
- Touch down, up, travel, time

We first collected almost 50,000 key-presses from 16 participants entering text phrases while sitting and while walking.

We also captured accelerometer data and touch data for each touch event.



Then we built multiple decision tree models using various features from the training data.

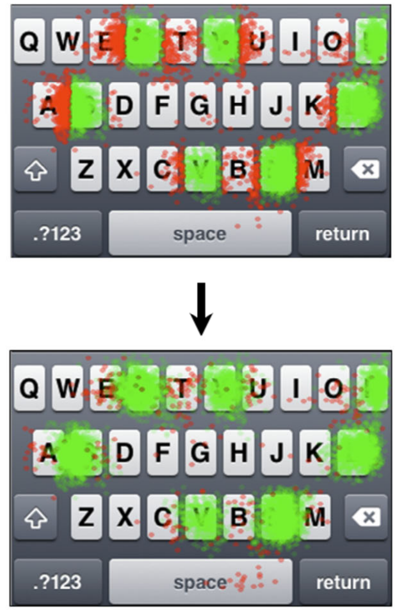
[Second model]
Vertical direction is detected by using the slope of the acceleration at the tap point. Upward in z means downward motion of the phone, and downward in z means upward motion.

[Third model]
When the right foot strikes, the phone moves counter-clockwise and that results in positive X-acceleration; the clockwise motion in the case of a left foot strike results in negative X-acceleration.

(A gyroscope would be a much better sensor for this but it was not very common on phones in 2011.)

WalkType

- Touch anchors at very center of each key (Gunawardana et al. IUI 2010)
- Else, majority rules from the three decision tree models
- If all models disagree, the Walking Pattern model wins
- Final classification accuracy: 97.3% (10-fold cross validation)



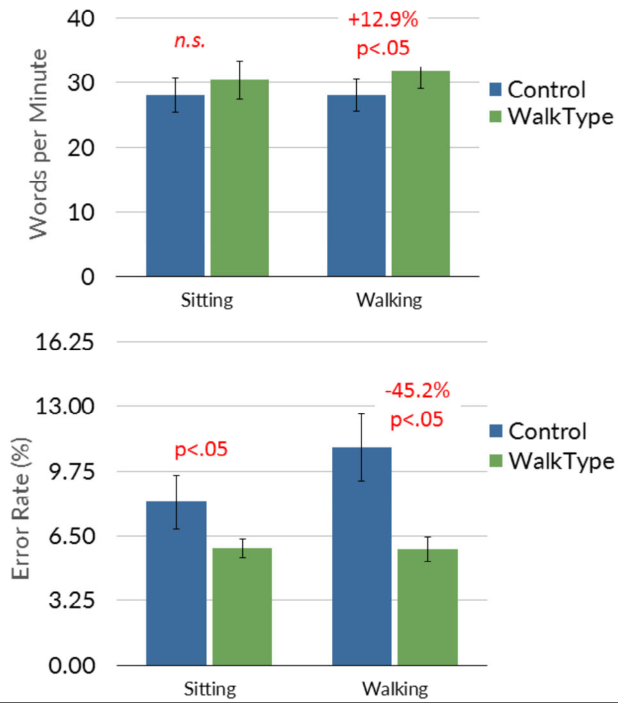
The final WalkType model used touch anchors at the very center of each key. If the key-press was outside the very center of a key, the three decision models you just saw each rendered a vote, and the majority classification would "win." If all three models disagreed, then the most complex model, the third one, wins.

The final key-press classification accuracy using 10-fold cross validation was 97.3%.

Evaluation

- 16 participants
- Control *vs.* WalkType
- Sitting and walking
- 30 phrases each
- 57,663 key-presses

- 14 of 16 participants preferred WalkType (blinded)



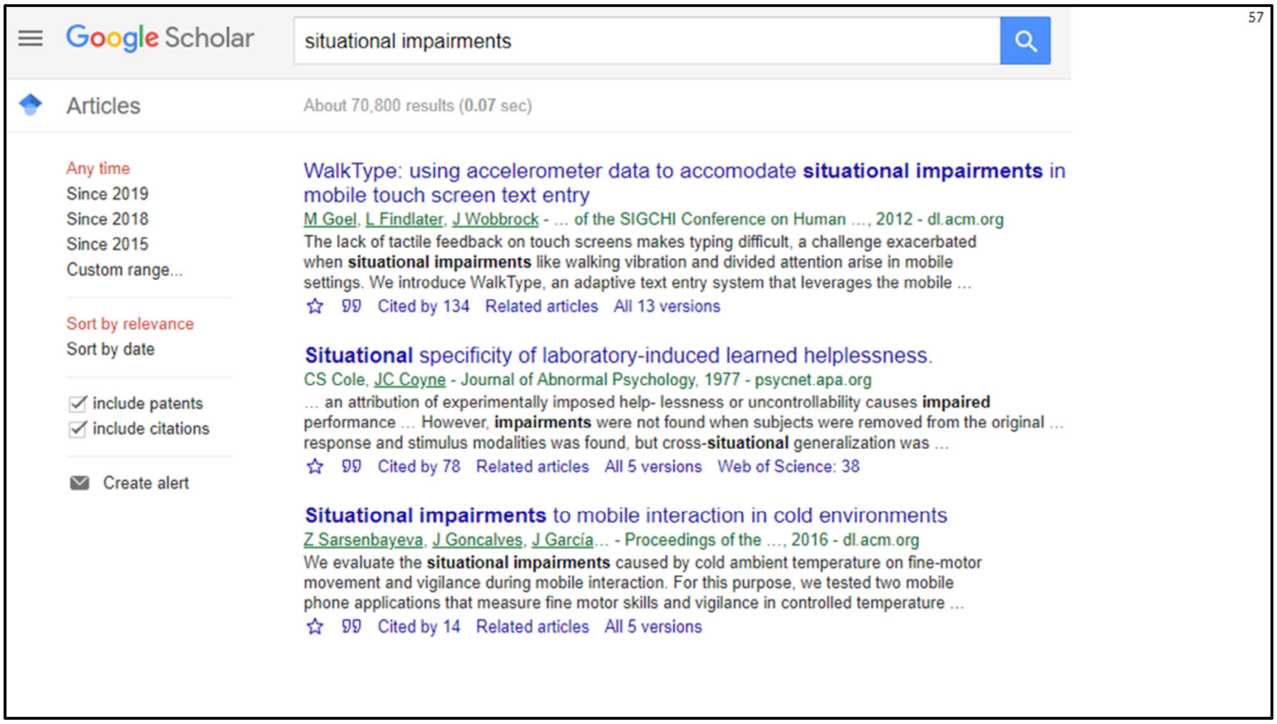
56

But it is not enough to do a classifier evaluation. We now had to deploy WalkType interactively to see if it actually improved typing accuracy for walking participants.

WalkType ran invisibly in the background during a study of 16 participants sitting and walking. We collected almost 60,000 key-presses.

WalkType was significantly faster while walking and more accurate while sitting and walking.

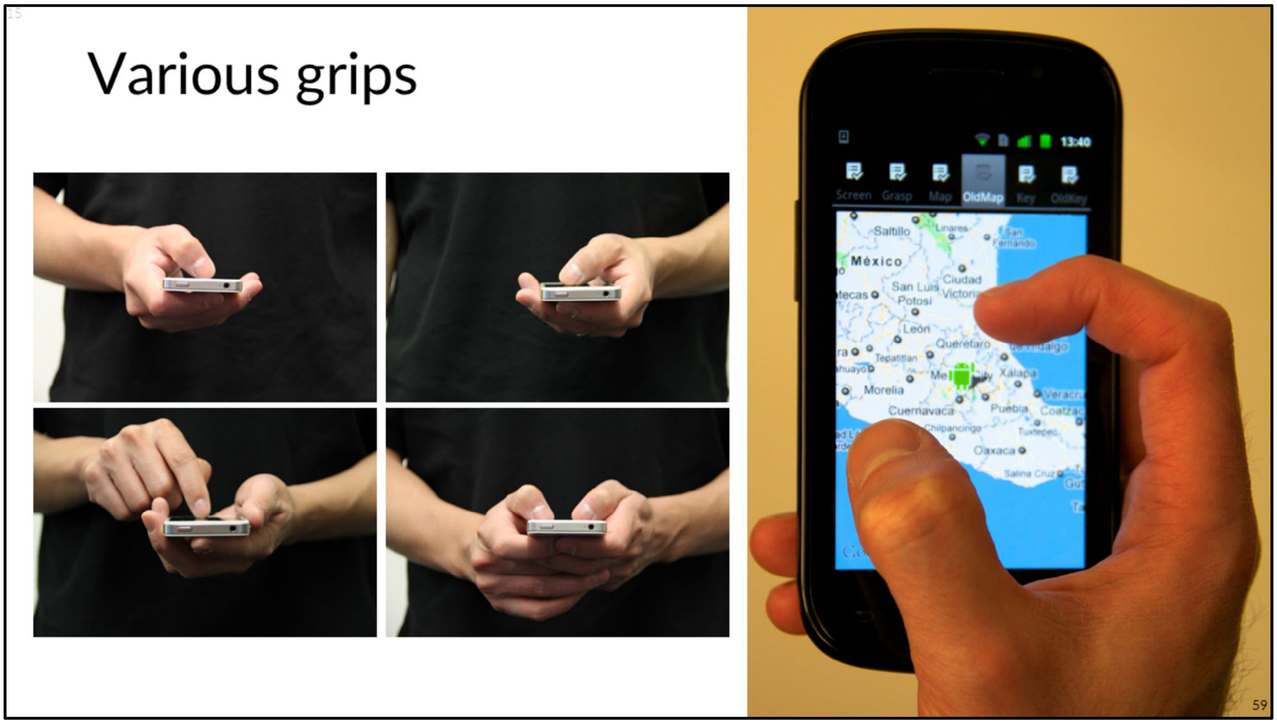
Also, without knowing when they were using WalkType, 14 of 16 participants said they preferred it over the control keyboard condition.



If you search for “situational impairments” in Google Scholar, the WalkType paper is the first result. That’s nice!

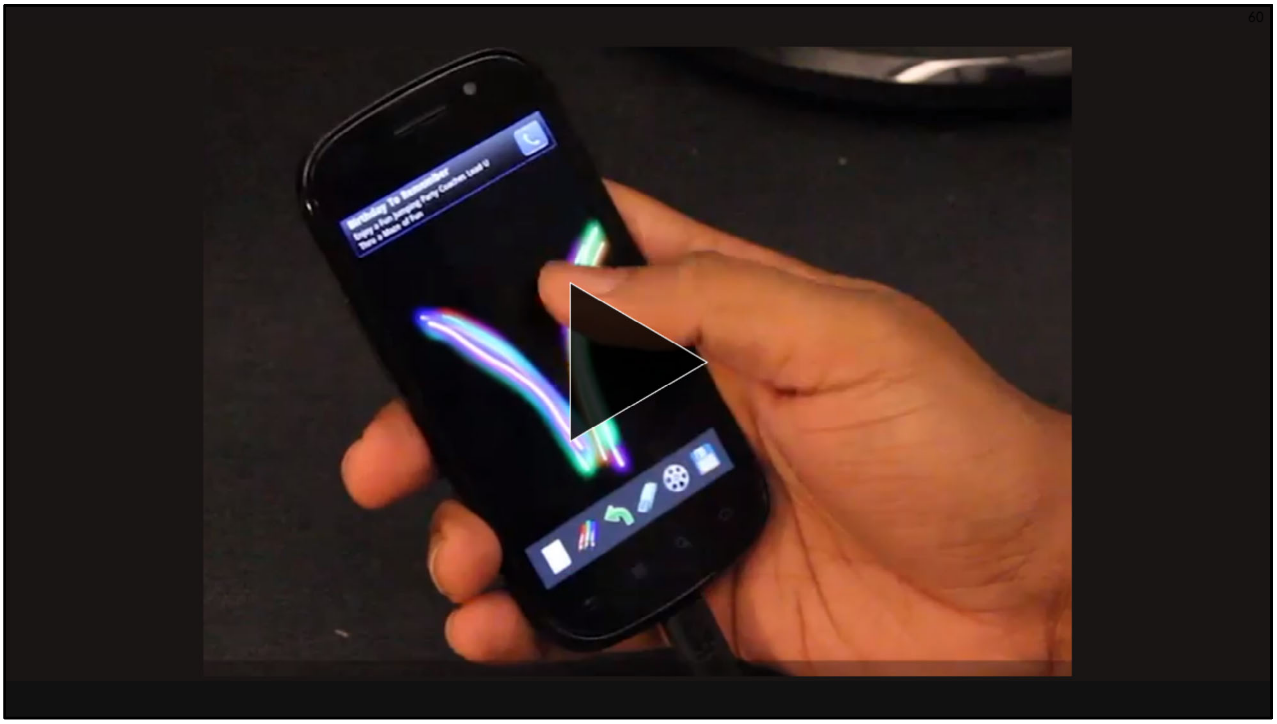
GripSense

Goel, M., Wobbrock, J.O. and Patel, S.N. (2012). **GripSense: Using built-in sensors to detect hand posture and pressure on commodity mobile phones.** Proceedings of the ACM Symposium on User Interface Software and Technology (UIST '12). Cambridge, Massachusetts (October 7-10, 2012). New York: ACM Press, pp. 545-554.



How many of us have tried to zoom with one hand like in the picture shown here? A situational impairment can come from how we hold a mobile device. Our devices currently are oblivious as to whether we are holding them with one hand or two hands, and if one hand, which hand we're using.

GripSense allowed us to determine which hand was holding the device. It also enabled pressure-sensing (without using a pressure-sensitive screen) by measuring the dampening of the gyroscope when the vibration motor was "pulsed."

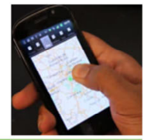


https://www.youtube.com/embed/pnfdwssfQwM?autoplay=1&start=21&end=115

Evaluation

Grip Detection

	Taps	Taps & Swipes
No. Interactions	5	24
Accuracy	84.3%	89.1%



Pressure Detection

	Accuracy
3 levels	95.1%
2 levels	97.9%

Signals used in rule-based classifier

Rotation of the device

Touch size

Shape of swipe arcs

Signals used in J48 classifier

Gyroscope

Touch size

Touch location

We ran a controlled study with 10 participants performing various grips and pressures in 45-minute sessions.

Rotation of the device was measured using the on-board gyroscope.

For grip data collection, we had one app that used taps and swipes (selecting Contacts), and another app that used only taps (an on-screen keyboard).

Results were comparable in an informal study of sitting versus walking, because we're using mostly high-frequency signals, and walking induces mostly low-frequency signals.

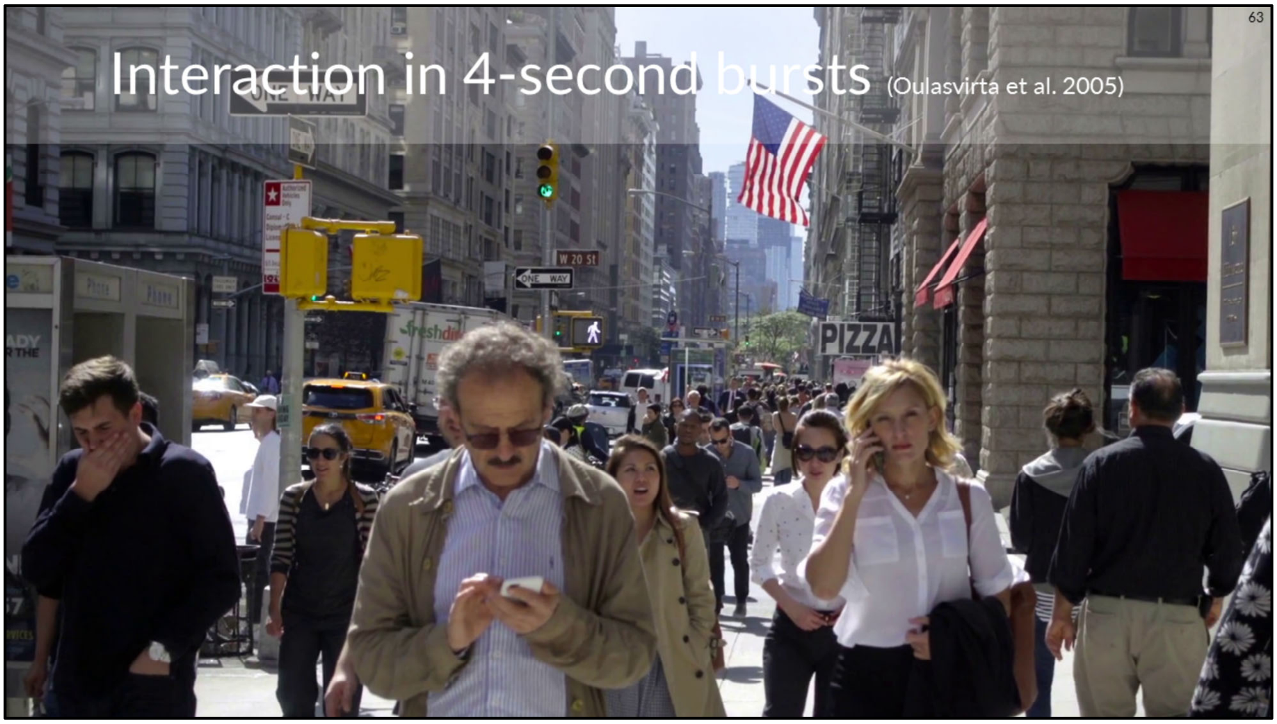
Thin-film force-sensitive resistors (FSRs) were used for pressure ground truth to train participants to exert three distinct levels of pressure. But FSR data was not used to train any model.

For touch size, we used Android's built-in touch size reporting. Without it, accuracy was 93.46% for 3 pressure levels.

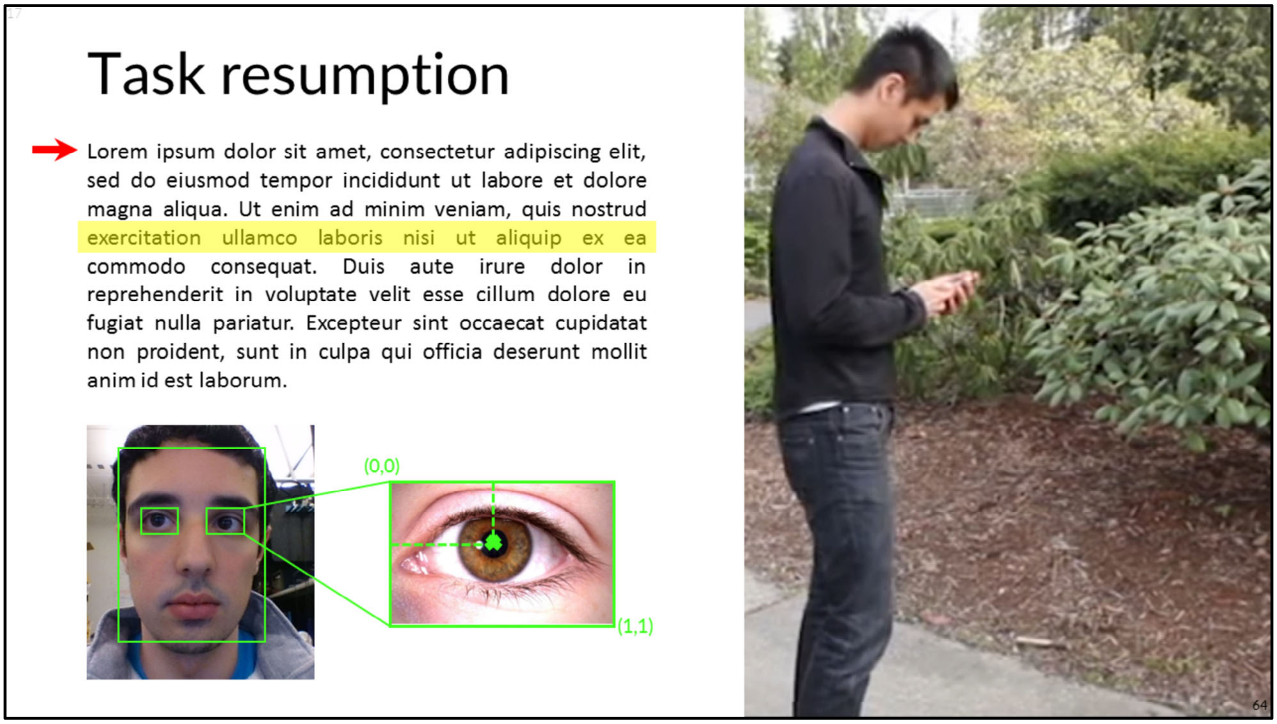
Models were user-specific because people hold and touch in different ways (i.e., high individual differences). But training is fast. Diminishing returns occur after gathering only 6 taps per pressure level per user.

SwitchBack

Mariakakis, A., Goel, M., Aumi, M.T.I., Patel, S.N. and Wobbrock, J.O. (2015). **SwitchBack: Using focus and saccade tracking to guide users' attention for mobile task resumption.** Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '15). Seoul, Korea (April 18-23, 2015). New York: ACM Press, pp. 2953-2962.



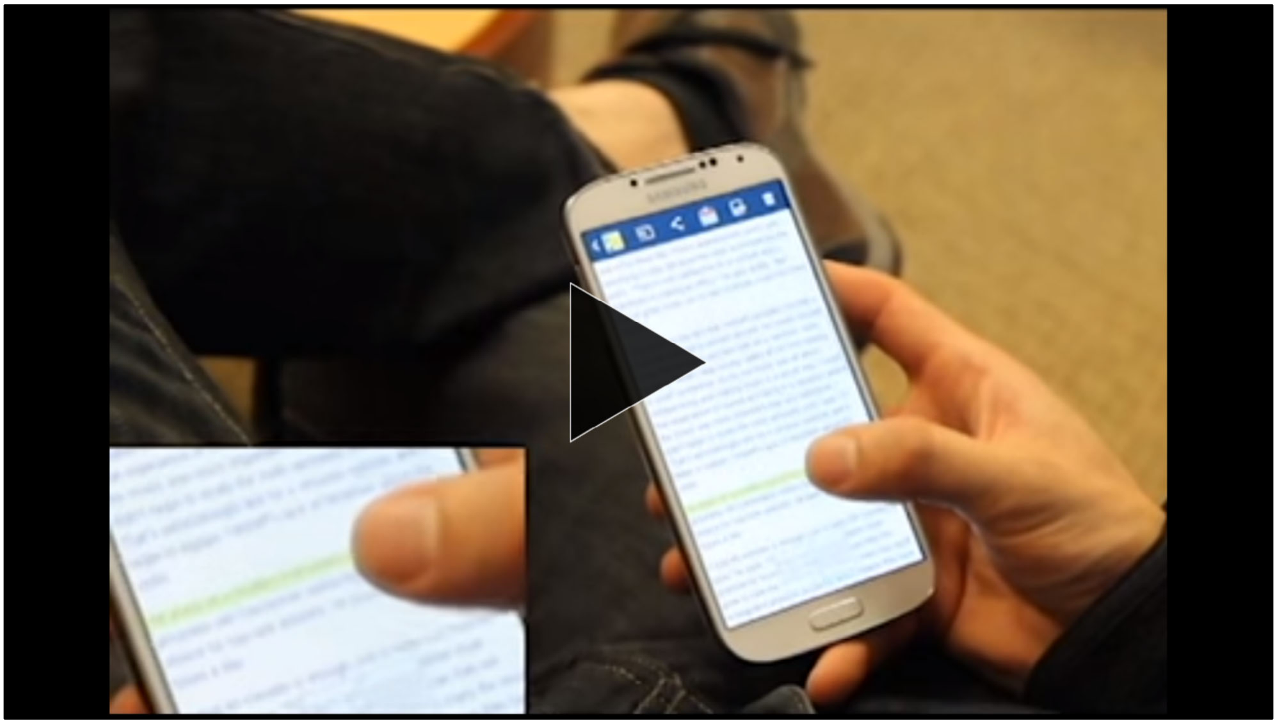
Prior work has shown we divert our attention from our smartphone screens every 4 seconds while on-the-go.



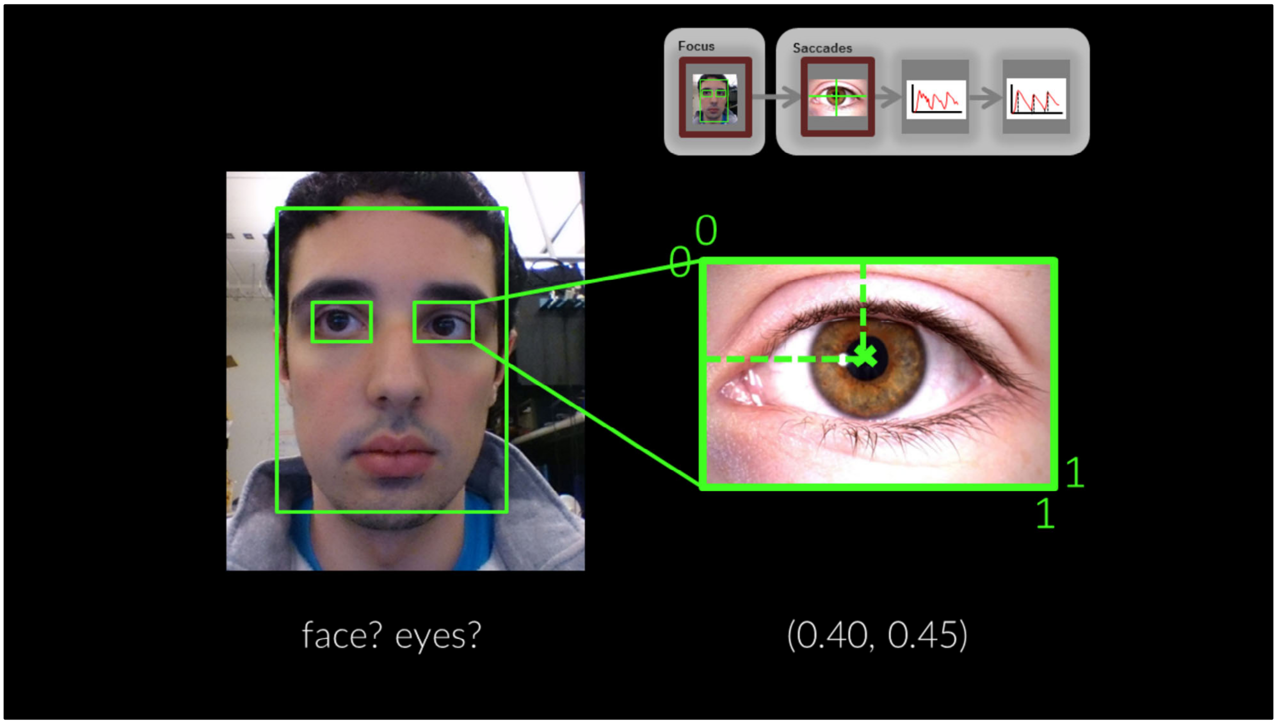
SwitchBack helped users resume tasks when they looked away, and then back at the screen.

When looking to and from the screen, we often can lose our place, especially while reading, and we have to spend precious moments recovering.

SwitchBack used the front-facing camera to track the eye-gaze position and highlight the last line of text we read when we return our gaze to the screen after looking away.

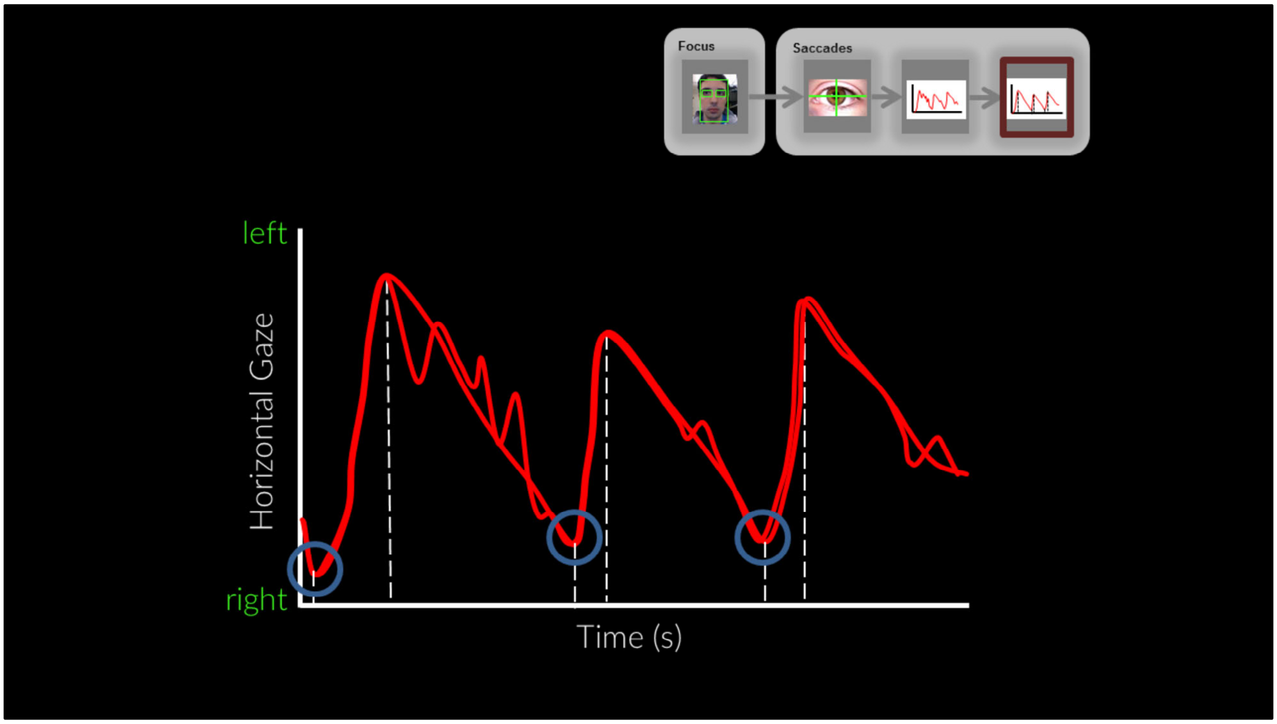


https://www.youtube.com/embed/uDsZXEZdLpY?autoplay=1&start=16&end=70

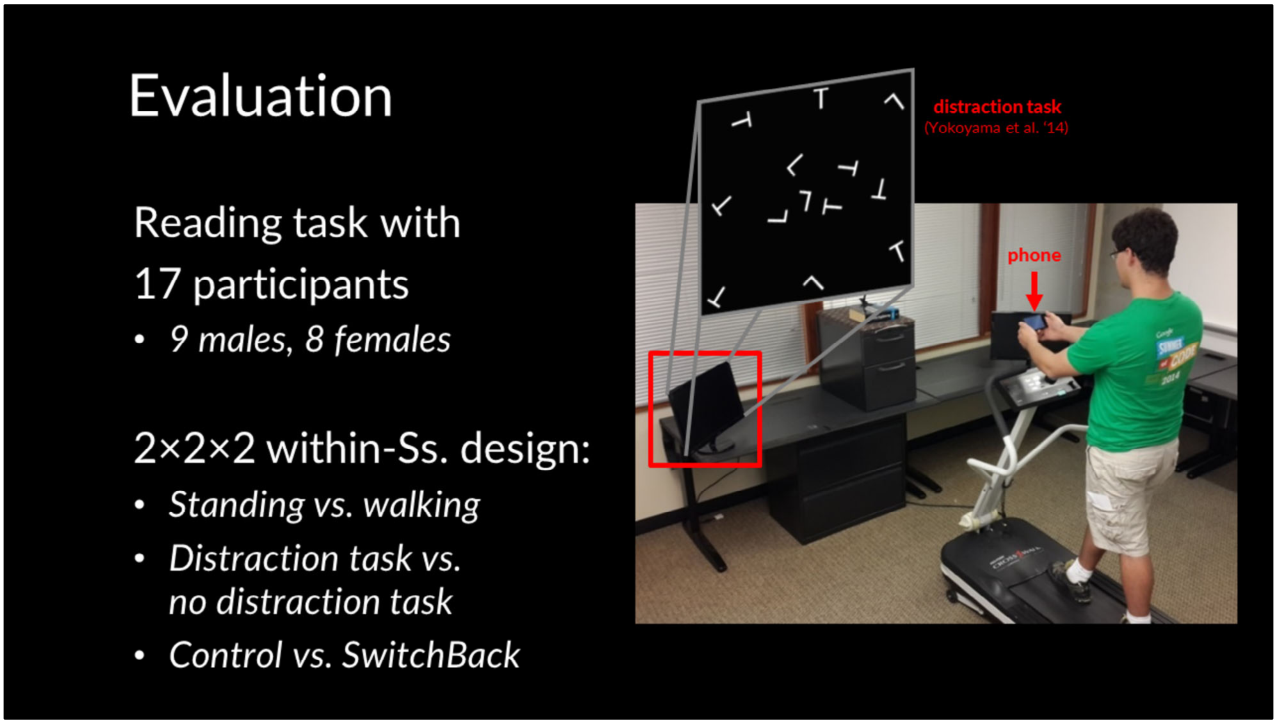


We can detect the face and eyes with the front-facing camera. We do this with standard computer vision techniques.

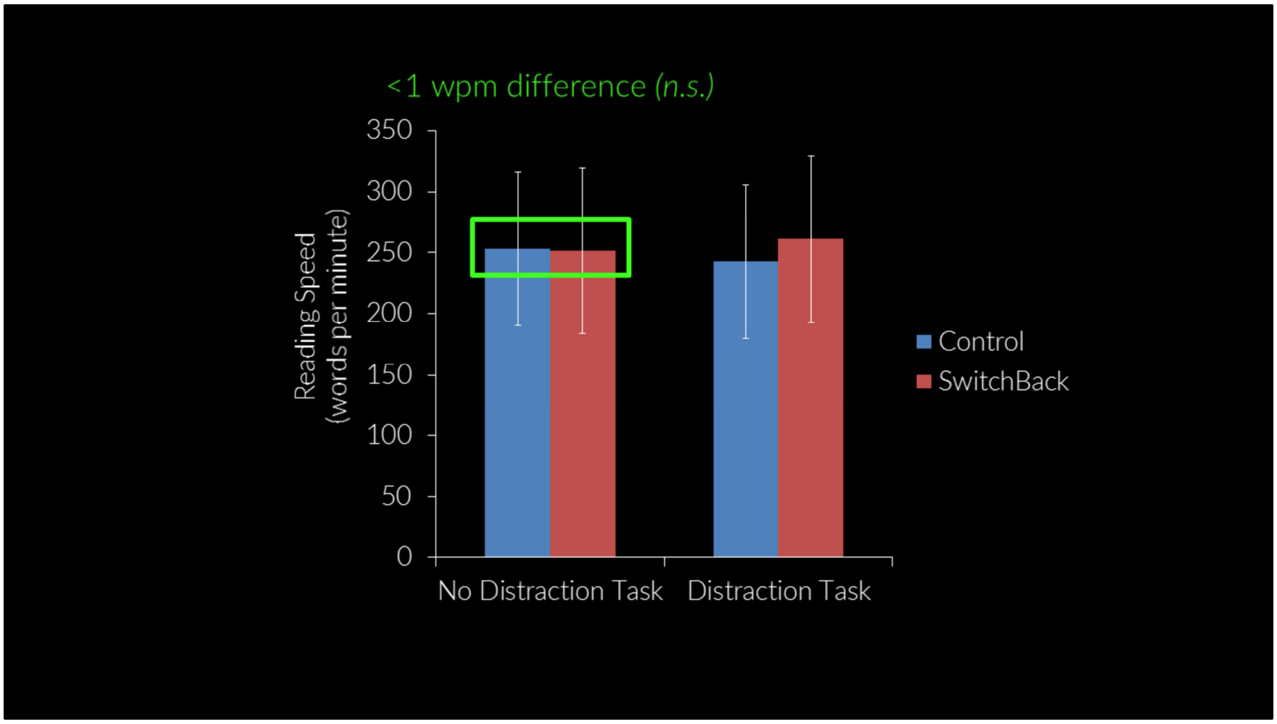
Then we watch for saccades and track them.
https://www.youtube.com/embed/uDsZXEZdLpY?autoplay=1&start=30&end=41&mute=1



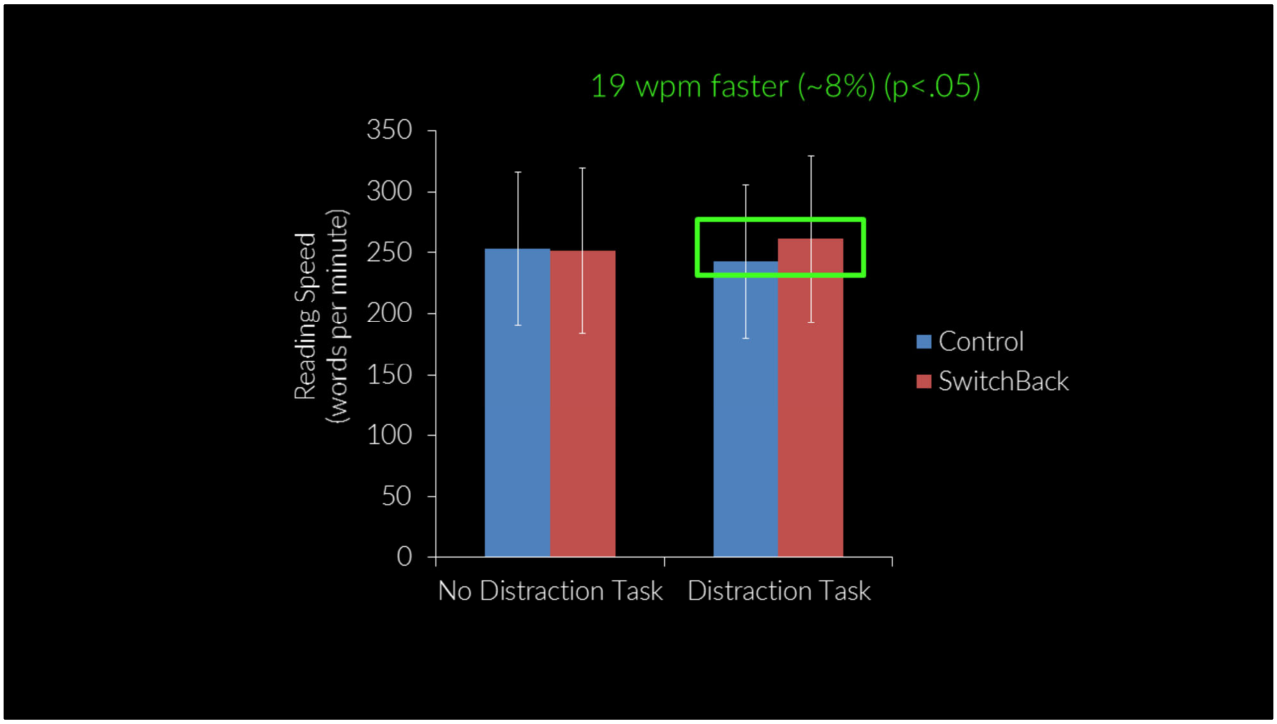
We smooth the signal and check for peaks and troughs to detect saccades.



In our evaluation, we had 17 participants walking on a treadmill perform a reading comprehension task with and without SwitchBack. They also had a distraction task that forced them to look away from their phone screen many times while reading.



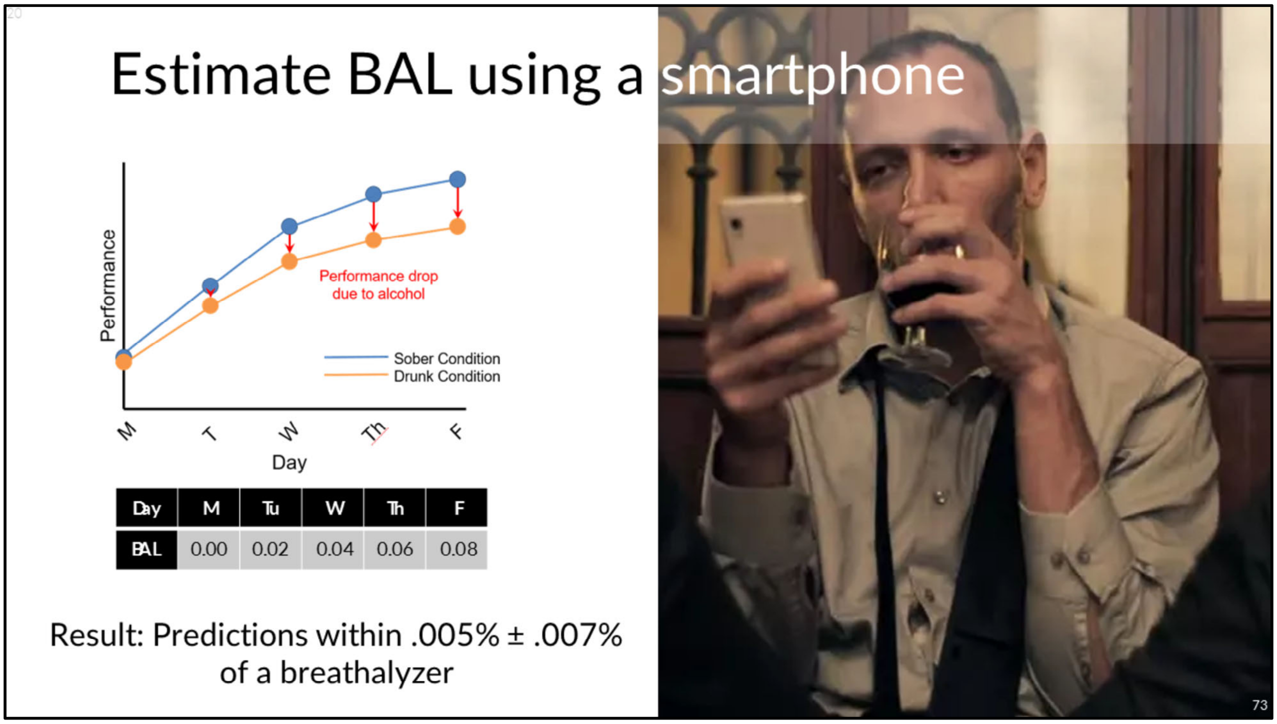
<1 wpm difference (n.s.)
Reading Speed
(words per minute)
350
300
250
200
150
100
50
0
No Distraction Task
Distraction Task
Control
SwitchBack



SwitchBack improved reading speed when users were walking and distracted by about 19 words per minute, or about 8%. There was no difference in comprehension for what was read.

Drunk User Interfaces
(DUIs)

Mariakakis, A., Parsi, S., Patel, S.N. and Wobbrock, J.O. (2018). **Drunk User Interfaces: Determining blood alcohol level through everyday smartphone tasks.** Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '18). Montreal, Quebec (April 21-26, 2018). New York: ACM Press. Paper No. 234.



With *Drunk User Interfaces*, or *"DUIs*," we are able to detect blood alcohol level (BAL) by having people perform a small set of tasks on their smartphone. We could get good results with user-independent models for users who interacted for only ~4 minutes with our DUI interfaces.

Why on a smartphone?


Drunk-driving prevention
encouraged by car insurance

Drunk texting prevention


Informal assessment
(e.g., by bartenders)


Self-awareness, education

In the U.S., the average drunk driver has driven drunk over 80 times before their first arrest (FBI ‘14, Jewett et al. ’15).

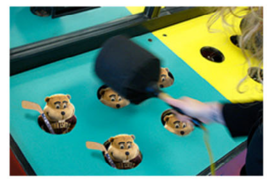
Drunk User Interfaces (DUIs)


Typing


Swiping


Balance + Heart Rate

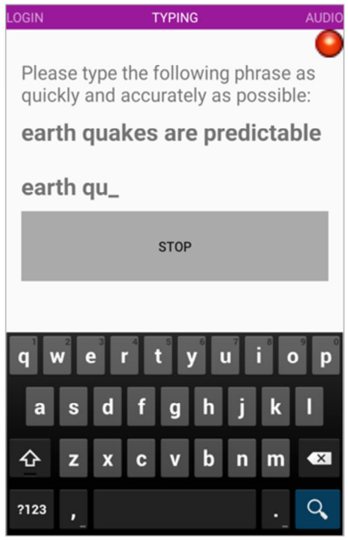

Simple Reaction


Choice Reaction

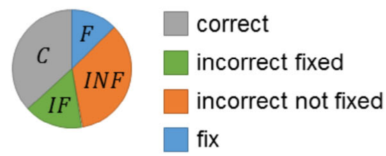
We have five tasks that comprise our DUIs. Together, they help us predict BAL.

I'm going to go through each of them very quickly.

Typing

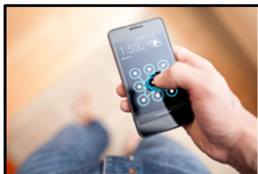


Purpose	Motor coordination Cognition
Inspirations	Breckenridge & Berger '90 Soukoreff & MacKenzie '03 Goel et al. '12 (WalkType)
Example Features	Utilized keystroke bandwidth Distance from key center Acceleration during touch

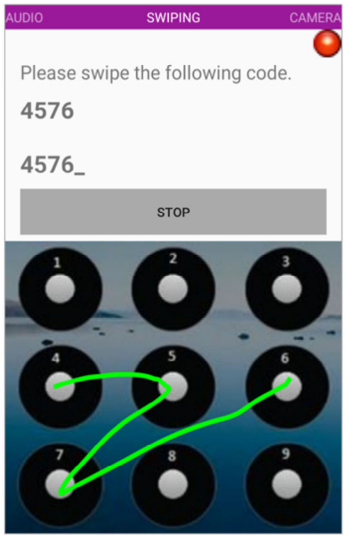


$$utilized\ bandwidth = \frac{C}{C + F + IF + INF}$$

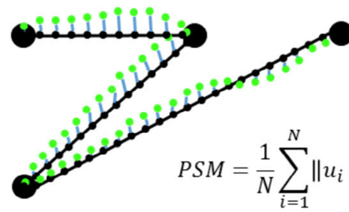
The first task was a standard phrase transcription text entry task. We could measure all of the standard text entry metrics from this task.



Swiping

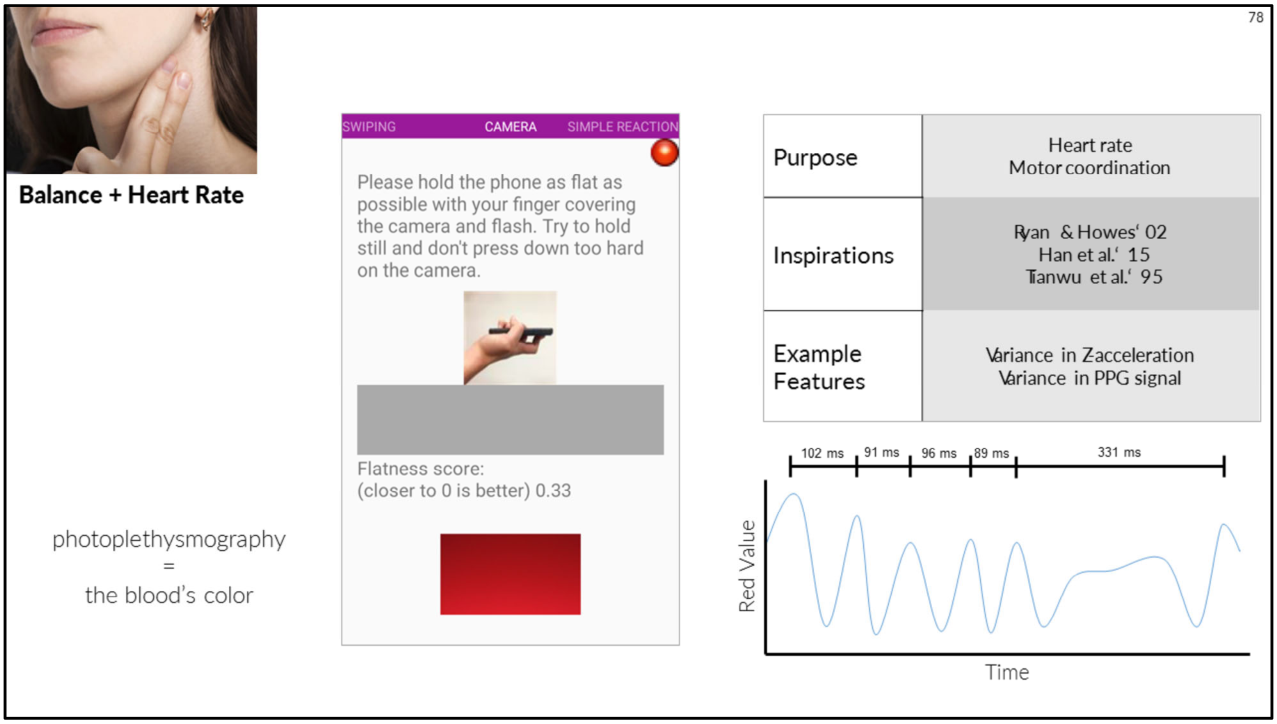


Purpose	Motor coordination Cognition
Inspirations	Hindmarch et al. '91 Kristensson & Zhai '04 (SHARK²) MacKenzie et al. '01 Flash & Hogan '85
Example Features	Proportional shape matching distance No. of task axis crossings) Mean jerk per segment



$$PSM = \frac{1}{N}\sum_{i=1}^{N}\|u_i - t_i\|_2$$

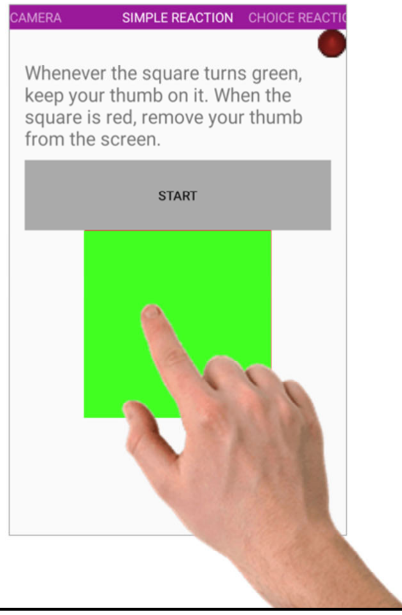
The second task was a device unlock screen where the user would trace an unlock gesture among points on the screen. We could measure deviation from the ideal path.



The third task combined the user's ability to balance the phone by holding it flat, and a measure of their blood color by covering the camera and flash with their finger. The blood's color can be measured through a technique called "photoplethysmography." This enables the heart rate to be detected.

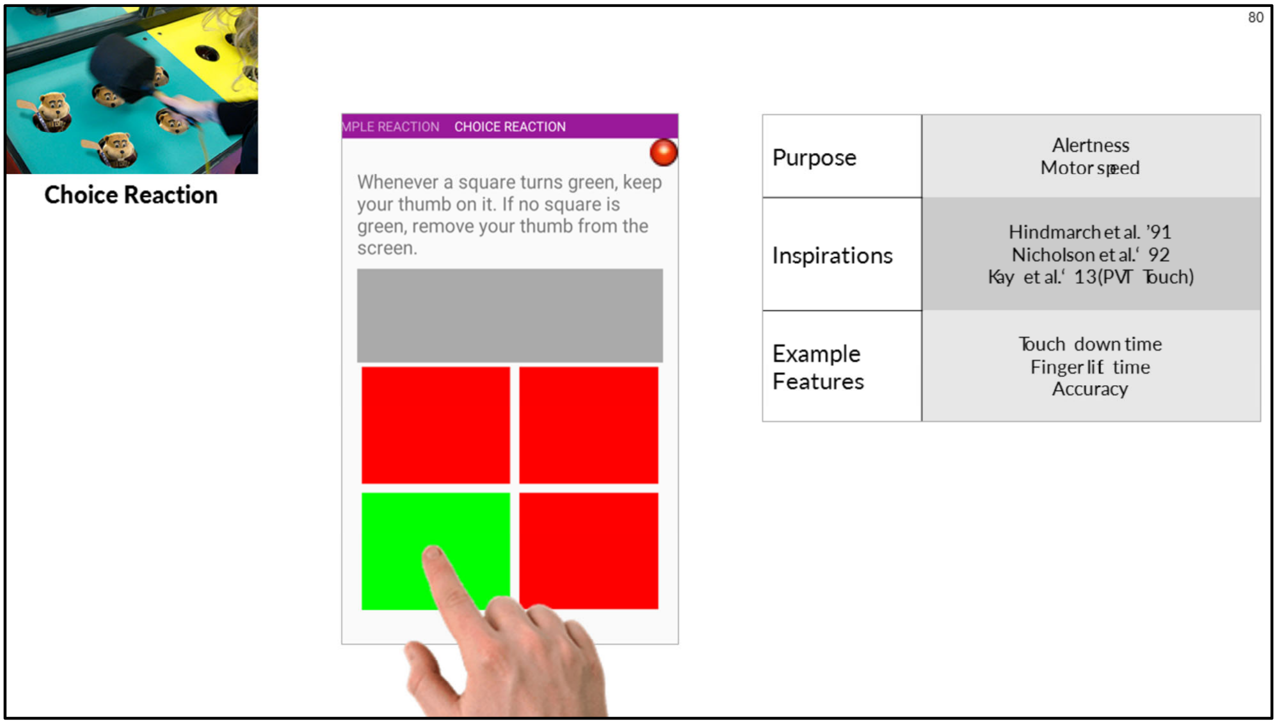
PPG = photo-plethy-smog-raphy – technique to measure the blood's color

Simple Reaction

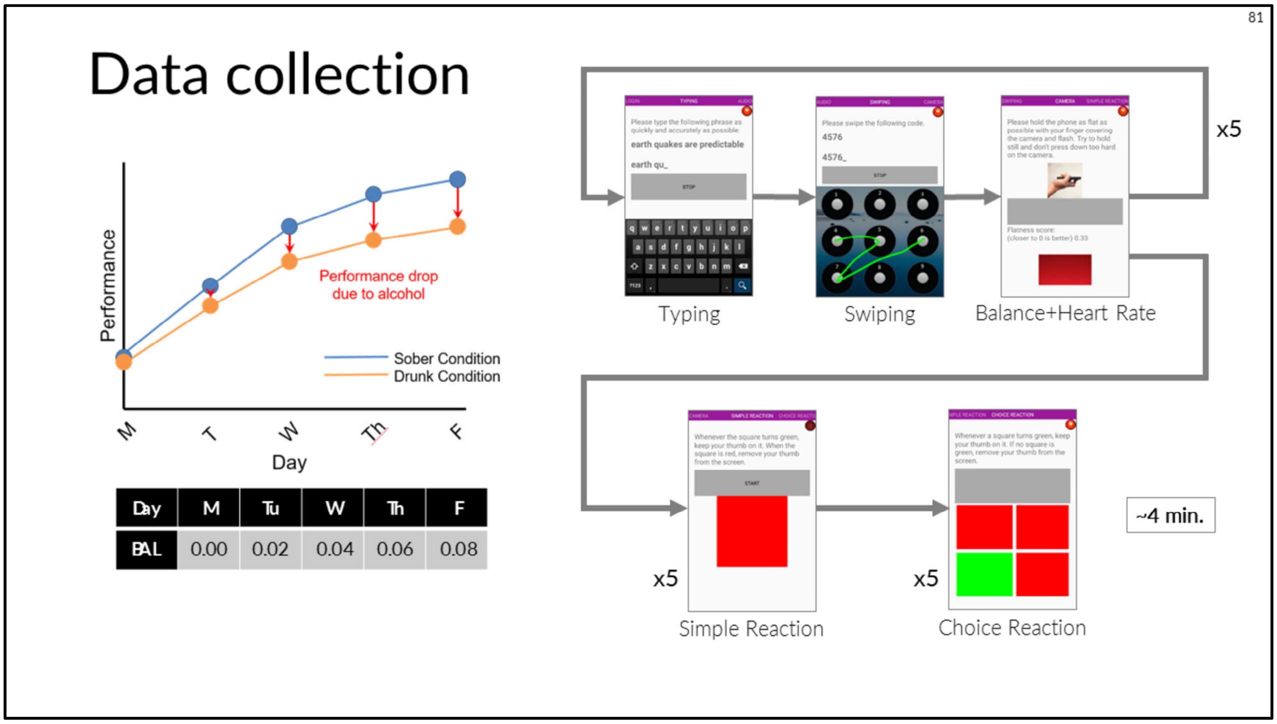


Purpose	Alertness Motor speed
Inspirations	Hindmarch et al. '91 Nicholson et al.' 92 Kay et al.' 13 (PVT Touch)
Example Features	Touch down time Finger lift time

Each simple reaction time trial has two measured times, one for touch down, and one for lift off.



Choice reaction time presented four squares and one of them turned green, just like in the simple reaction time task.



Data collection was from 14 participants.

Each day was assigned a BAL in increasing increments of 0.02% from 0.00% to 0.08%.

Participants started at 5 PM each day to control for any time-of-day effects.

Participants used the app while sober each day as a baseline. So although we're training user-independent models, the input data was normalized by the sober baseline for each day.

Then once participants reached the target BAL for that day, they used the *DUI* apps again.

Model

Random forest regression for BAL prediction.

Mean and standard deviation of features were generated within and across trials of the same task.

Time-based features were log-transformed.

Task	Most Important Features
Typing	Mean touch radius while lifting Mean distance from key center Mean force during touch Mean touch duration
Swiping	Mean segment speed Min segment speed Min segment jerk Mean throughput Mean touch radius
Balancing+ Heart Rate	Mean heart rate
Simple Reaction	Mean finger lift time
Choice Reaction	Mean finger lift time

We built our model using random forest regression to predict BAL.

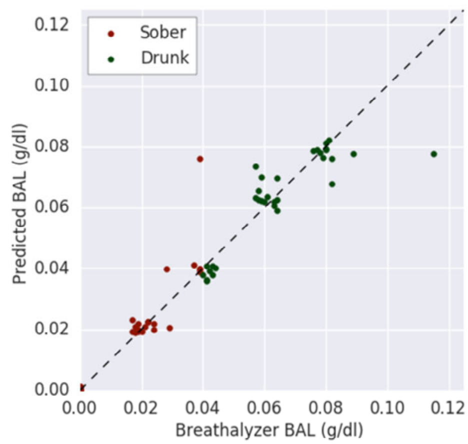
Evaluation

Test	Mean Absolute Error	Pearson *r*
T+S+BHR+SR	0.015± 0.014%	0.71
T+S+BHR+CR	0.004± 0.007%	0.96
T+S+SR+CR	0.005± 0.007%	0.96
T+BHR+SR+CR	0.013± 0.012%	0.78
S+BHR+SR+CR	0.004± 0.007%	0.96
T+S+BHR+SR+CR	0.005± 0.007%	0.96

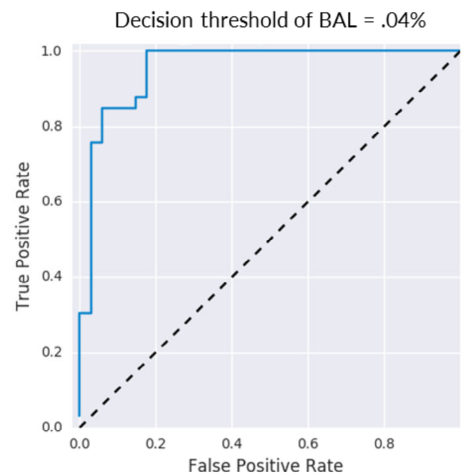
T = typing, S = swiping, BHR = balance+heart rate, SR = simple reaction, CR = choice reaction

Using leave-one-out cross-validation, we found multiple good performing user-independent models. The model with all five tasks included had a mean absolute error from the breathalyzer predictions of 0.005% with a standard deviation of 0.007% and a Pearon *r* of 0.96.

Results



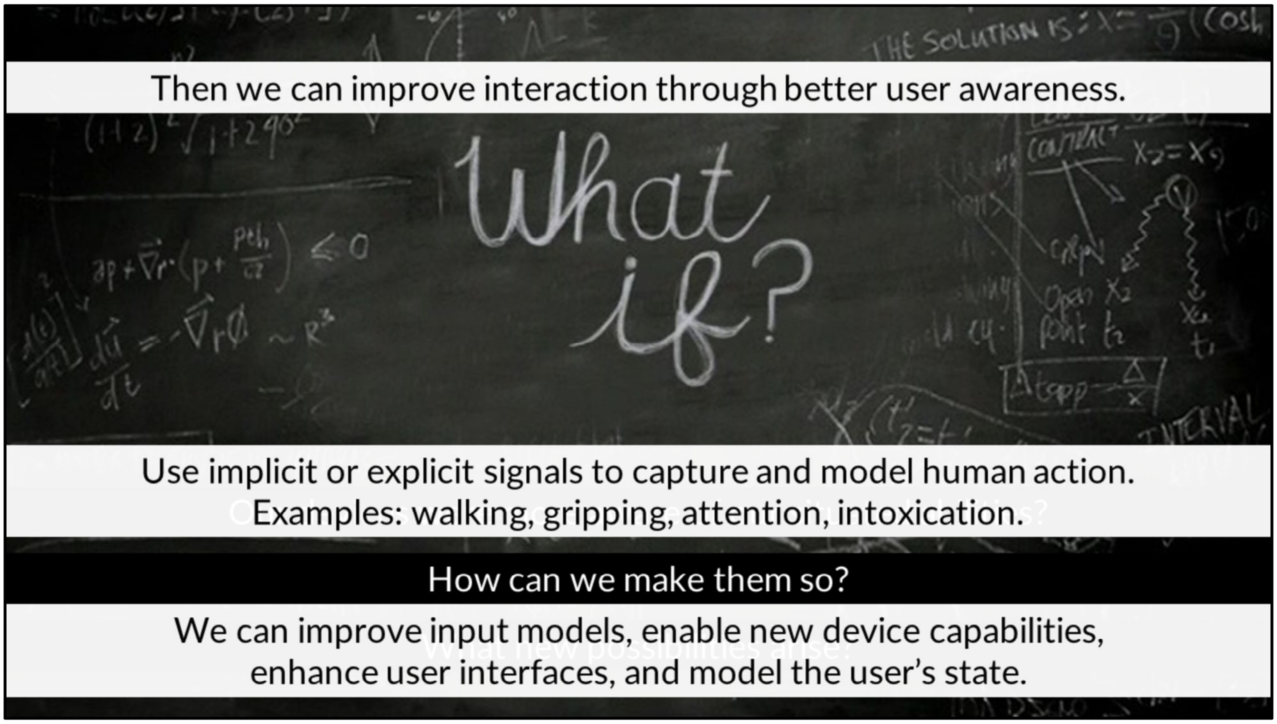
Mean absolute error: +0.005%



Sensitivity (true positive): 93.9%
Specificity (true negative): 82.3%

The National Advisory Council on Alcohol Abuse and Alcoholism defines a person to be sober at or below 0.04% BAL.

True positive: DUI says you're drunk and you're drunk
True negative: DUI says you're sober and you're sober



I'd like to return to the research questions I posed earlier in this talk.

Before I conclude my talk, I want to raise a couple of serious issues for us to consider.

We must ask ourselves whether we *should* be designing to enable people to perform better under SIIDs? Or should we be designing to discourage them from interacting when under SIIDs in the first place? On the one hand, people are going to do it anyway, so at least make it safe (the “safe sex” answer). On the other hand, potential for significant harm can exist, so maybe we should take a stronger stance to discourage or even prevent it (the “abstinence” answer).

If we *are* going to have our devices and systems know more about users and their situations, what privacy concerns does that raise?

I call this the “Smartphone Eye of Sauron,” the all-seeing eye. The conundrum is that “by knowing more, it can do more *for* us. But by knowing more, it can do more harm *to* us.”

It’s rather like the Ring of Power that can do great things but also becomes a great threat in the process.

Despite these challenges, I do think this vision is worth pursuing in a careful way. This vision can also serve as a Grand Challenge. To bring it about would require multiple breakthroughs in sensing, modeling, and adaptation.

The ideas I've talked about today are part of a larger research approach that I've refined over the last decade called "Ability-Based Design." You can read about it more in last year's June's issue of the CACM.

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I want to particularly thank all my co-authors, collaborators, mentors, and especially Ph.D. students or post-docs from the MAD Lab who have worked with me over the years.

I want to acknowledge the financial support of these institutions for helping me and my students pursue these and other challenges.

I'm also a part of an NSF and UW initiative called AccessComputing that works to increase the participation of people with disabilities in computing fields. If you want to know more about this initiative, see the AccessComputing website or come see me.

Thank you!

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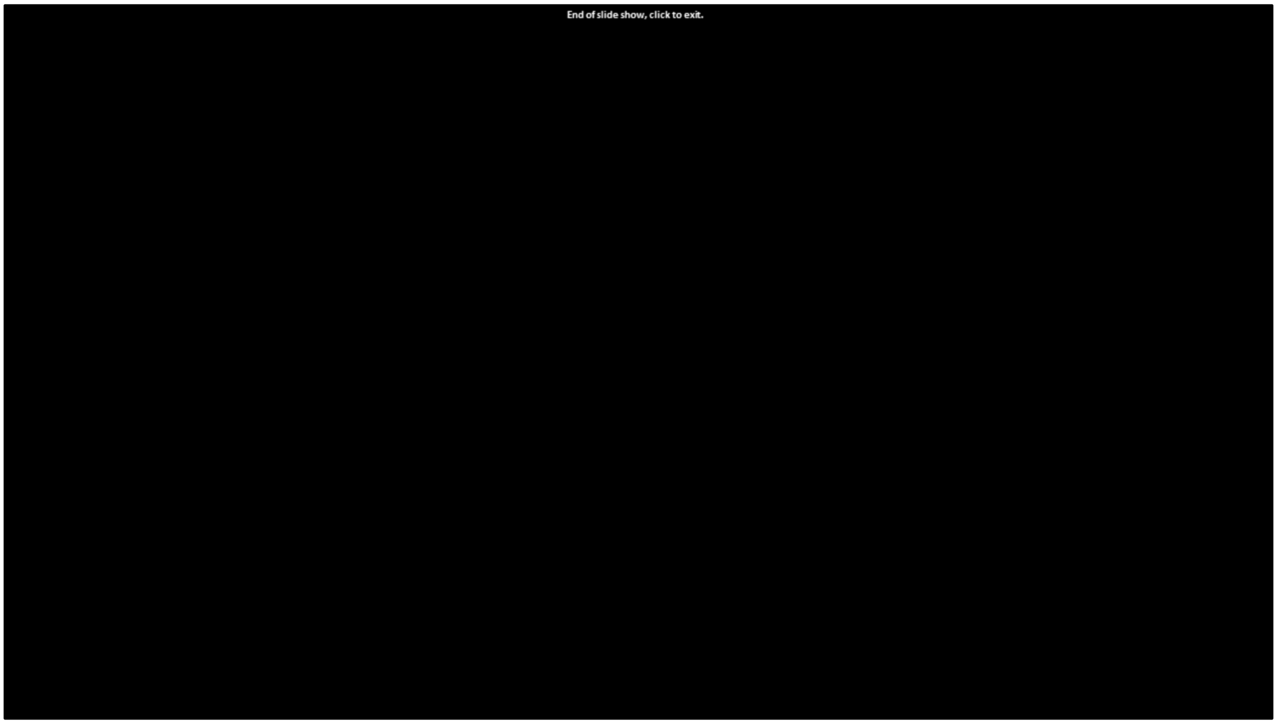
DUB DESIGN USE BUILD
Information School UNIVERSITY of WASHINGTON
MADlab mobile + accessible design

Thank you very much!



False ending before Appendix.

Each DUI separately

Test	Mean Absolute Error	Pearson *r*
Typing	0.016 ± 0.015%	0.68
Swiping	0.015 ± 0.015%	0.69
Balance + Heart Rate	0.017 ± 0.018%	0.57
Simple Reaction Time	0.017 ± 0.016%	0.65
Choice Reaction Time	0.001 ± 0.008%	0.97

Why not use just choice reaction time?

We don’t want to just use just one task because subjects can habituate and become practiced, making it less sensitive and easier for them to “fool.”