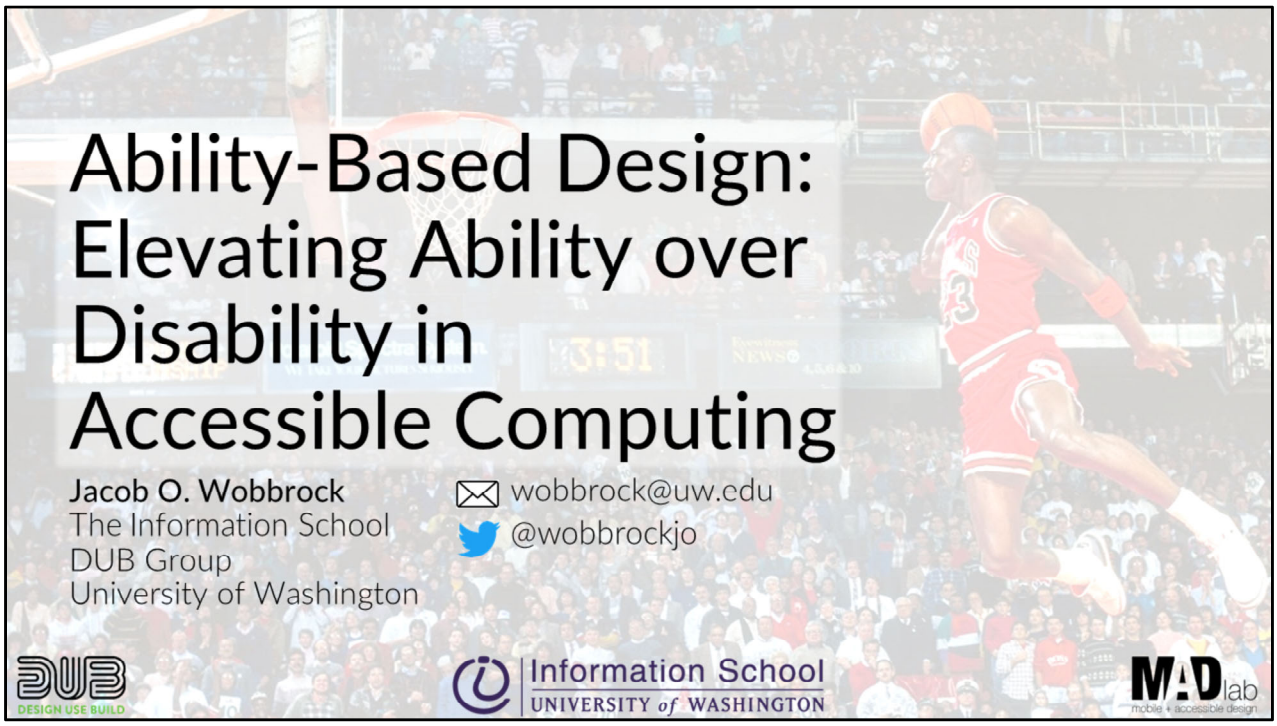
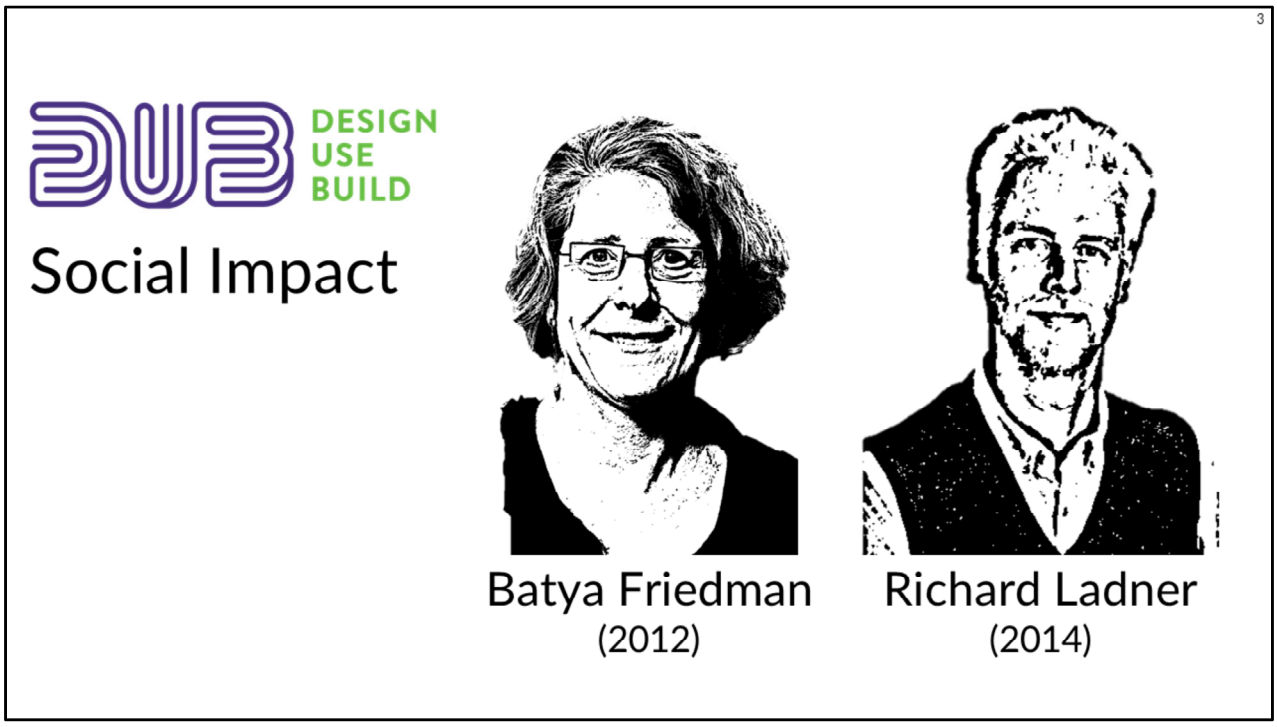


2017 SIGCHI SOCIAL IMPACT AWARD TALK

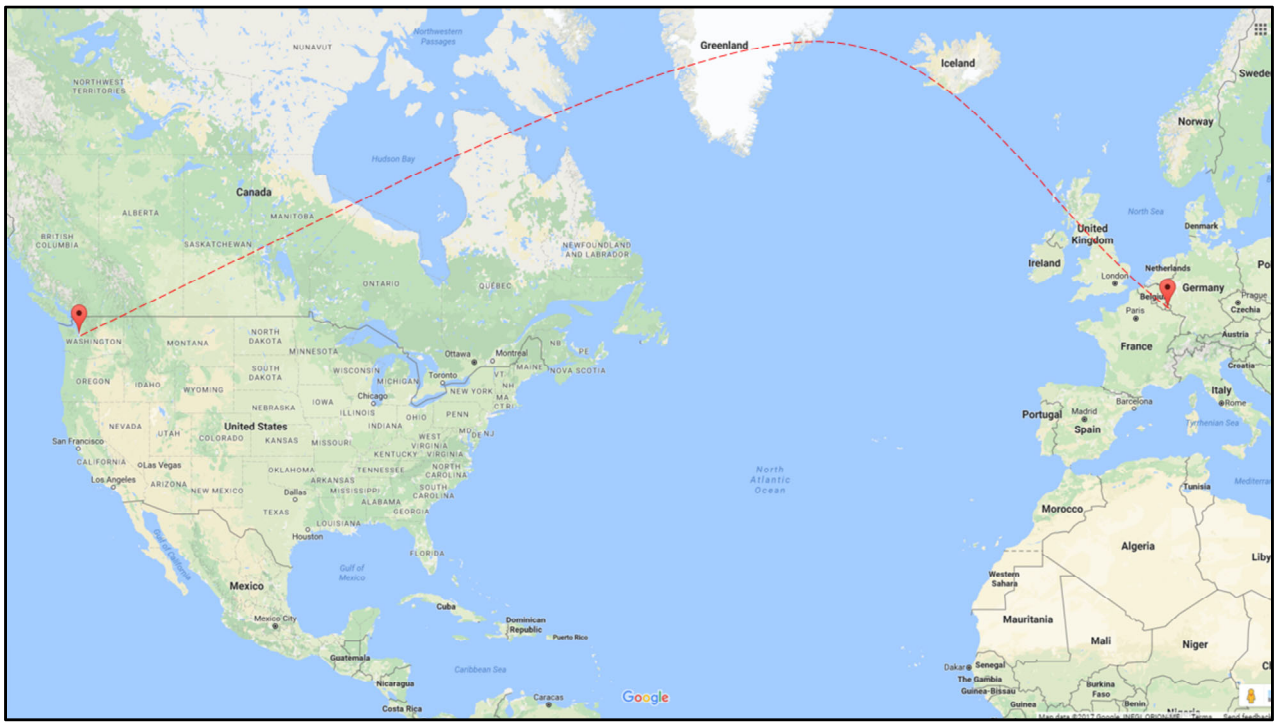
https://sigchi.org/awards/sigchi-award-recipients/2017-sigchi-awards/

[As of May 2017] **Jacob O. Wobbrock** is an Associate Professor in the Information School and an Adjunct Associate Professor in the Department of Computer Science & Engineering at the University of Washington, where he directs the Mobile & Accessible Design Lab. He is a founding member of the design: use: build: Group (DUB Group) and the multi-departmental Master of HCI & Design program at UW. Dr. Wobbrock's research seeks to scientifically understand people's interactions with computers and information, and to improve those interactions through design and engineering, especially for people with disabilities. His specific research topics include interaction techniques, human performance measurement and modeling, HCI research and design methods, mobile computing, and accessible computing. He pursues "Ability-Based Design," where the human abilities required to use a technology in a given context are questioned, and systems are made operable by or adaptable to alternative abilities. For example, his Slide Rule project (with Shaun Kane and Jeffrey Bigham) was the first to make touch screen smartphones accessible to blind people using gestures, influencing Apple's VoiceOver design for iOS. Dr. Wobbrock has co-authored over 120 peer-reviewed publications, receiving 19 paper awards, including seven best papers and seven honorable mentions from ACM CHI. He is the recipient of an NSF CAREER award and five other National Science Foundation grants. He is on the editorial board of ACM Transactions on Computer-Human Interaction. His advisees, to whom he owes his success, have become professors at Harvard, Cornell, Colorado, Maryland, Brown, Simon Fraser, and elsewhere. Dr. Wobbrock received his B.S. in Symbolic Systems and his M.S. in Computer Science from Stanford University; he received his Ph.D. in Human-Computer Interaction from Carnegie Mellon University. Upon graduation, he was honored with CMU's School of Computer Science Distinguished Dissertation Award.

I'm very honored to be a 2017 SIGCHI Social Impact Award recipient.



And I'm especially honored because I'm the third recipient from the University of Washington in the last few years.



A few months ago I gave a version of this talk in Luxembourg at the Luxembourg Institute of Science & Technology. This was roughly my flight path and it was quite a trip to get there from Seattle.

I had to take quite a few different forms of transportation.

And it all had one purpose: To move myself from point A to point B.

And the task wasn't just moving myself and my things. I had to do so in close proximity to many *other* people moving *themselves* and *their* things.

It struck me just how much time and energy we spend, both as a society and individually, moving physical things through our physical world.

As computing professionals, we're used to thinking of our data zipping instantly through our networks. Our information moves across the globe at almost light-speeds.

But much, even most, of life still revolves around moving physical things, including ourselves, through a physical world.

To make this point, consider the largest container ship in the world. Each one of these boxes is the size of a semi-truck that you would see on a freeway.

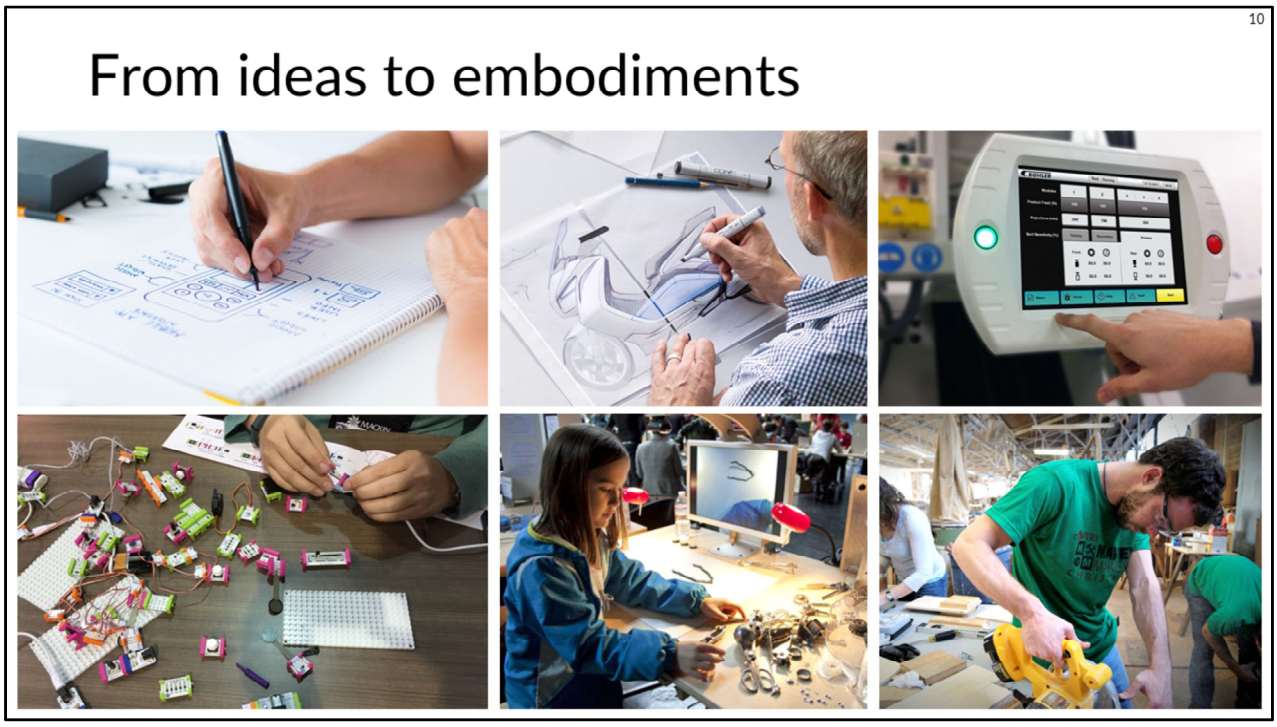
And to give you a sense of scale, this little speck is actually a full-size Coast Guard vessel.

Last fall, I was the Program Co-Chair for UIST 2016 in Japan, and there's nothing like a Tokyo subway at rush hour to remind you of just how physical you are. We *are* our physical bodies and their movement through a physical world.

We are so tied to our bodies and their movement through the physical world that some of our most memorable moments come from drastically changing *how* our bodies experience that world.

When you watch this video, don't think about what you *see*, but about what you *would feel* if your body were to move this way.

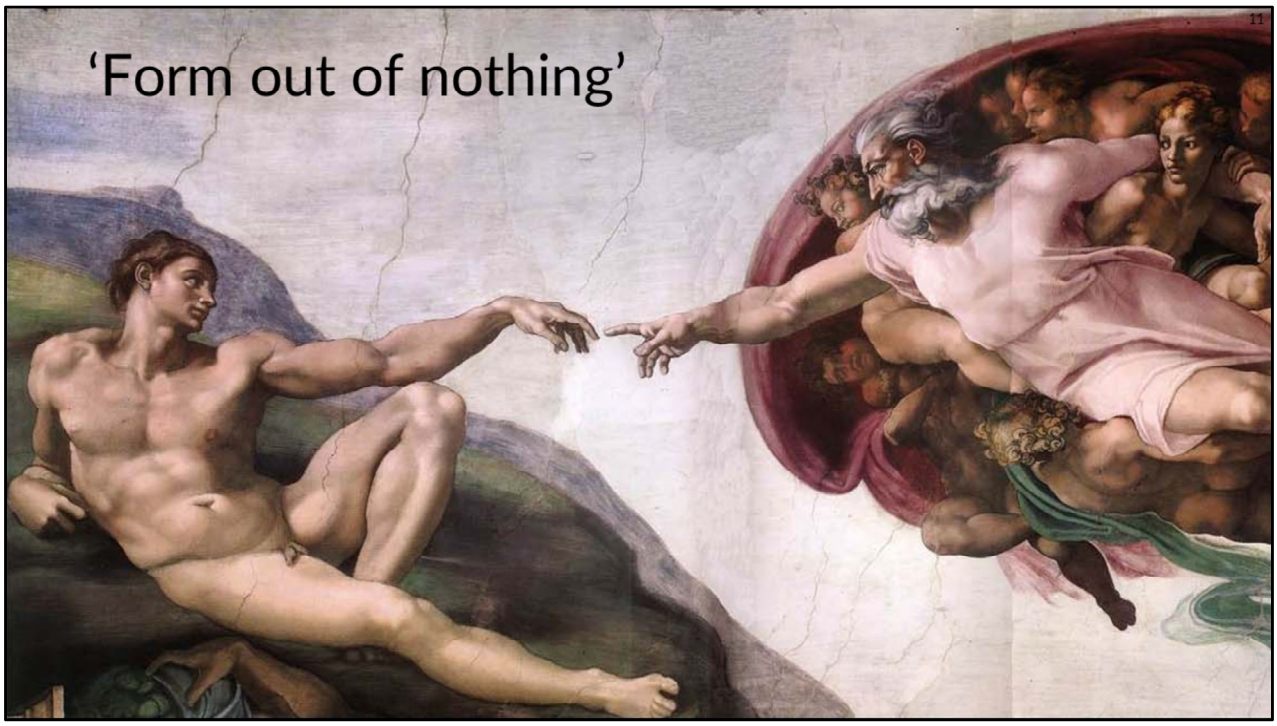
Source:
https://www.youtube.com/embed/BCIaSKCOcec?autoplay=1&start=77&end=109



So what does this all have to do with HCI and Design?

When we design things, we take ideas, which are disembodied, and we give them form; we embody them in the physical world.

Whether they are paper sketches, cardboard mockups, pixels on a screen, or electronic devices, we give *bodies* to *ideas* that are then meant to be *encountered by embodied, physical people*.



Giving *form* to *ideas* is a profound move.

It was not long ago that the creative act of giving ideas physical form was considered the domain of the Divine.

The word “create” comes from the Latin “creare,” which means “form out of nothing.”

When we design, we create form out of nothing.

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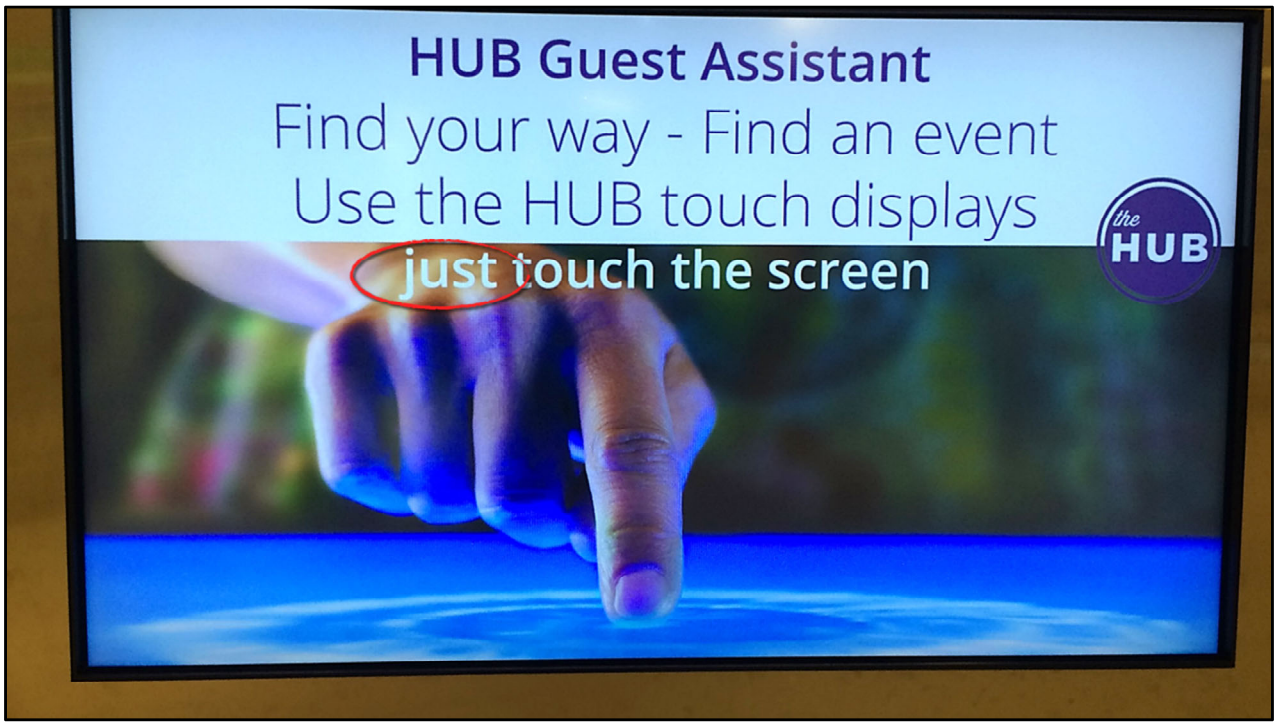
Rigid embodiments

The problem is, unlike the Divine, *we cannot anticipate how the embodiments we create will interact with the embodied people who encounter them*.

And the world can end up a very rigidly embodied place as a result.



Here is an example from my own university.

This screen is from the student center at the University of Washington, and one word in particular always strikes me: “just”.

The word ignores that there are, in fact, a lot of ability requirements that must be satisfied for someone to touch the screen. They must have a finger they can extend, they must be able to reach out, suspend their arm, avoid touching with all but one fingertip, and land and lift without sliding. And they must be standing so they can reach the wall-mounted screen.

There’s really no “just” about it.

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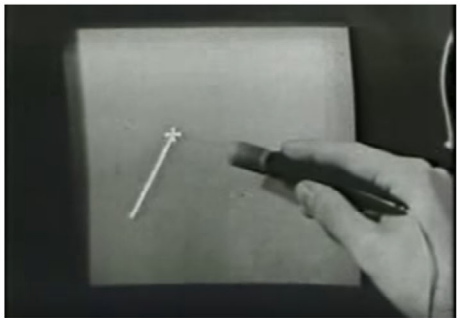
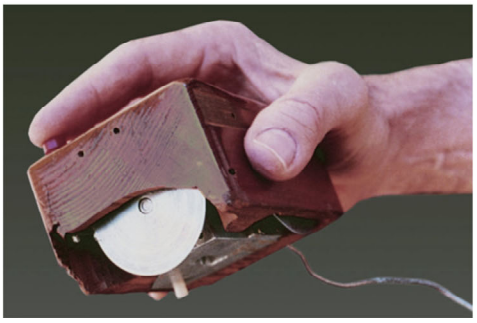
HCI embodiments

What abilities must a person have to use each?



Sketchpad
(Sutherland 1963)



NLS
(Engelbart 1968)

iPhone
(Apple 2007)

Many of our greatest breakthroughs in HCI have come as a result of improved embodiments. But these, too, contain assumptions about how embodied people are meant to use them.

What abilities must a person have to use some of our field's greatest inventions?

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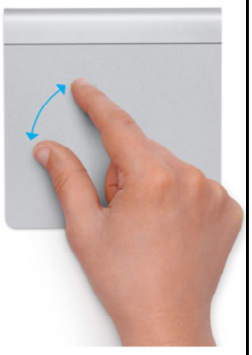
Ability assumptions

Our inventions contain “ability assumptions.”

Do these assumptions reflect:

- our own abilities?
- the abilities we imagine other people might have?
- the abilities of the “**average person?**”



Consciously or not, we bring into our embodiments certain “ability assumptions.” Maybe those assumptions reflect the abilities we ourselves have. Or maybe they reflect the abilities we imagine *most* people having. Or the “average person” having…

On this last point, allow me to share a story about the "flaw of averages."

In the 1950s, due to high rates of crashes and pilot deaths (up to 17 non-combat crashes in one day), the U.S. Air Force decided to entirely redesign their cockpits. They measured 4000 pilots on 140 dimensions and designed cockpits to suit the mathematically average person. But even based on just the 10 most important dimensions, with a 30% tolerance around those average values, none of the 4000 pilots was "average" by this definition.

Only when they designed for the 5^{th} – 95^{th} percentile and made the cockpits pilot-configurable did the crash rates drastically go down.

Notes:

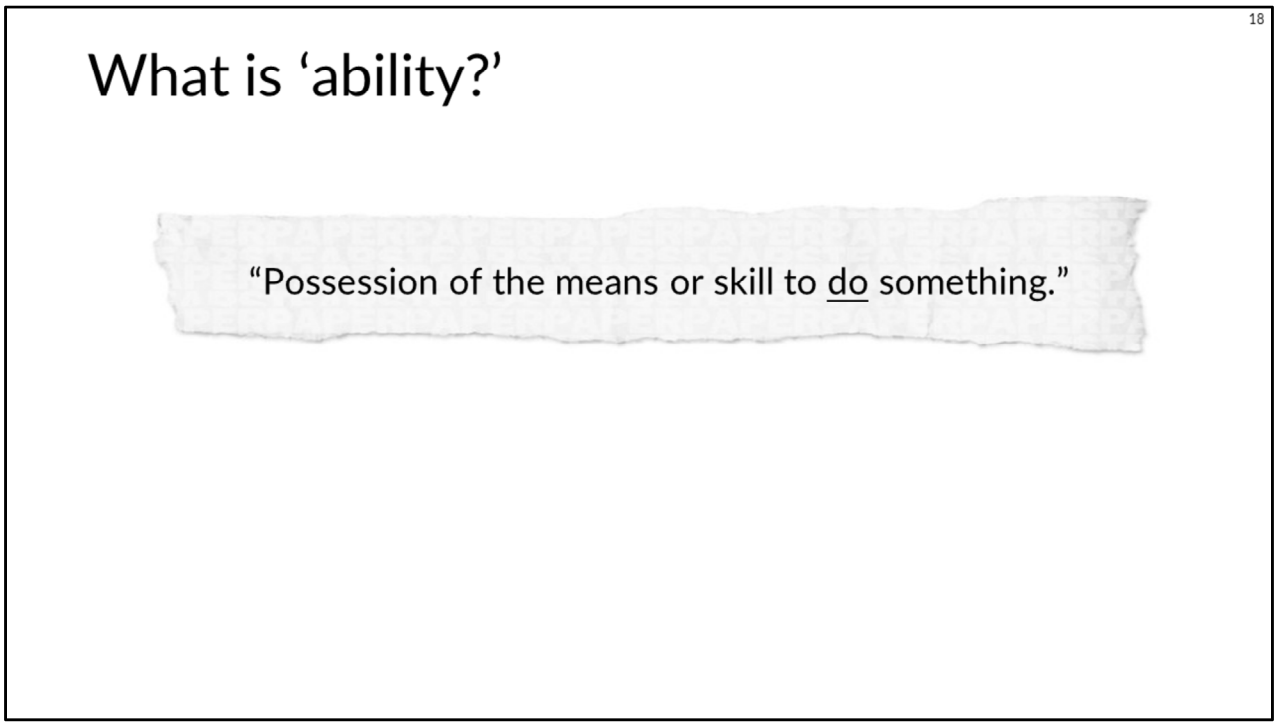
"Daniels published his findings in a 1952 Air Force Technical Note entitled *The 'Average Man'?* In it, he contended that if the military wanted to improve the performance of its soldiers, including its pilots, it needed to change the design of any environments in which those soldiers were expected to perform. The recommended change was radical: the environments needed to fit the individual rather than the average.

"Amazingly — and to their credit — the air force embraced Daniels' arguments. '[O]nce we showed them the average pilot was a useless concept, they were able to focus on fitting the cockpit to the individual pilot. That's when things started getting better.'

"By discarding the average as their reference standard, the air force initiated a quantum leap in its design philosophy, centered on a new guiding principle: *individual fit*. Rather than fitting the individual to the system, the military began fitting the system to the individual."

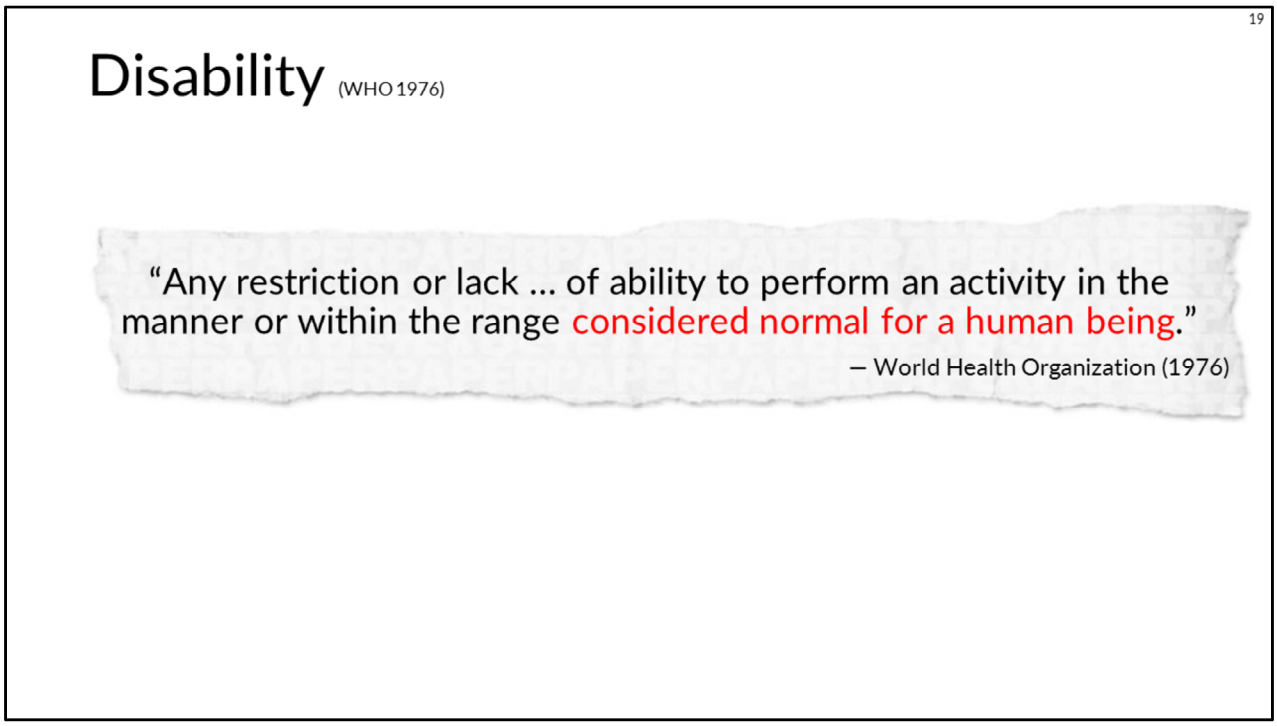
Excerpted from The End of Average by L. Todd Rose © 2016. Published by HarperCollins Publishers Ltd. All rights reserved. See https://www.thestar.com/news/insight/2016/01/16/when-us-air-force-discovered-the-flaw-of-averages.html

I've spent the better part of the last 20 years thinking about human ability, human bodies, and the interactive systems we create as HCI designers and engineers. This talk captures the perspectives I've developed in that time.



Let's start with a definition of human ability. The Oxford dictionary definition is: "possession of the means or skill to do something." I emphasize "do" because abilities are about taking action in the world, not just thinking about it – the realm of the embodied physical, not of ideas and the mental.

https://www.lexico.com/en/definition/ability



So what, then, is disability?

In 1976, the World Health Organization put forth the following definition of disability. It's got some uncomfortably normative language at the end there.

http://hcdg.org/definition.htm

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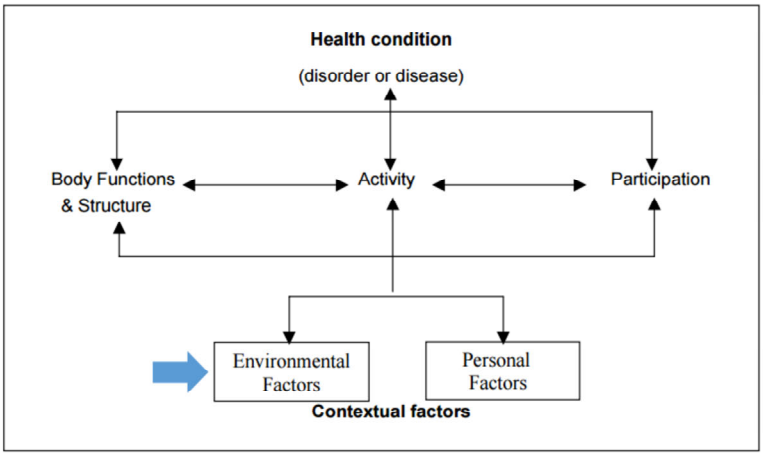
Disability (WHO ICF 2001)



Fortunately, a new definition was developed in 2001 that recognized the complex interplay between the various factors like health conditions, activities, and environmental factors. I want to highlight environmental factors because we'll come back to those as being very consequential when thinking about abilities.

Notes:

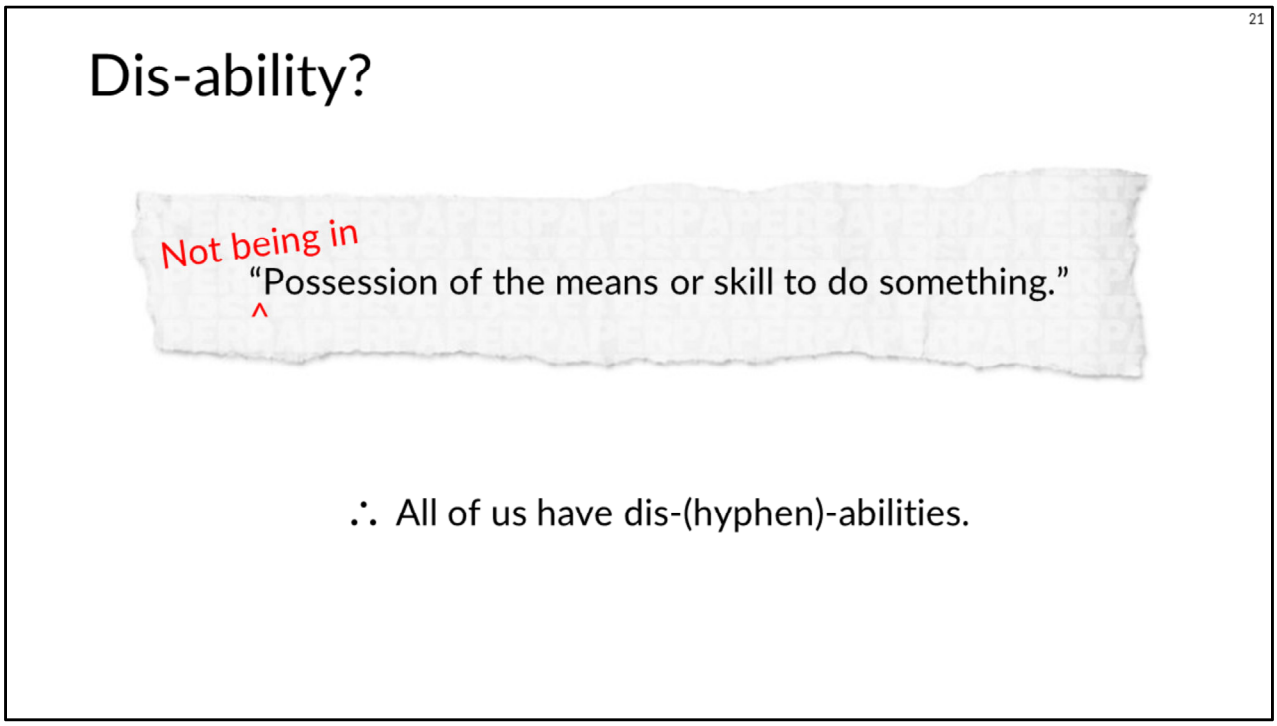
- Impairment is a loss of function;
- Disability is an activity limitation; and a
- Handicap is a participation restriction.

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



Now, there is another way to think about disability. I call it dis-hyphen-ability.

If "ability" is the "possession of the means or skill to do something," then "dis-hyphen-ability" could mean *not* having the means or skill to do something. Under such a definition, we all have dis-hyphen-abilities, because there are many things each of us cannot do.

I like this definition because it "de-binarizes" disability, reminding us that ability and disability are a more fluid notion, something everyone encounters, and is a reflection of the diversity of human life.

Notes:
Let me be clear that I do not intend to suggest that some people in our society do not need special protections and accommodations. Such accommodations have been hard-won over many decades and I am not saying "everyone is the same and it's all just a matter of degree."

What I *am* saying is that disability should not be viewed as a simple binary, as if the concerns of disability only apply to some people and not to others. We all have a relationship to disability because we all have limitations, especially as we progress through our lives.

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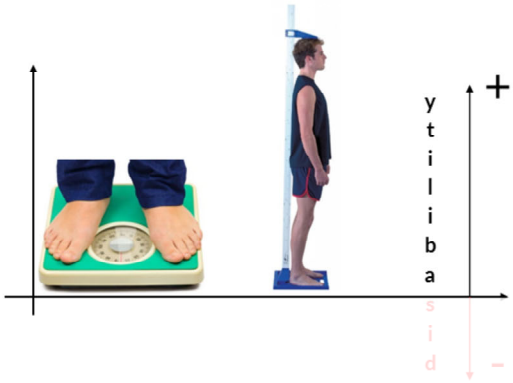
Dis-weight? Dis-height?

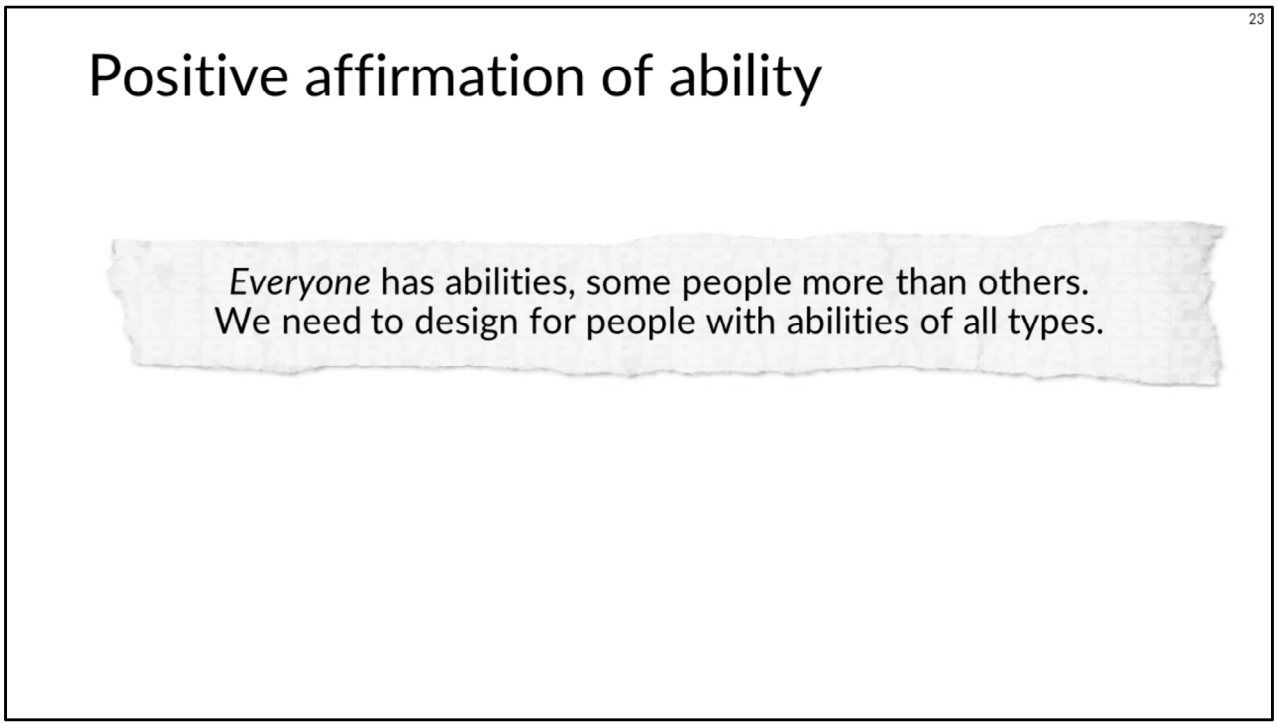
We think of weight or height as positive-valued only.

What would happen if we think of ability the same way?



There are certain aspects of people that we refer to as positive-valued only. We don't say "thin people" have "dis-weight," or "short people" have "dis-height." But with abilities, we conceive of a negative-valued region where some people are below the zero-line (some implicit norm?). The same could be applied to weight and height, but we don't do that.

How would it change our perspective and our treatment of people if we considered "ability" as positive-valued only?



I call this perspective “the positive affirmation of ability,” which says that abilities are only present, not absent. They are positive-valued only, like weight and height.

A perspective shift comes as we begin looking for what people *can* do, not what they *can’t do*.

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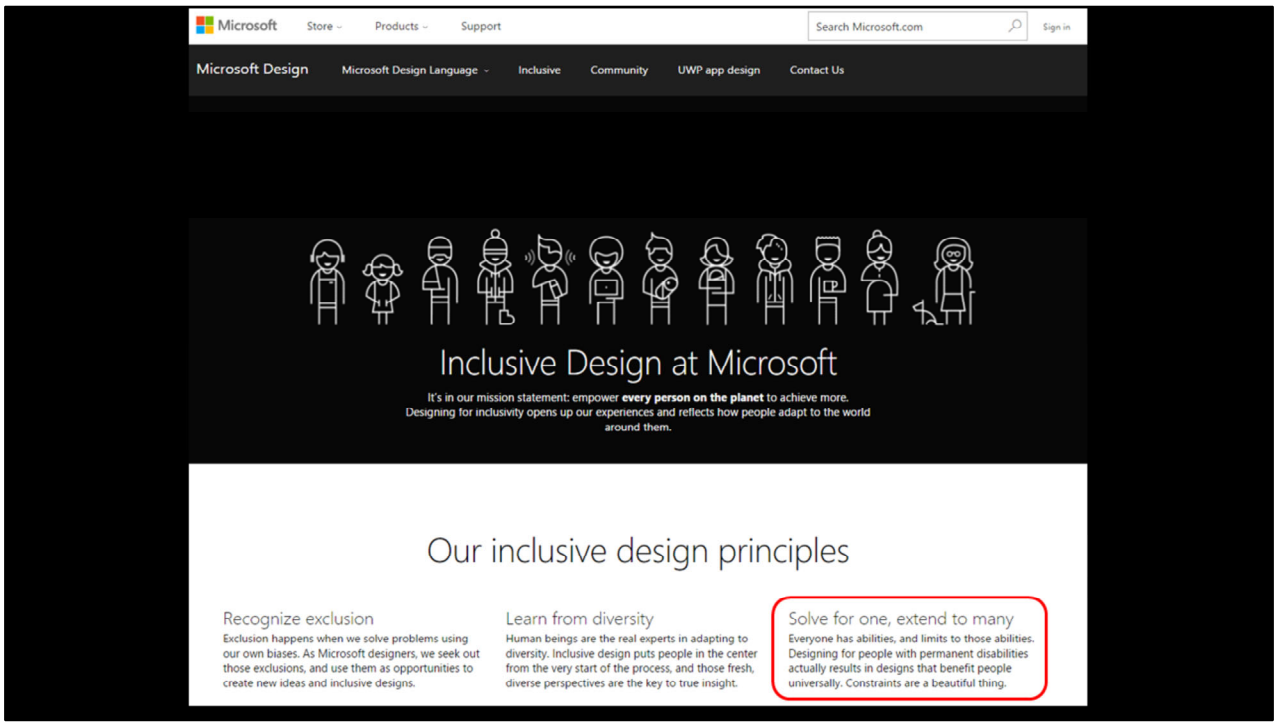
Extra-ordinary abilities

"Common sense and observation show us that every human being has a set of abilities, some of which can be described as 'ordinary' and some which are very obviously extra-ordinary."

– Alan F. Newell (1995)

I'm certainly not the first person to make this point.

Alan F. Newell, who won the SIGCHI Social Impact Award in 2011, put forth a perspective he called "extra-ordinary abilities."



And we've seen these ideas start to appear in industry as well. Microsoft's Inclusive Design principles state: …

https://www.microsoft.com/design/inclusive/

Here is a photo from the U.S. Men's MurderBall Team. http://www.murderballrugby.com/

I love this photo because it challenges our usual notions of *disability* and *ability*. It is a beautiful juxtaposition of the two.

This athlete is jumping and diving in his wheelchair, and yet wheelchairs are most people's conception of *disability*.

Clearly this person has extra-ordinary abilities.

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Assistive technology

Now, maybe this “positive affirmation of abilities” seems obvious and modern, but it wasn’t always so.

Assistive technology grew out of the post-WW2 era with a focus on restoring lost function through technology to help make people *compliant* with the built world around them.

If you lost an arm, we gave you an arm. If you lost a leg, we gave you a leg.

Notes:
Eye glasses are assistive technologies
So are hearing aids
So are wheelchairs

Image from https://everybody.si.edu/media/655

https://www.who.int/disabilities/technology/en/

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We adapt ourselves

Assistive technologies help *people* adapt to a rigid world. They help us “close the gap” between ourselves and our physical or social environment.

Humans are more adaptable than anything else we know, so it makes sense that we would *take it upon ourselves* to conform to the fixed environment around us.

Now we have computers. They can do a lot more than mechanical appendages like arms and legs. So we need to demand much more of them.

But when it comes to our computing systems, we still adapt ourselves to them, and they have little or no idea that we are doing so.

So this person here with the hand pointing-stick is making himself compliant to the ability assumptions of the keyboard. And the keyboard has no idea he is doing so. The woman above is typing with her feet because she has no arms, but the laptop is entirely unaware of this. The trackball has no idea it is being used by someone's chin.

How could our systems do more for us if they knew how we were using them? How could our abilities drive what they *do, instead of their ability assumptions driving how* we *change ourselves?*

30

Computing environments have changed

1980s

Today

To complicate things, our computing environments have drastically changed in the last 30 years, and those changes can dramatically affect our abilities.

A “computer user” from the 1980s could be assumed to:

- be seated at a stable surface,
- with ample lighting,
- comfortable temperatures,
- a quiet environment, and
- few distractions.

Today, we’re constantly adapting ourselves to various situations and contexts. In the example shown here, this person is sitting on a beach, typing on his knees; the hat suggests it might be cold, and there’s probably a lot of sunlight glare on his screen.

Over 20 years ago, Allen F. Newell made the observation that our situations disable us. He described a soldier stuck in the mud and, in this moment, unable to do much of anything at all, even in an workplace office setting.

Source:

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.

If you prefer a real-life version, here's a shot by Newsweek in Afghanistan.

What do you think the abilities of these soldiers are in this moment?

https://www.newsweek.com/2014/11/07/physical-and-mental-trauma-souvenirs-battle-afghanistan-280405.html

33

Situationally-induced impairments and disabilities

(SIIDs)

"Both the environment in which an individual is working and the current context (e.g., the activities in which the person is engaged) can contribute to the existence of impairments, disabilities, and handicaps."

– Andrew Sears & Mark Young (2003)

Andrew Sears and Mark Young called these ability limitations *situationally-induced impairments and disabilities (SIIDs)*.

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

Interacting while walking

Reduced reading speed
(Mustonen et al. 2004)

Reduced motor accuracy
(Lin et al. 2005)

Divided attention; 4 second "bursts" of interaction time
(Oulasvirta et al. 2005)

Reduced 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.

Stockholm, Sweden

To alert drivers to people texting while walking, Sweden has put up some new warning signs in Stockholm.

(You can see a pedestrian texter in the background there.)

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

Here is a sign in the town of Hayward, California.

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

Chongqing, China

In China, they've tried to provide two separate walking lanes, one for walking while texting and one for walking without using your phone. Apparently this scheme is failing, not because people don't use the correct lanes, but because tourists and bystanders block the lanes trying to get photos of these instructions on the pavement.

In 2012, the Utah Transit Authority imposed a $50 civil fine for "distracted walking," which includes phone use.

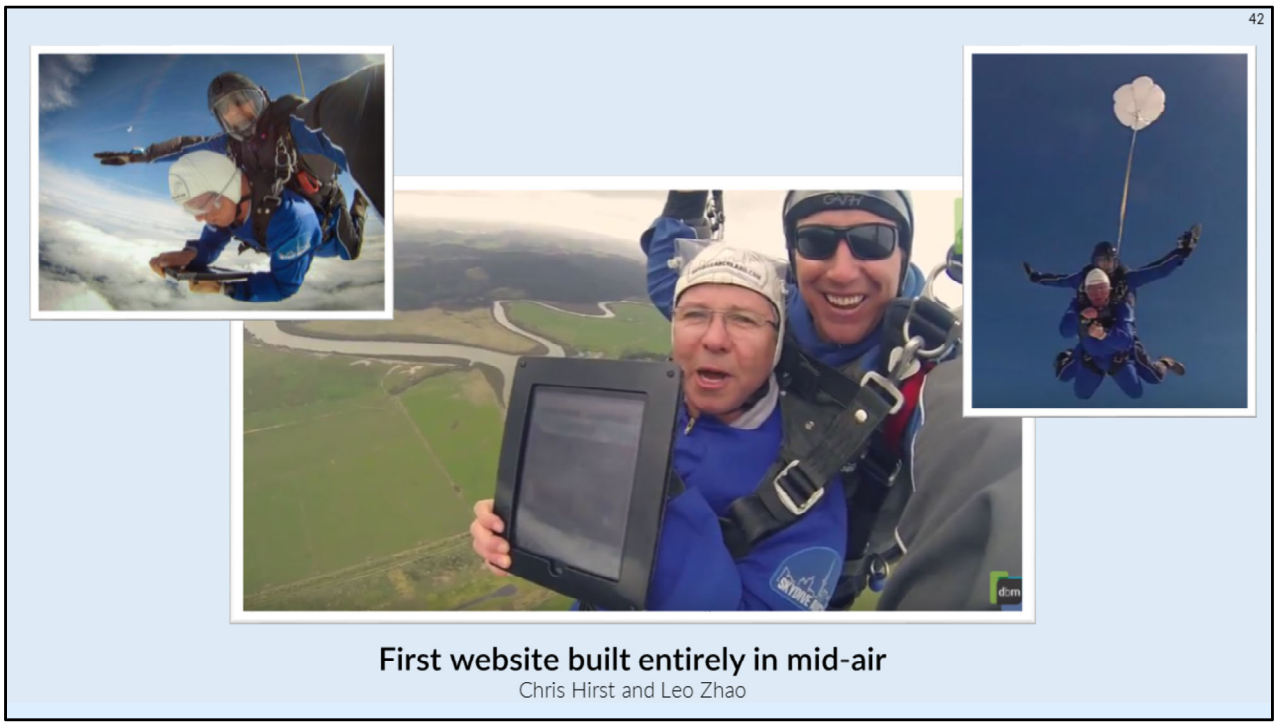
http://www.businessinsider.com/apps-and-street-signs-to-get-people-to-stop-texting-and-walking-2016-2/#a-fine-for-distracted-walkers-5

The Federal Communications Commission says, “At any given daylight moment across America, approximately 660,000 drivers are using cell phones or manipulating electronic devices while driving, a number that has held steady since 2010.”

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

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

I have no idea why, but this person is texting while standing on a motorcycle facing backwards!



Here's an amusing if extreme computing situation to make the point. Chris Hirst and Leo Zhao built a website from start to finish while skydiving.

Of course, they are heavily situationally-impaired while doing this and their tablet has no idea that it isn't in that nice quiet office.

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

Can watch the video here: http://www.youtube.com/watch?v=A7_jXvWkFHo

But we don’t have to be extreme to make the point that SIIDs can impair us.

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 the capacitive sensing fingertips on the thumbs and index fingers.

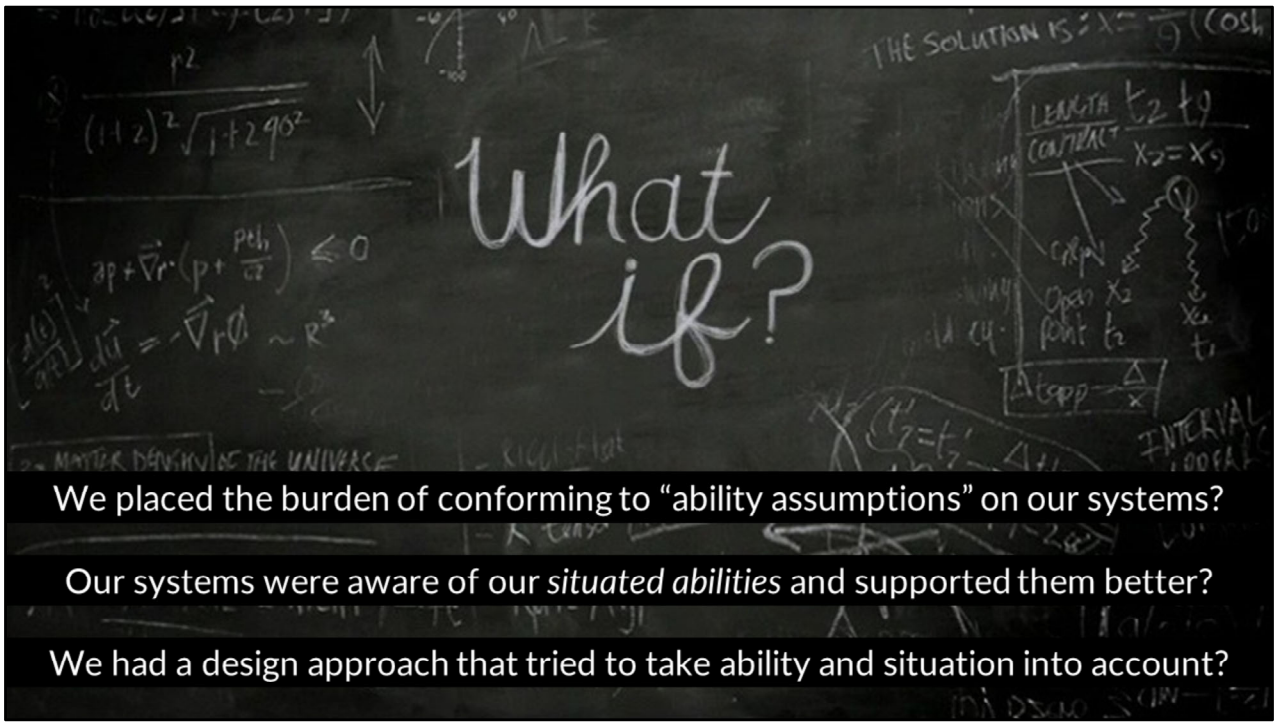
So even the things we design to *overcome* situational impairments can actually cause them.

There are many ways situational impairments can arise, and the point is that our technologies in each of these cases know very little about the situations we're in when we're using them.

Many sources of SIIDs

- vibration
- divided attention
- distraction
- diverted gaze
- device out-of-sight
- intervening objects
- body motion
- vehicle motion
- uneven terrain
- physical obstacles
- awkward postures or grips
- occupied hands
- cold temperatures
- impeding clothing (e.g., gloves)
- encumbering baggage
- rainwater
- light levels (e.g., darkness, glare)
- ambient noise
- social interactions (e.g., interruptions)
- multitasking
- stress
- fatigue
- haste
- intoxication

In my work, we've tried to surface a number of SIIDs and then brainstorm ways that we might address the most important ones, usually those with safety implications.



So let’s step back and ask “what if?”

What if…

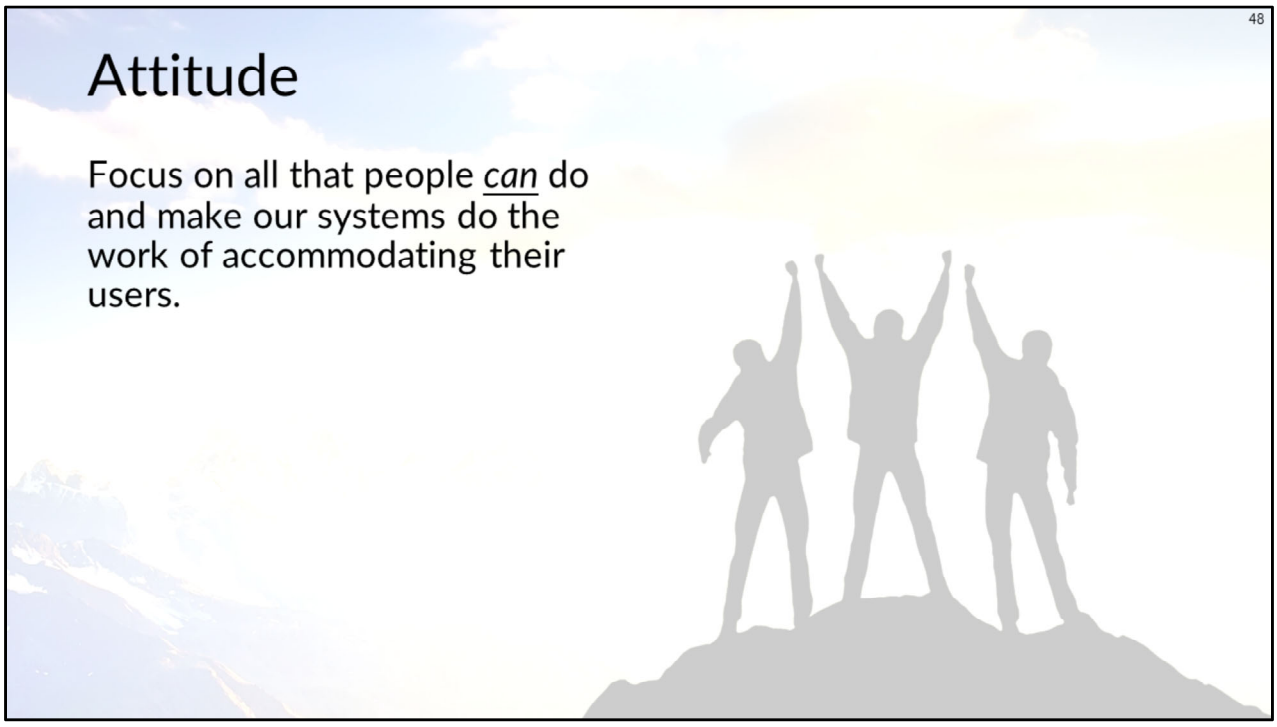
47

Ability-Based Design

"A design approach in which the human abilities required to use a technology in a given context are scrutinized, and systems are made operable by or adaptable to alternative abilities."

– Wobbrock et al. (2011, 2014)

This brings us to Ability-Based Design.



Ability-Based Design calls on us to “focus on all that users can do and make our systems do the work of accommodating them, rather than the other way around.”

Some strategies

- Automatic ability-based **adaptation**
  - System adapts to user
- High **configurability** by end user
  - e.g., U.S. Air Force story
- Ability-specific **customization**
  - But challenges of scaling
- Usable by a **wide range** of abilities
  - e.g., Universal Design

✓ Systems match users' abilities

✗ Users don't strive to satisfy systems' rigid assumptions

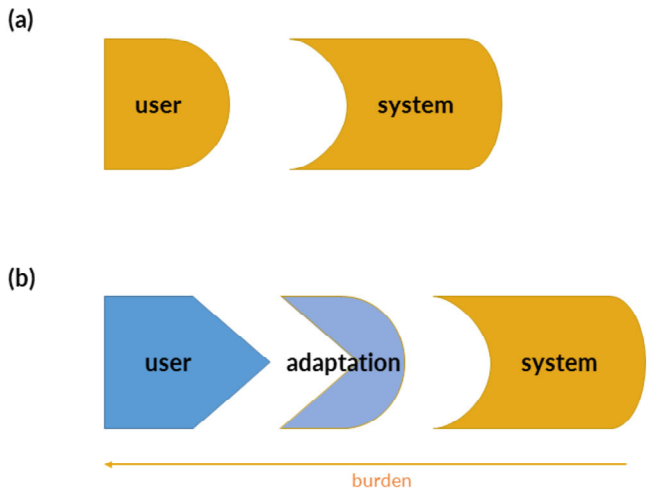
There are various strategies by which Ability-Based Design might be realized.

Ability-Based Design is agnostic to *how* it is achieved but it is insistent on *what* is achieved and what is avoided.

In all cases, systems need to match users' abilities and not put the burden on users to satisfy systems' rigid ability assumptions.

Notes:
Note how ability-based design and universal design can work together, insofar as a universal design is based on serving a wide range of people's abilities.

Visual language (Alistair D. N. Edwards 1995)



A visual language can help make Ability-Based Design clear. I take this visual language from Alistair Edwards.

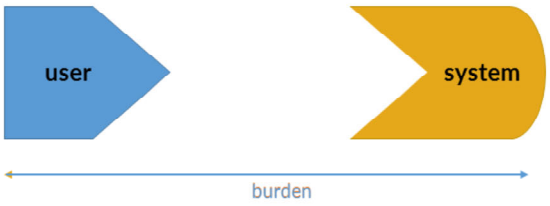
When a user's abilities and a system's ability assumptions match, they fit nicely together and "all is well in the world."

But when the user does not match the system, then today, usually the user must find an adaptation to make himself agreeable to the system.

Note how it is the user being adapted to fit the system because the burden falls to the user to procure the adaptation. The burden gets pushed from the system to the user because of the assumptions present in the system's design, and the system's ignorance of the user's abilities.

Make systems do more

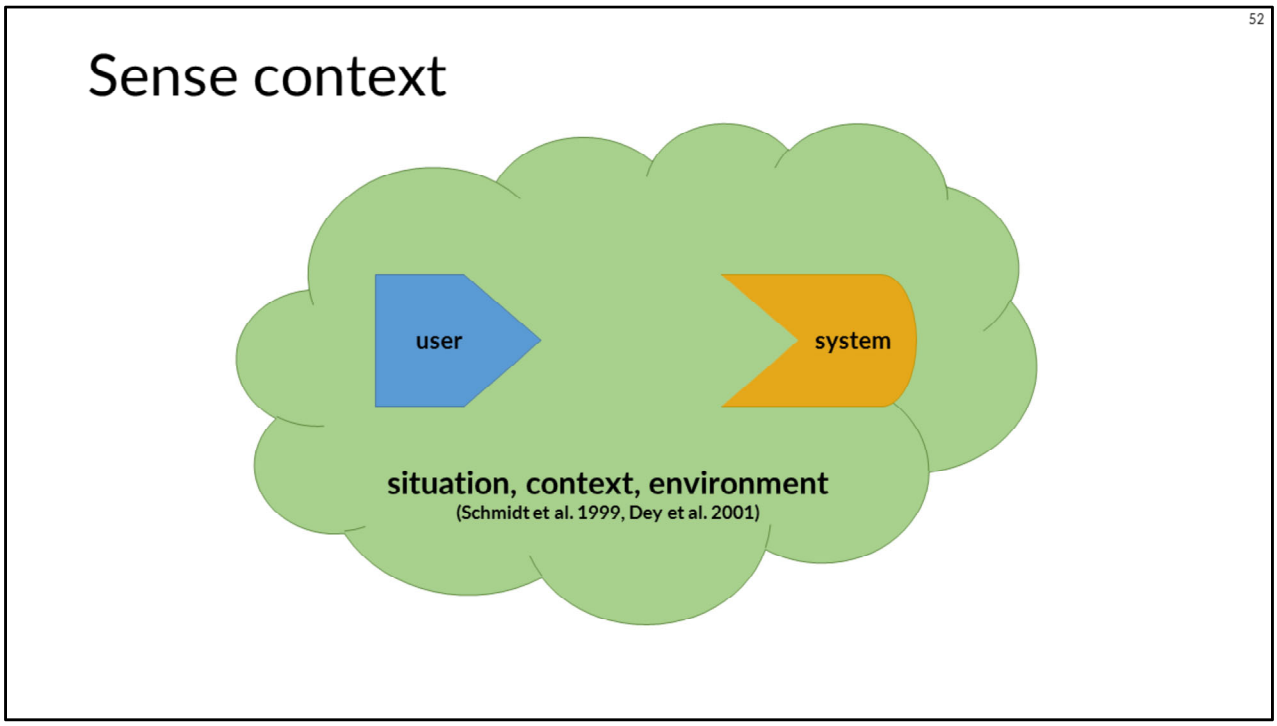
(c)



We can and should expect more from our systems. They are no longer purely mechanical prosthetic arms and legs. They are computational devices that can sense and adapt to the user.

So imagine instead if it were the user's abilities that put a burden on the *system* to make the match…

This is one way to achieve Ability-Based Design. (We'll see an example of this later.)

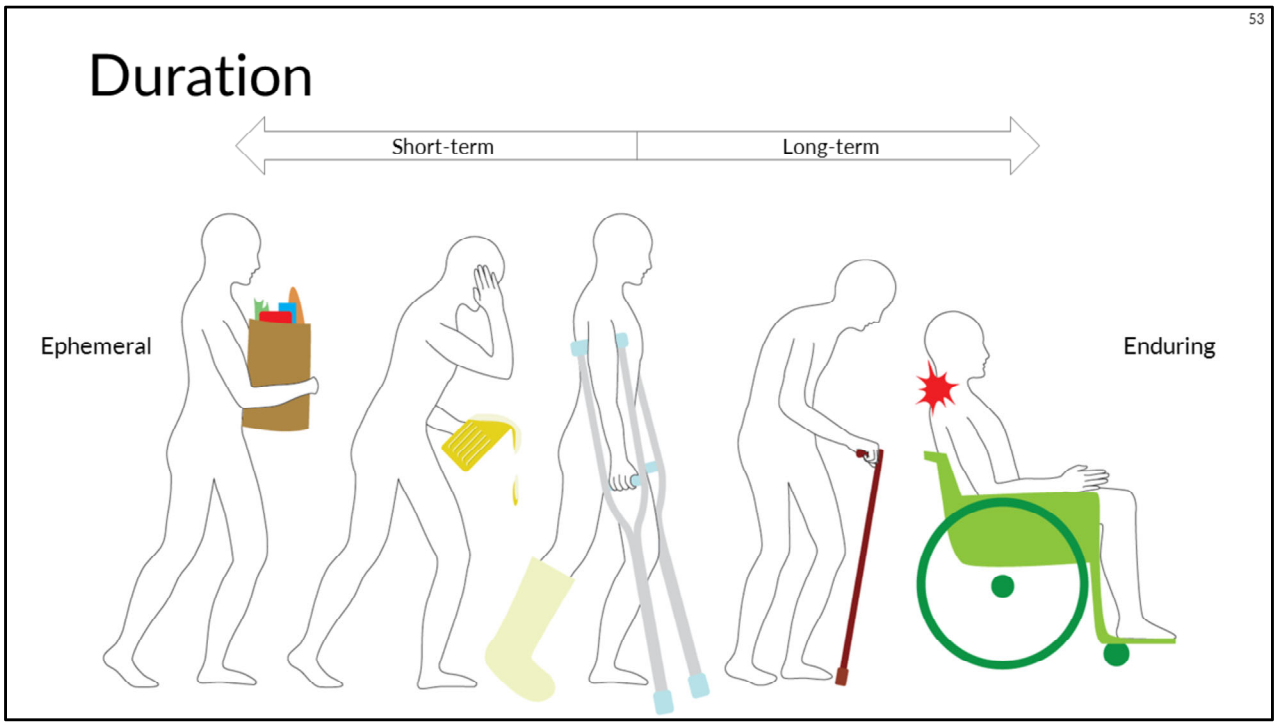


As we've seen, disability has a lot to do with situation, context, and environment… It seems vital that systems be more aware of these things.

Notes:
(Note: What context *is* has been addressed by prior work by Schmidt et al. and Dey et al.)

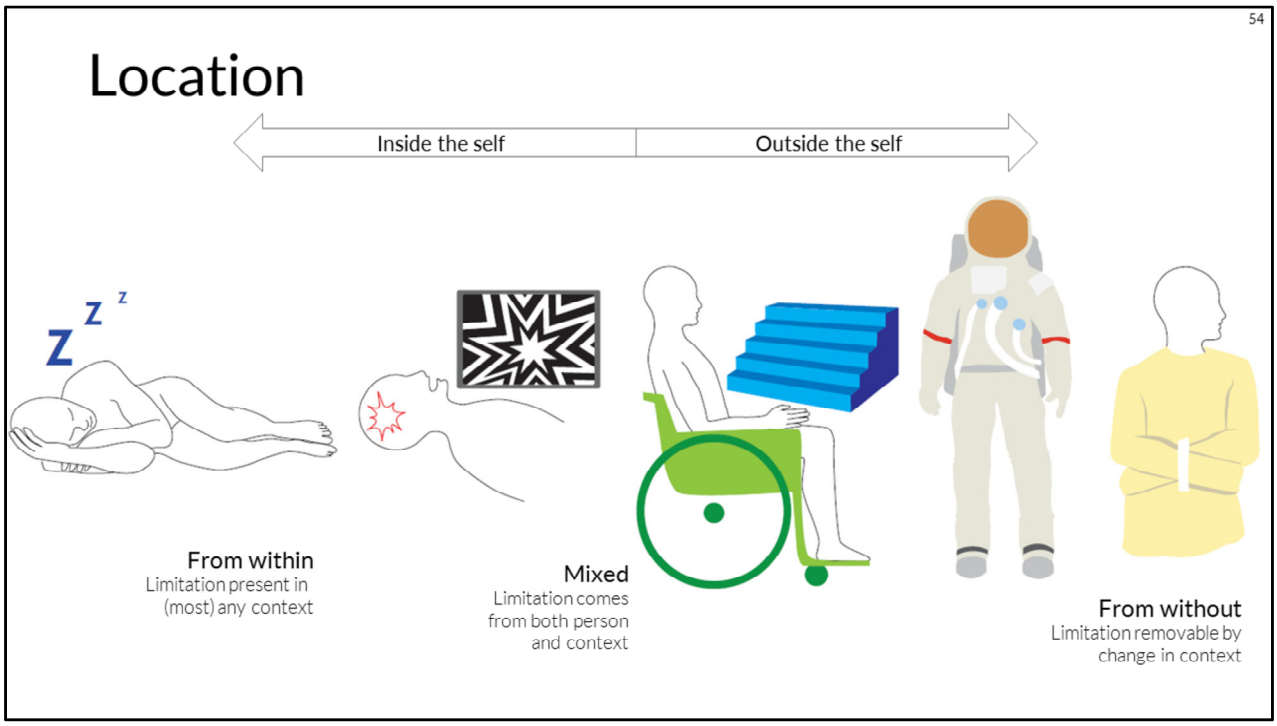
Schmidt, A., Aidoo, K. A., Takaluoma, A., Tuomela, U., Laerhoven, K. V., & Velde, W. V. d. (1999). Advanced Interaction in Context. In *Proceedings of the HUC*, 89-101.

Dey, A. K., Abowd, G. D., & Salber, D. (2001). A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications. *Human-Computer Interaction*, 16, 97-166.



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

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

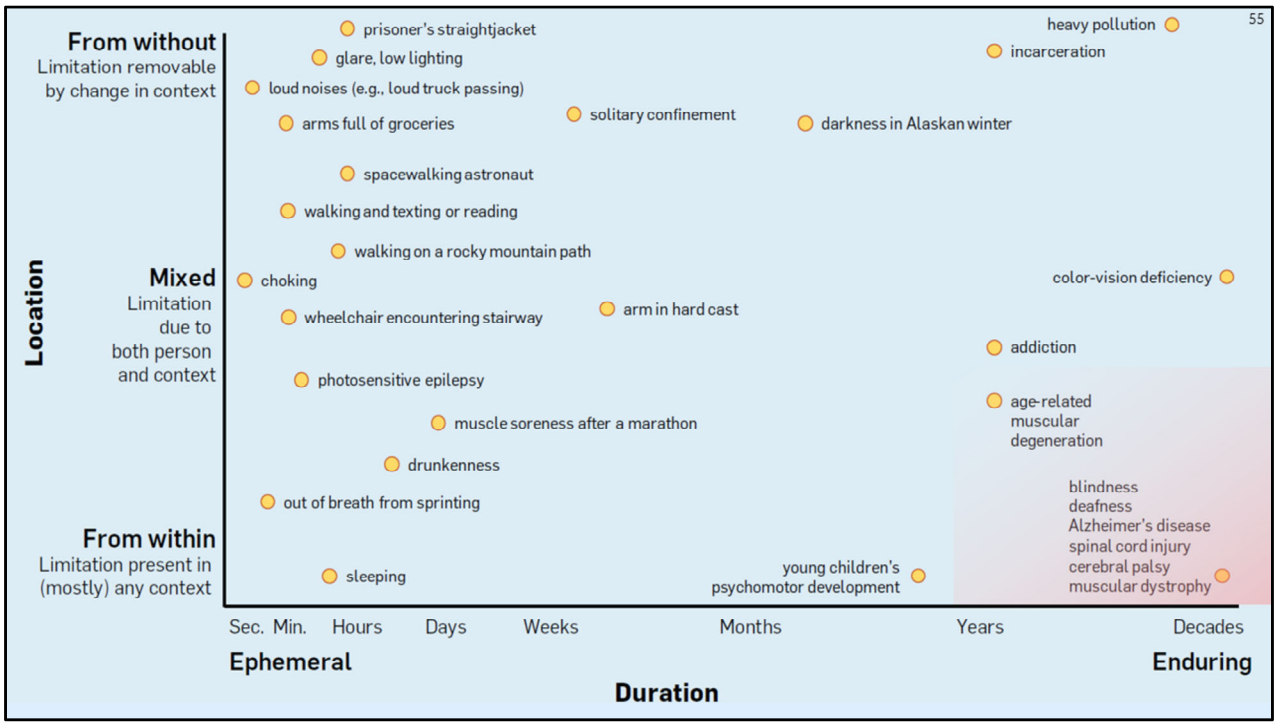


We can also consider the *Location* of an ability limitation.

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

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

If I put Michael Jordan in a prisoner's straightjacket, it doesn't matter very much that he's the greatest basketball player of all time. He can do very little because of the external constraints on his abilities.



When taken together, these two dimensions of *Duration* and *Location* give us a "Space of Impairments and Disabilities."

The purview of traditional assistive technology is the lower-right part of this space, making it clear how much opportunity there is to address other sources of impairment.

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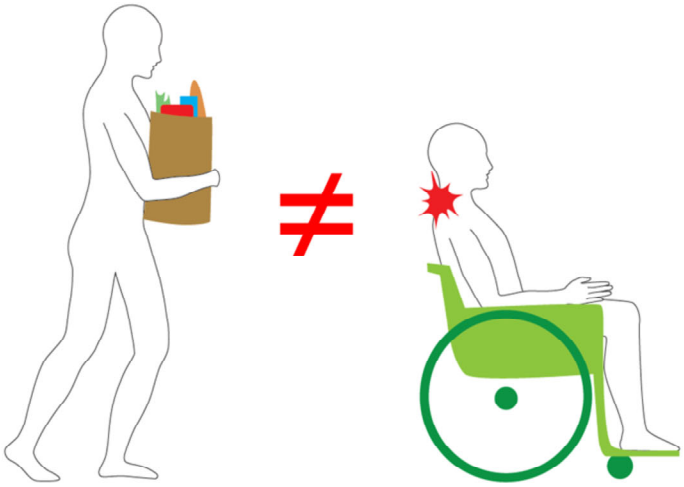
"No claim they're the same"

- Different lived experience
- No stigma
- No culture of disability
- No need for social or legal protections to be enshrined

And yet…

- Very real impairing effects
- Potential design benefits



Now, to be clear, the claim I'm making is NOT that the lived experience of situational impairments is the same as the lived experience of disability. Obviously the sources of these things and their effects on people's lives are entirely different. The lived experience of situational impairments has little to do with the lived experience of physical disability.

What I <u>am</u> claiming is that a design approach focused on *ability* can address both challenges. Although a person carrying groceries *is not the same as* a person with one arm, both might benefit from designs for one-handed use.

By focusing on *ability* in design, we unify our approach towards everyone, rather than treating design for disability as a design approach for "those people."

	Principle	*Description*
Designer Stance (required)	Ability	Designers focus on users' abilities, not disabilities, striving to leverage all that users can do in a given situation, context, or environment.
	Accountability	Designers respond to poor usability by changing systems, not users, leaving users as they are.
	Availability	Designers use affordable and available software, hardware, or other components acquirable through accessible means.
Adaptive or Adaptable Interface (optional)	Adaptability	Interfaces might be adaptive or adaptable to provide the best possible match to users' abilities.
	Transparency	Interfaces might give users awareness of adaptive behaviors and what governs them and the means to inspect, override, discard, revert, store, retrieve, preview, alter, or test those behaviors.
Sensing and Modeling (optional)	Performance	Systems might sense, monitor, measure, model, display, predict, or otherwise utilize users' performance to provide the best possible match between systems and users' abilities.
	Context	Systems might sense, monitor, measure, model, display, predict, or otherwise utilize users' situation, context, or environment to anticipate and accommodate effects on users' abilities.

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To help designers, engineers, and researchers think in terms of abilities, I've formulated 7 principles for Ability-Based Design. The first 3 of the 7 are required. The rest play a role in many ability-based innovations.

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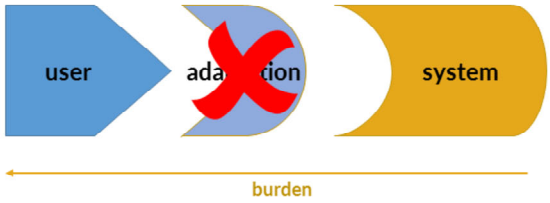
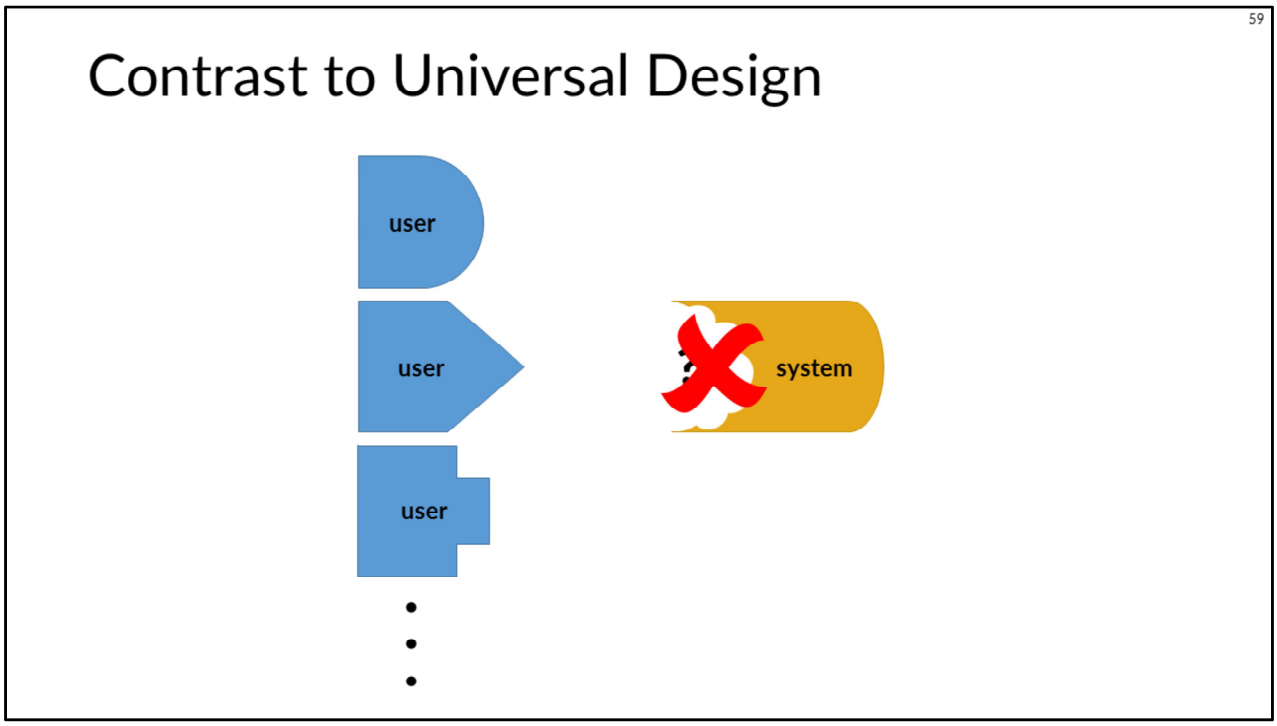
Contrast to Assistive Technology



It should be clear by now how Ability-Based Design differs from assistive technology. Ability-Based Design tries to avoid the user having to procure the “add-on” in the middle.



Ability-Based Design is also different from Universal Design, although the two can work together.

Ability-Based Design insists on having *as tight a match as possible between a person's abilities and the system they're using*. It rejects any *vague or general notion* of how different abilities might be compatible with a system's ability assumptions.

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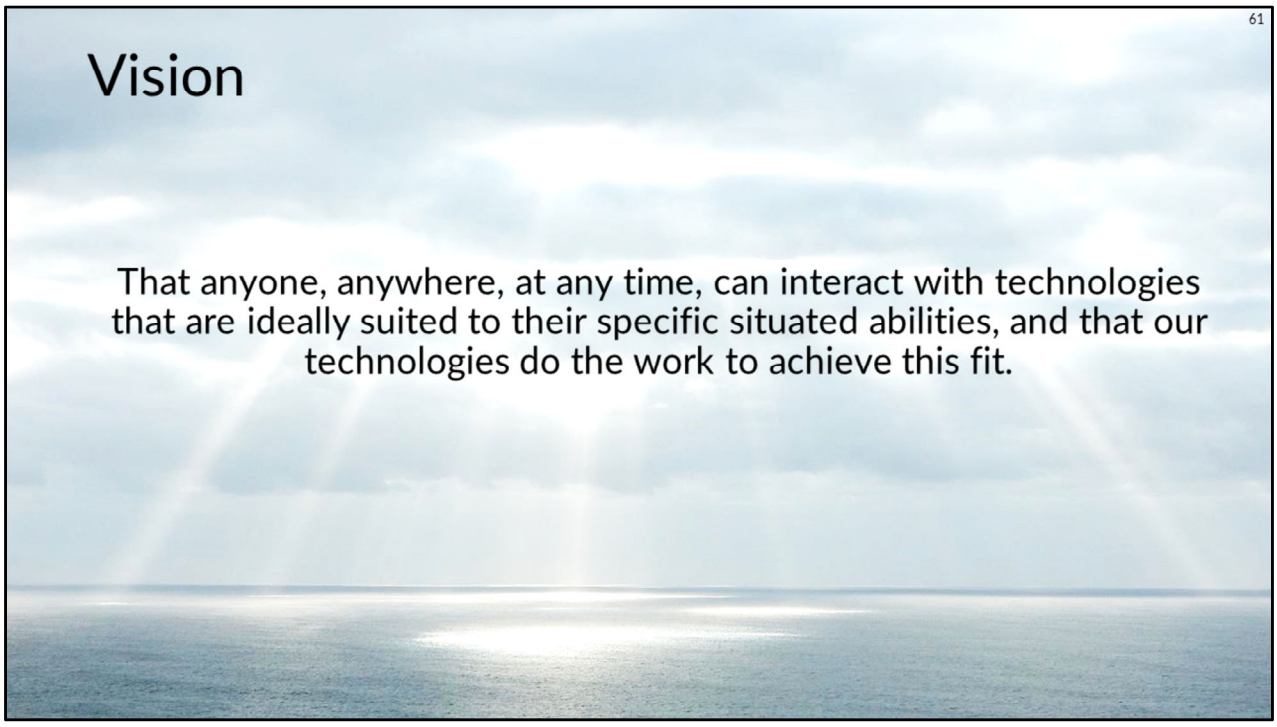
Design-for-One

"To create universal usability by designing for all involves making generalizations about users, and it is these exact generalizations that have led to so many users being excluded from the technological world in the first place. [U]niversal usability *is* possible but not by using this design-for-all ethos … It is only possible by 'design-for-one.'"

– Simon Harper (2007)

On this last point, Simon Harper was getting at the need for a tight, not overly general, fit between users and systems when he described his idea of *Design-for-One*.

He said…



This leads us to an ambitious vision for Ability-Based Design:

“That anyone, anywhere, at any time, can interact with technologies ideally suited to their specific situated abilities, and that the technologies do the work to achieve this fit.”

The challenge and opportunity of Ability-Based Design can drive innovations in many areas of computing, including: adaptive systems, sensing, user modeling, human factors, and user interface innovations.

Now the fun part!

I am going to show some video clips from various projects I've worked on that highlight aspects of Ability-Based Design. And because this isn't a regular CHI paper session, I'm not going to show you a single *p*-value. ☺

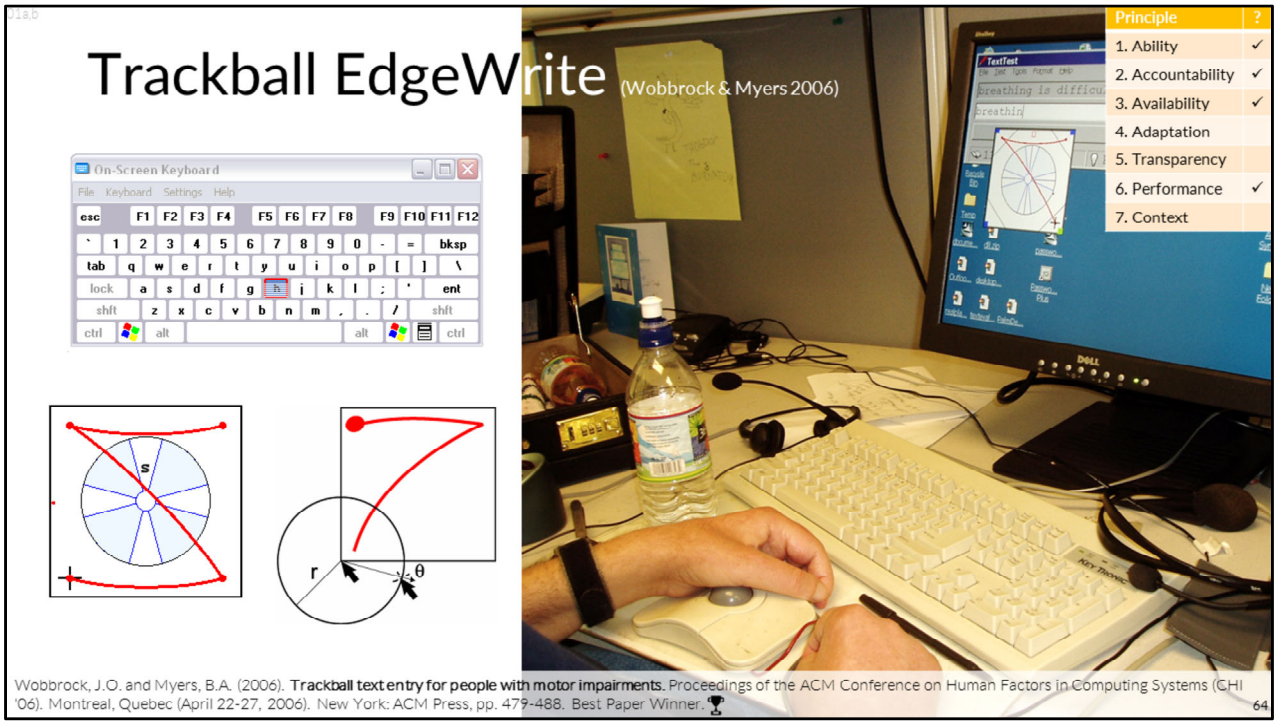
So just let these examples wash over you and (I hope) you'll begin to get the flavor of Ability-Based Design.

Students

Krzysztof Gajos | Shaun Kane | Susumu Harada | Jon Froehlich | Alex Jansen

Leah Findlater | Shiri Azenkot | Mayank Goel | Martez Mott | Alex Mariakakis

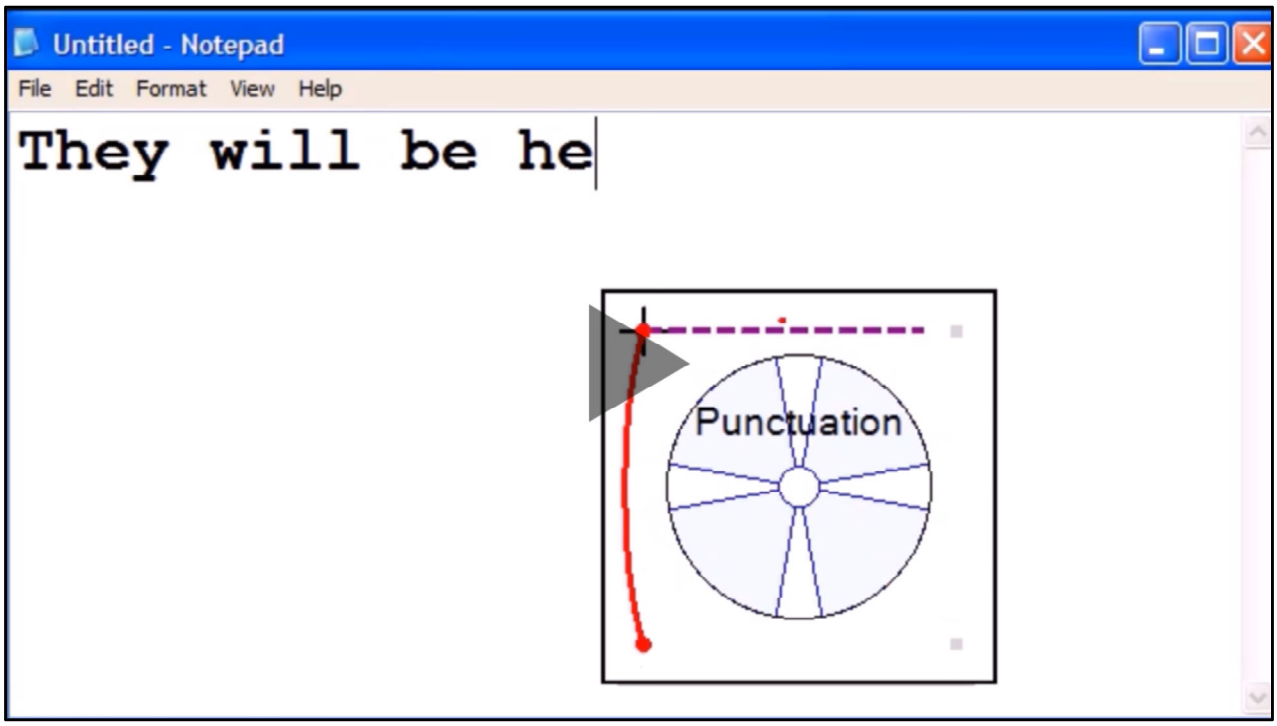
Before I go into the projects, however, I want to highlight that most of these projects were led by my Ph.D. advisees or other student collaborators. The people on this slide in particular deserve much credit for what you're about to see.



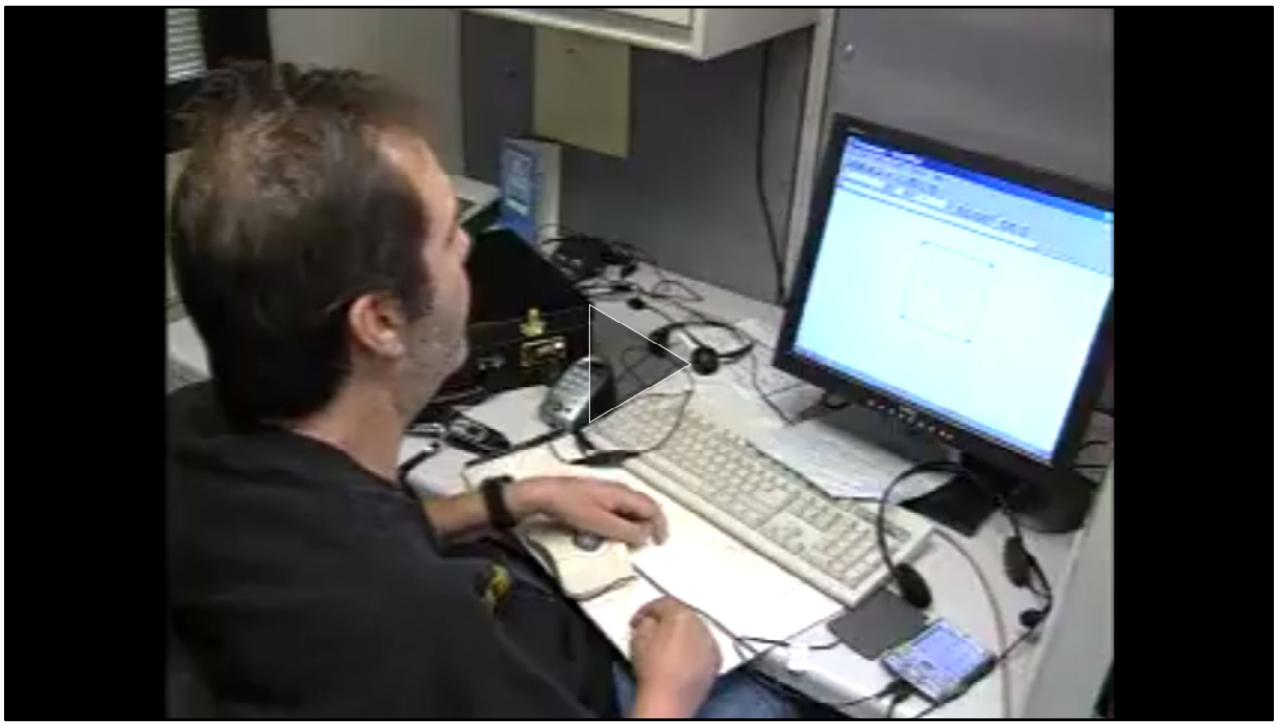
People with spinal cord injuries often use trackballs for pointing, but text entry is really tedious with on-screen keyboards. The user has to hover his mouse over each key and wait for a dwell-time to complete before each letter is entered.

EdgeWrite allows users to make strong ballistic movements with the trackball in any direction to write letter-like gestures. Instead of pointing to targets, the user just “pulses” the ball in a direction. This action requires much less fine motor control.

First let’s see Trackball EdgeWrite in action; then I’ll play a short video clip of someone using it.

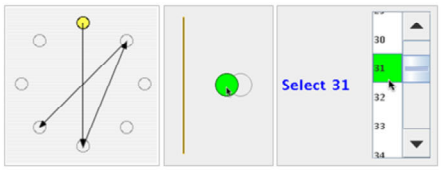


http://www.youtube.com/embed/PVzSnuQRIoo?autoplay=1&start=52&end=104



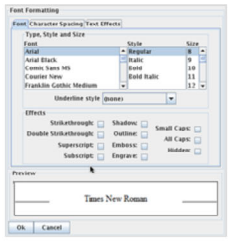
http://www.youtube.com/embed/aMflE8i-xR4?autoplay=1&start=51&end=91

SUPPLE (Gajos et al. 2007-2010)

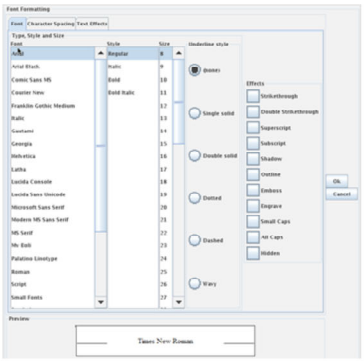


Principle	?
1. Ability	✓
2. Accountability	✓
3. Availability	✓
4. Adaptation	✓
5. Transparency	✓
6. Performance	✓
7. Context	

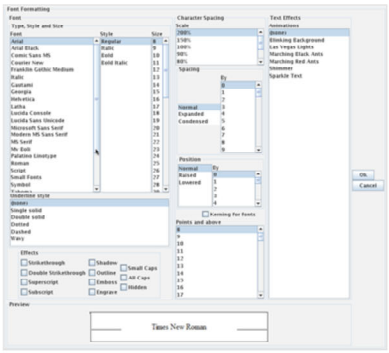
Microsoft Word font dialog



For someone with Cerebral Palsy



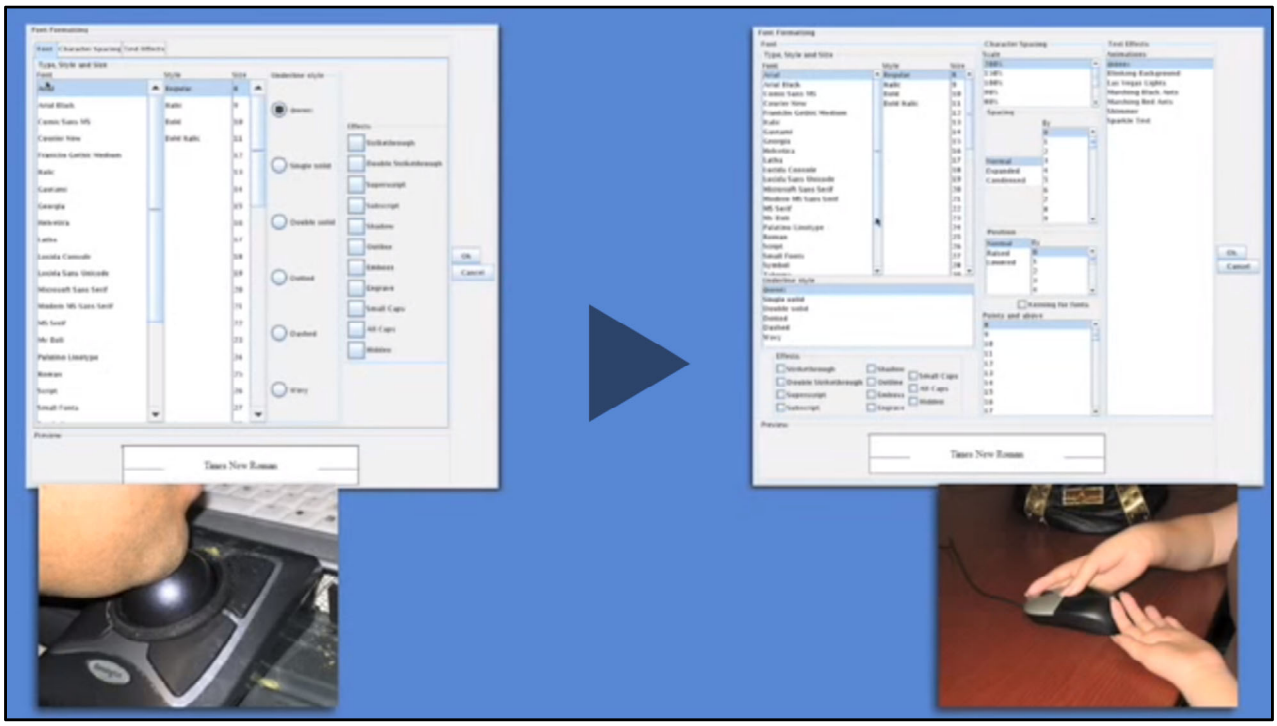
For someone with Muscular Dystrophy



Gajos, K.Z., Wobbrock, J.O. and Weld, D.S. (2008). **Improving the performance of motor-impaired users with automatically-generated, ability-based interfaces.** Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '08). Florence, Italy (April 5-10, 2008). New York: ACM Press, pp. 1257-1266. Best Paper Winner. 🏆 67

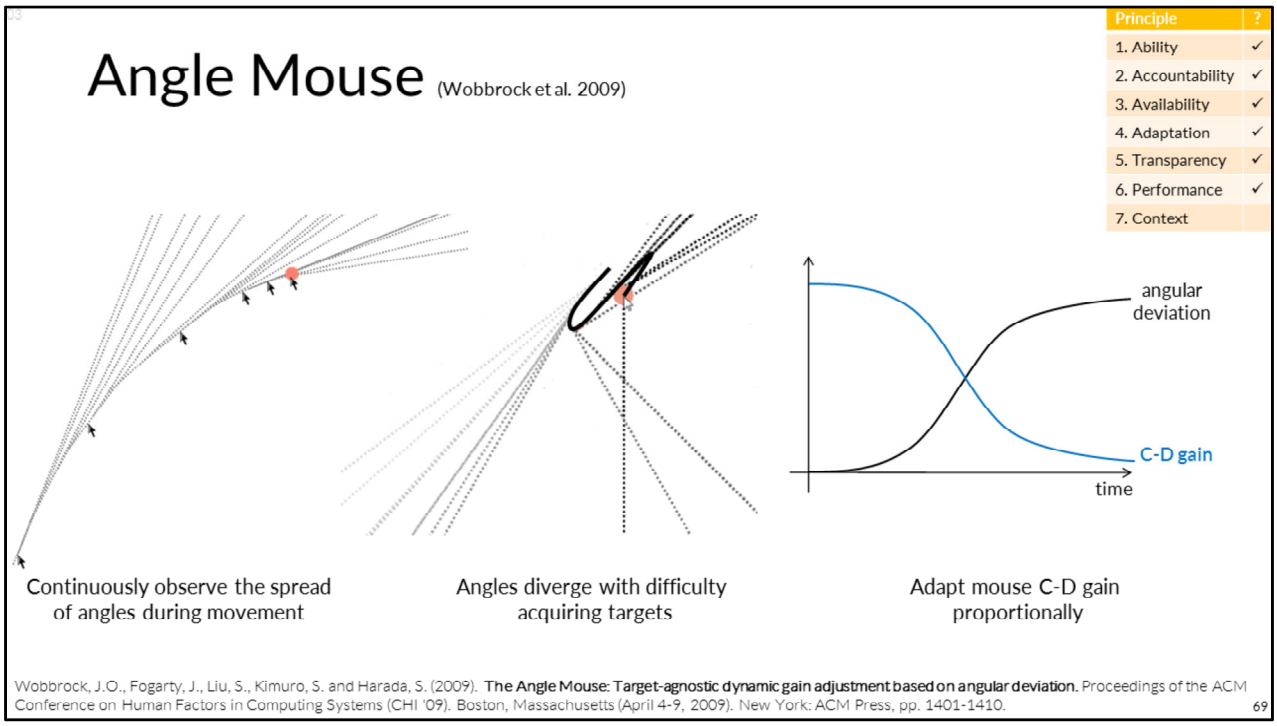
SUPPLE was the dissertation work of Krzysztof Gajos, whom I had the pleasure to co-advise with Dan Weld. SUPPLE really broke open the idea of an "ability-based user interface," where human motor performance in low-level tasks parameterized a decision-theoretic automatic user interface generator.

SUPPLE-generated interfaces were about 26% faster and made 73% fewer errors for people with motor impairments.



http://www.youtube.com/embed/B63whNtp4qc?autoplay=1&start=95&end=189

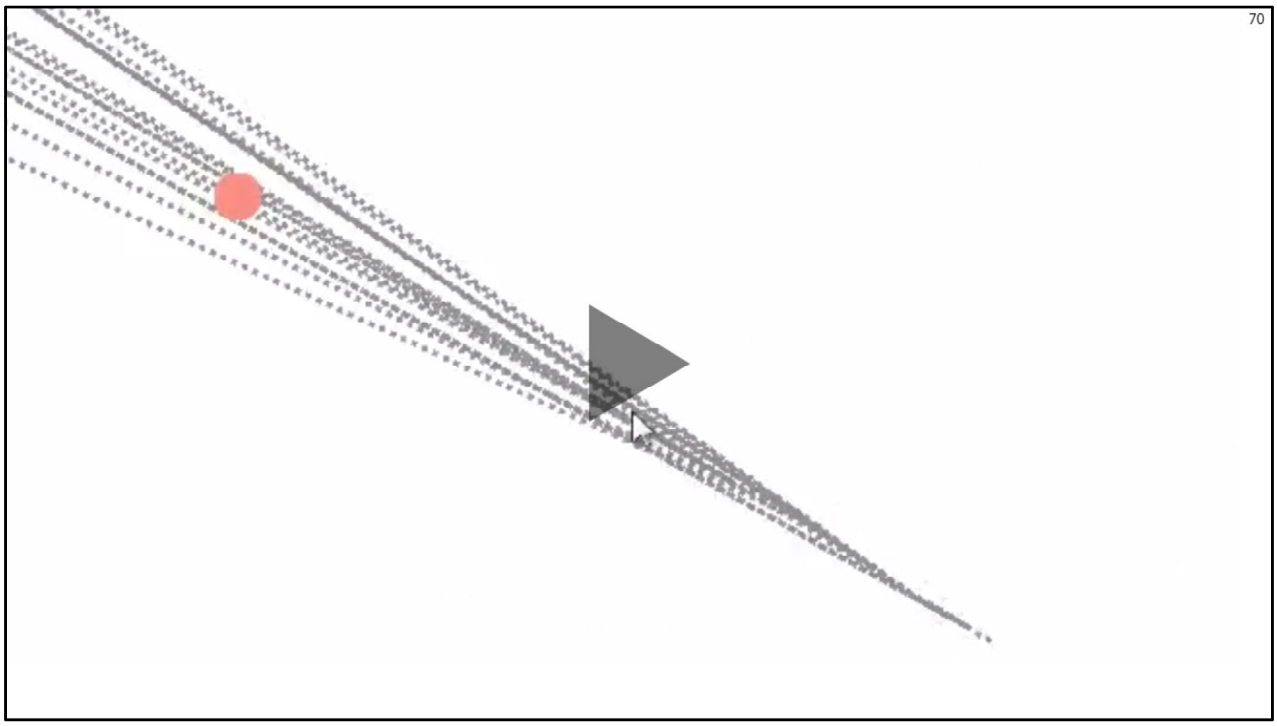
Notes:
A full talk by Krzysztof Gajos on SUPPLE is available here: https://www.youtube.com/watch?v=ODrE7SodLPs



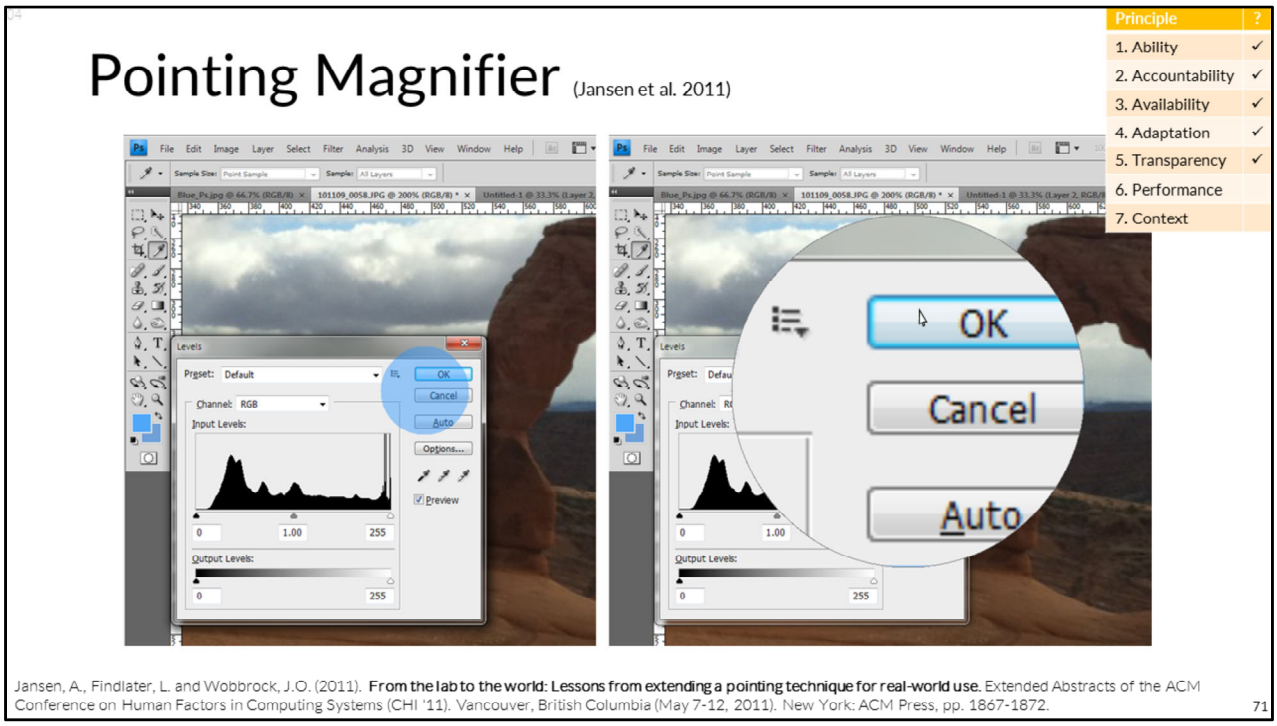
The Angle Mouse didn't change the UI like SUPPLE; instead, it changed the mouse pointer that *acts on the UI*.

The Angle Mouse adapted the control-display gain based on constantly observing the "angular deviation" (or spread of angles) during movement, realizing it was much greater when users were trying to get inside a target during the final corrective stages of movement.

The Angle Mouse gave about a 10% improvement in pointing throughput for people with motor impairments.



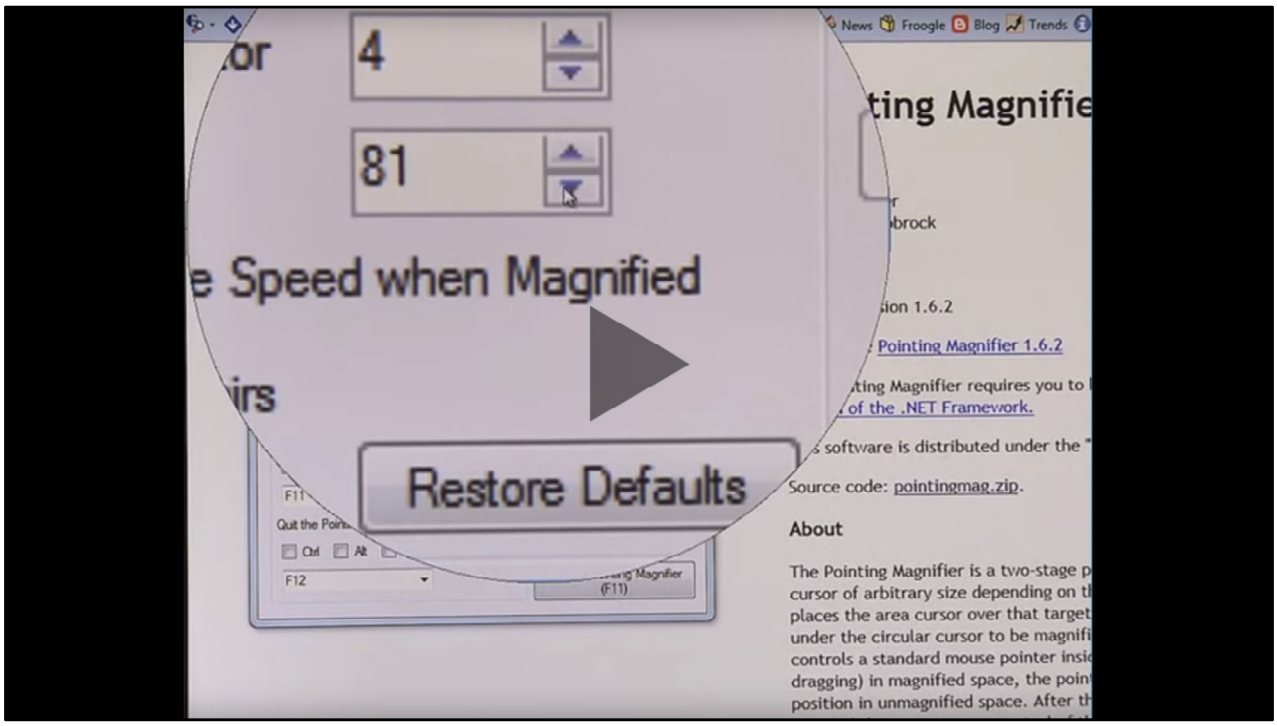
http://www.youtube.com/embed/O4ahGmHenps?autoplay=1&start=78&end=114



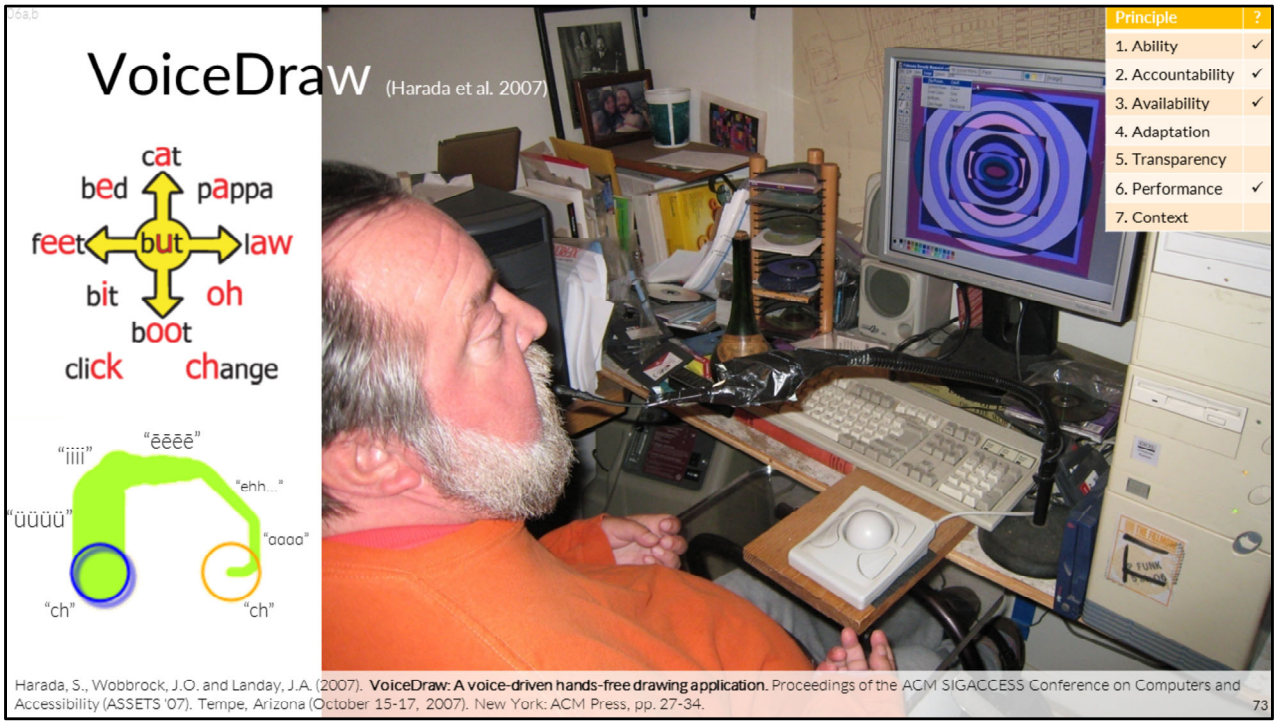
Area cursors are known to be easier for people with motor impairments, and screen magnifiers have been used for people with low vision, but to our knowledge, in 2010-2011 these two ideas had not yet been combined.

In the *Pointing Magnifier*, we created a two-stage pointing technique for people with motor impairments that magnifies the area beneath a highly configurable area cursor, and then accepts a second click within that enlarged space.

Note that in the enlarged space, the mouse cursor is *not* enlarged, so this is not a purely visual screen-magnifier where no motor-space advantage is gained, it is both a visual-space and motor-space magnifier.



http://www.youtube.com/embed/pD9X6kwhmhk?autoplay=1&start=131&end=191

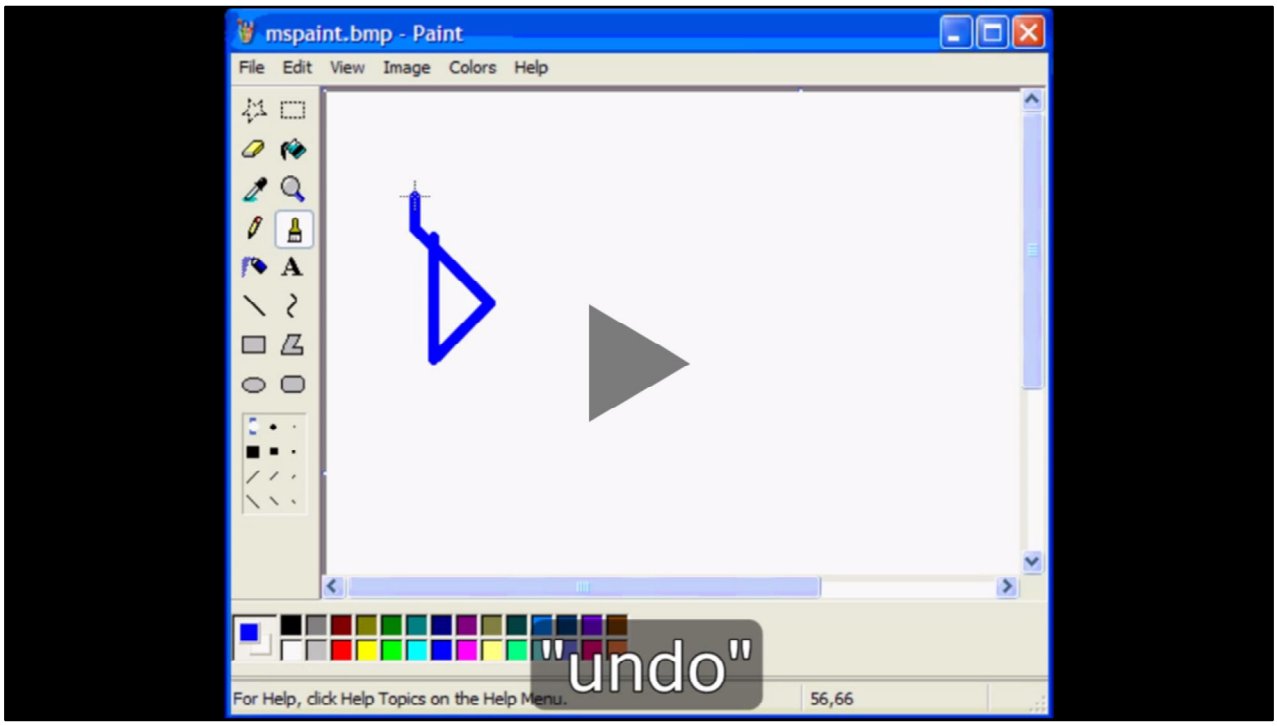


We then questioned whether we need to point with our hands at all?

Work at the University of Washington by Jeff Bilmes and others created the "Vocal Joystick," which enabled non-speech vowel sounds to indicate a direction fluidly and continuously.

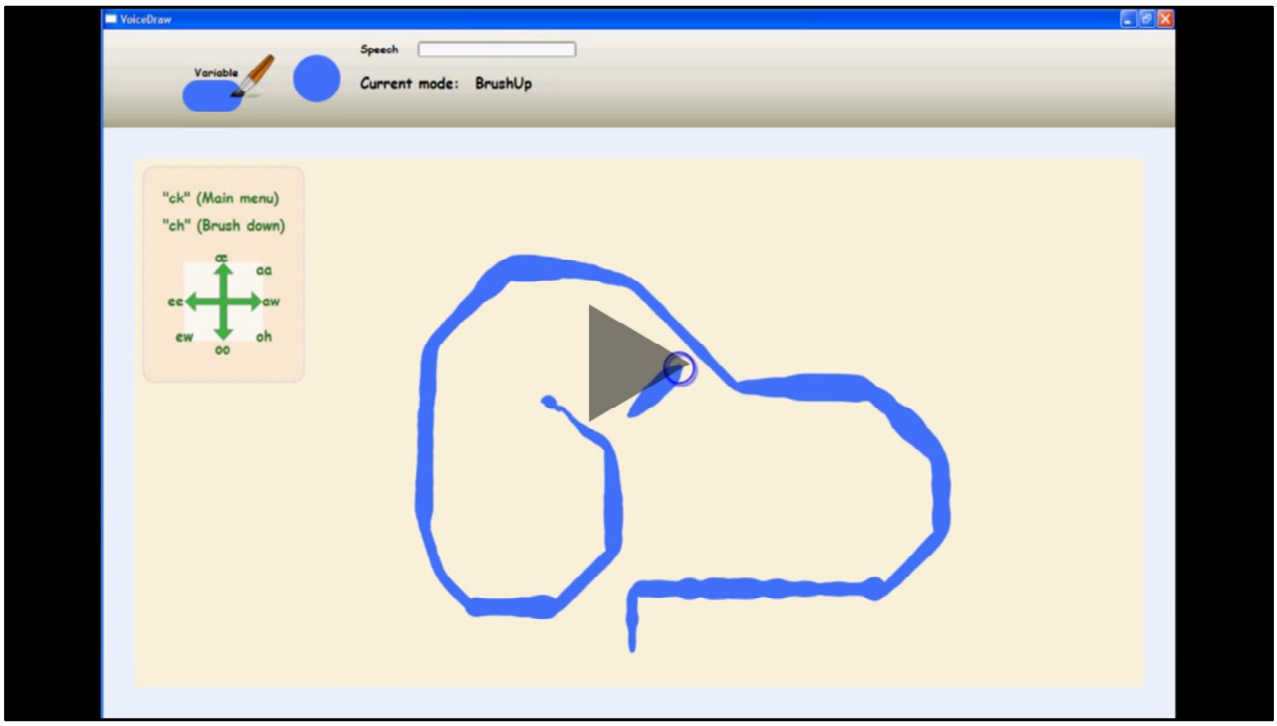
We built on top of the Vocal Joystick to create VoiceDraw, an entirely hands-free drawing application that could support continuous control of brush strokes, varying brush thickness, progressive and partial undo or redo, and brush strokes that had a very "paint-like" quality.

We worked with a self-described "voice artist" from the Bay Area named Philip Martin Chavez to improve and evaluate VoiceDraw.



This first clip shows the problems of mapping *discrete* speech sounds to *continuous* movements. The mapping is a poor one, and the errors caused by speech misrecognitions are really problematic.

http://www.youtube.com/embed/qHLHoe6_-L8?autoplay=1&start=87&end=119

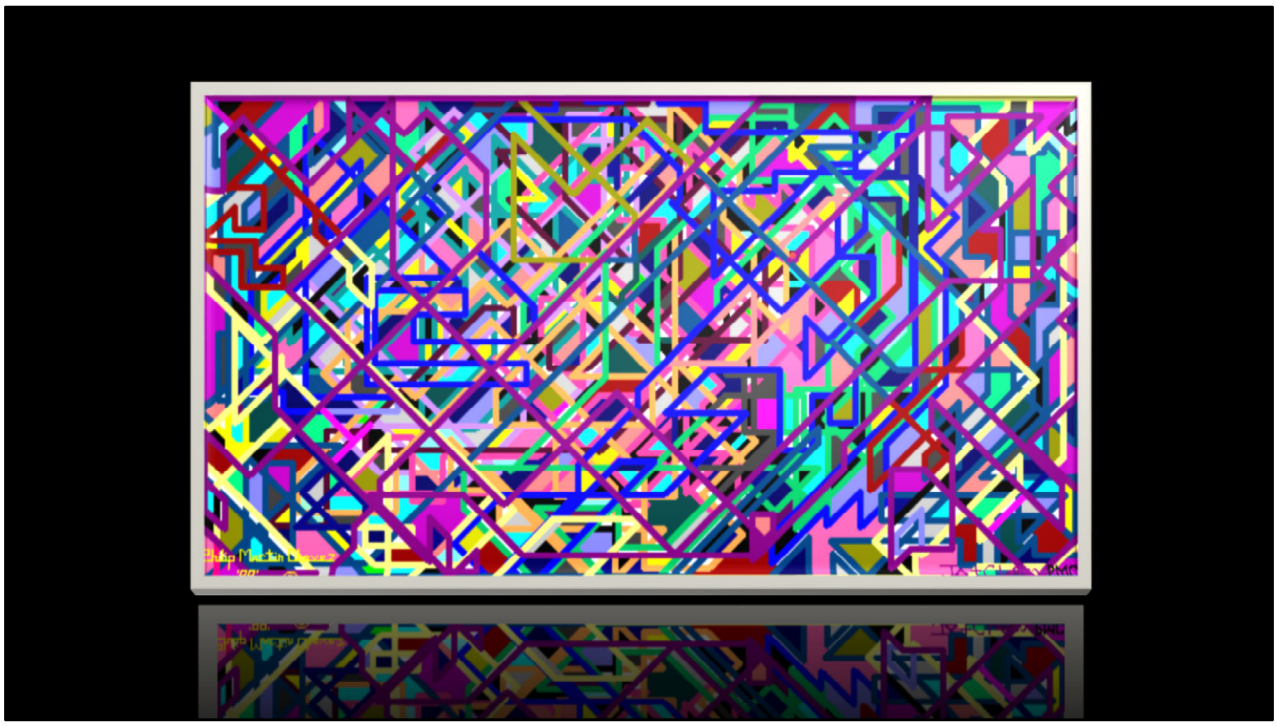


By contrast, VoiceDraw maps continuous vowel sounds to continuous movements.

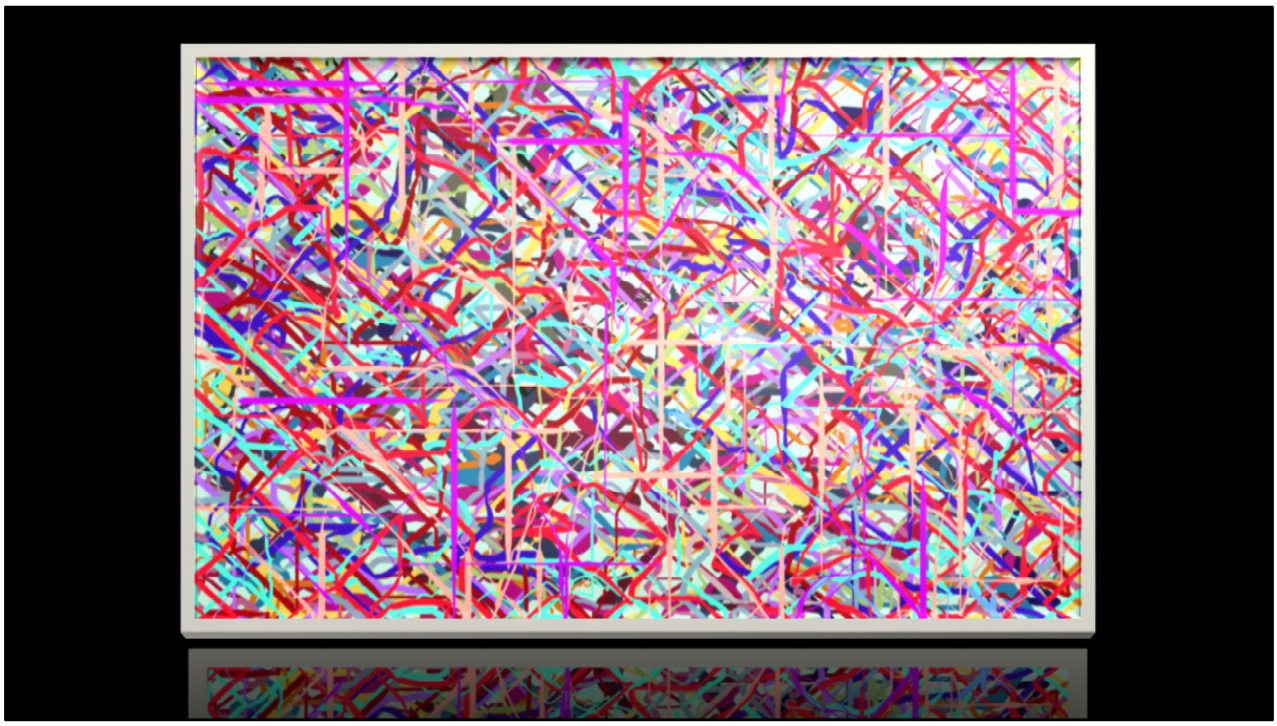
http://www.youtube.com/embed/qHLHoe6_-L8?autoplay=1&start=1&end=23

Here is a clip from a news story of our work with Philip Martin Chavez, the voice artist.

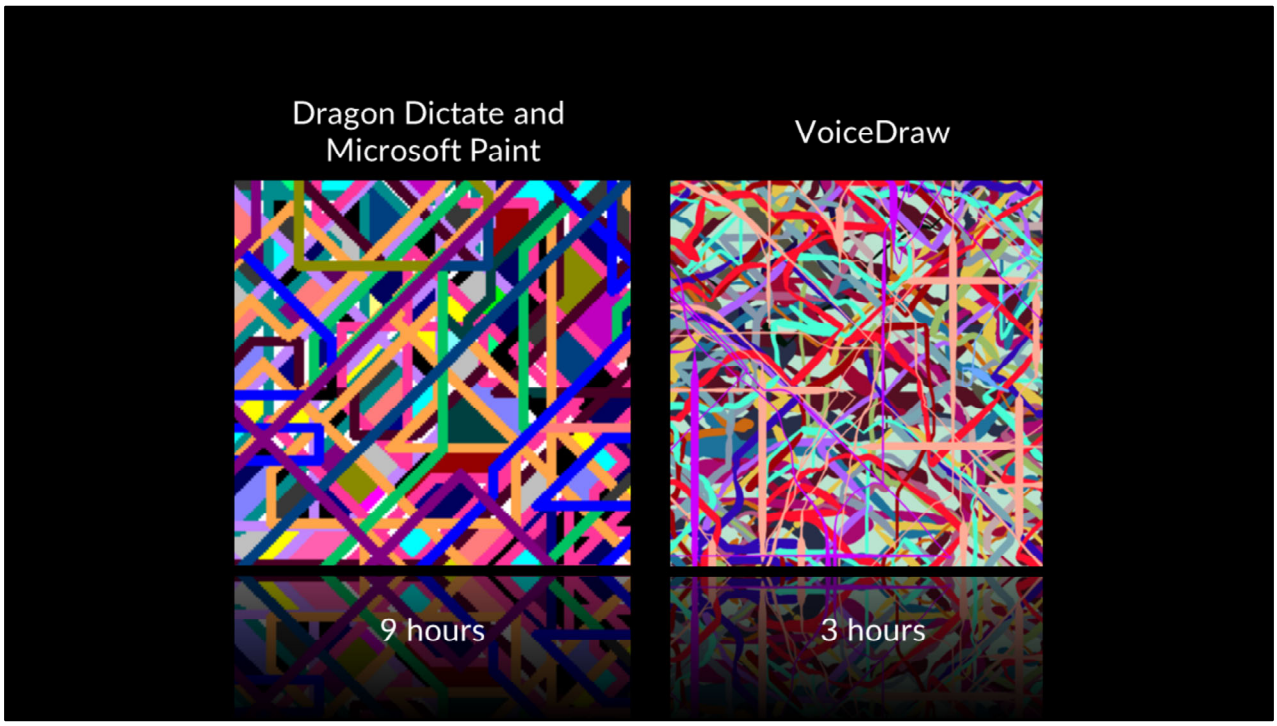
http://www.youtube.com/embed/iE5dzgKRkk8?autoplay=1&start=191&end=251



Here is one of Mr. Chavez's paintings before VoiceDraw. Here he used Dragon Dictate and Microsoft Paint.



We asked him to create a similar work using VoiceDraw, and he came up with this.

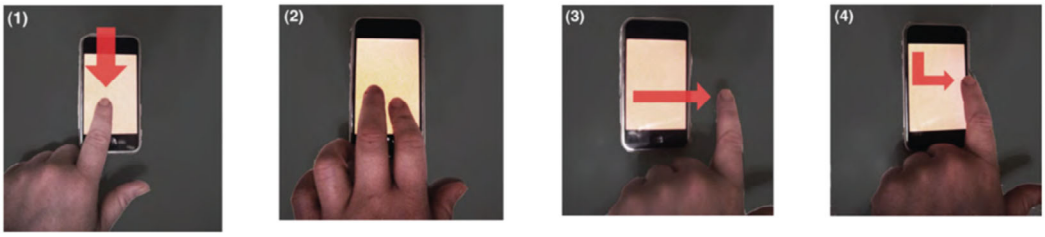


It is pretty clear that the VoiceDraw version contains curved and variable thickness strokes, and looks much more like actual paint strokes. It also took a third of the time to make despite being a new tool.

Here is another VoiceDraw painting.

Slide Rule (Kane et al. 2008)

Principle	?
1. Ability	✓
2. Accountability	✓
3. Availability	✓
4. Adaptation	
5. Transparency	
6. Performance	
7. Context	



Reading-finger drives screen reader

Second finger taps anywhere to trigger reading-finger target

Flick gestures for target-less navigation

L-gesture to navigate hierarchies

Kane, S.K., Bigham, J.P. and Wobbrock, J.O. (2008). **Slide Rule: Making mobile touch screens accessible to blind people using multi-touch interaction techniques.** Proceedings of the ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '08). Halifax, Nova Scotia (October 13-15, 2008). New York: ACM Press, pp. 73-80.

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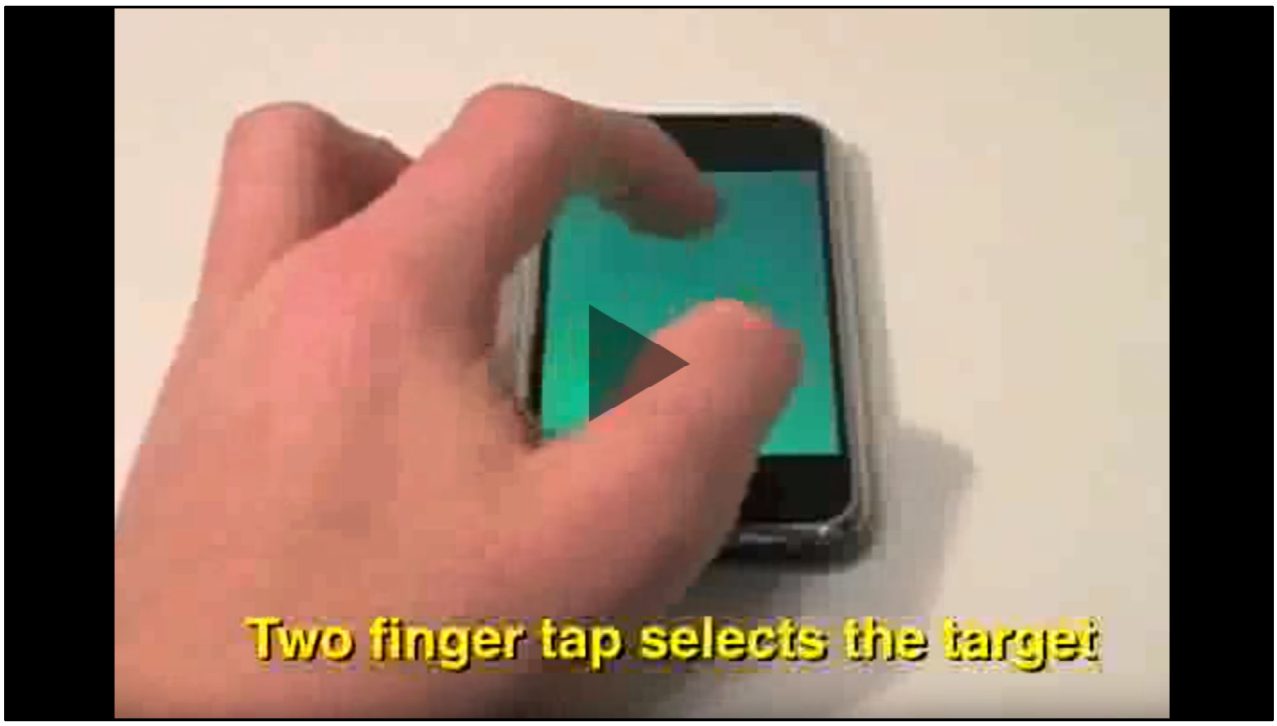
When the mobile touch screen revolution came in 2007, we observed that blind people, who previously had used mobile phones with tactile buttons, would not be able to feel any buttons on these new touch screen phones. We asked ourselves, "If you're blind, how will you be able to operate a touch screen device?"

We created a prototype called *Slide Rule* that, among other things, exhibited two key insights: (1) you could read the screen with a finger, and the level-of-detail read would be proportional to your finger's speed in passing over each item; and (2) to select an item, rather than lift from the screen, which can be disorienting, you can leave your reading-finger where it is and tap *anywhere* with a second finger. This made for very comfortable and accurate target activation.



http://www.youtube.com/embed/496IAx6_xys?autoplay=1&start=10&end=48

In 2010, we received an email indicating that Slide Rule was known to Apple and informed their design of VoiceOver, which is highly popular built-in accessibility software among blind people.

What we had called "second-finger tap" Apple named "split tap." I guess that's what a great marketing department will get you. ☺

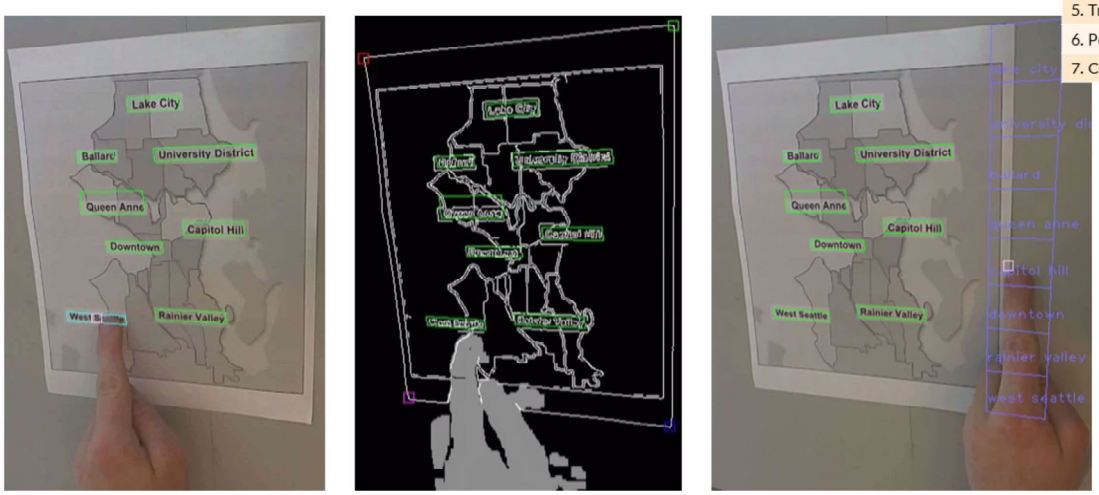
VoiceOver is built into every iOS device, of which there are now over one billion in the world.

Android has a similar feature called *TalkBack*.

Notes:
Learn VoiceOver gestures: https://help.apple.com/ipod-touch/9/#/iph3e2e2281

Access Lens (Kane et al. 2013)

Principle	?
1. Ability	✓
2. Accountability	✓
3. Availability	✓
4. Adaptation	
5. Transparency	
6. Performance	
7. Context	



Kane, S.K., Frey, B. and Wobbrock, J.O. (2013). **Access Lens: A gesture-based screen reader for real-world documents.** Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '13). Paris, France (April 27-May 2, 2013). New York: ACM Press, pp. 347-350.

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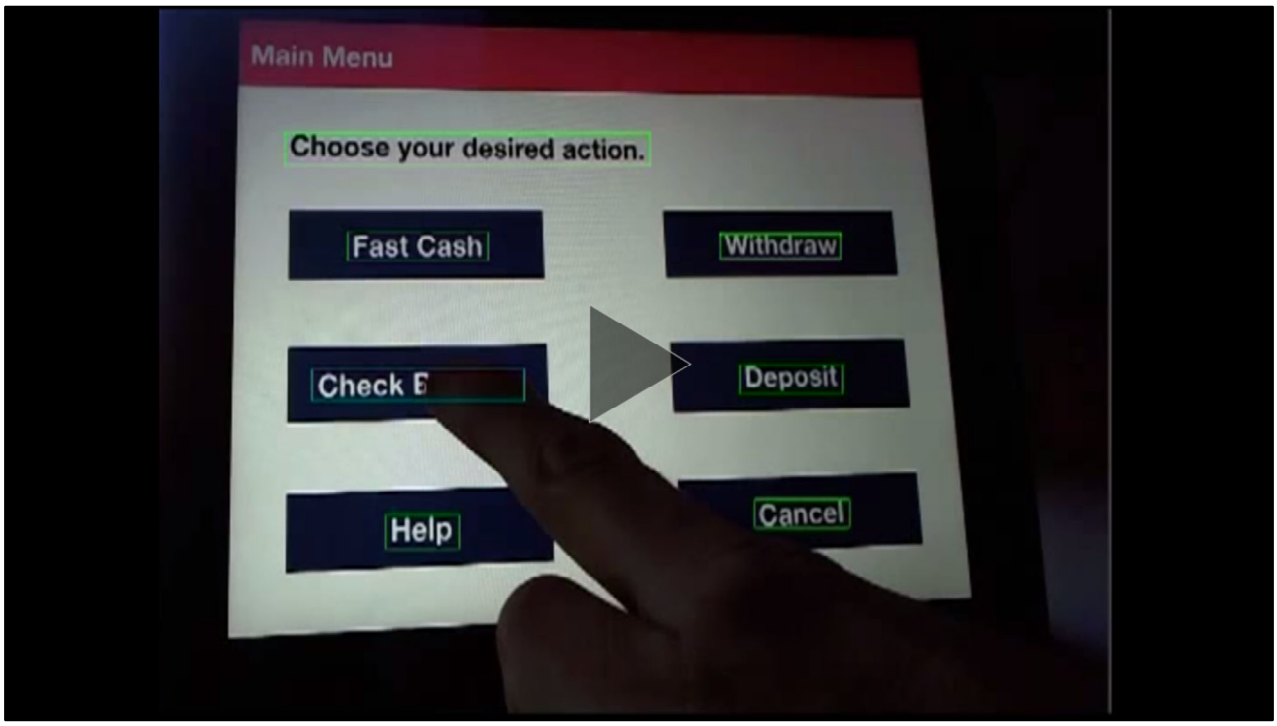
We applied the same idea from Slide Rule to physical documents like paper, or to non-touch-based screens like some ATMs, in Access Lens. It used a camera and computer vision to allow finger-based screen reading of text.

http://www.youtube.com/embed/gyBT4e_PoK8?autoplay=1&start=52&end=60



http://www.youtube.com/embed/gyBT4e_PoK8?autoplay=1&start=94&end=111

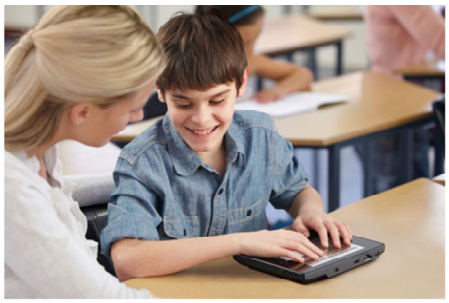
Exploring screens and selecting targets dominate a lot of what we do on touch screens, but we also need to enter text. *Perkinput* was a project that utilized not just the low-level psychomotor abilities of users, but also their *literacy abilities*, namely their knowledge of Braille. Here, Braille is used for input (i.e., writing), not output (i.e., reading) as we might usually think of it.

We also did some innovative stuff around probabilistic hit-testing using maximum likelihood to improve accuracy, allowing the fingers to drift over time; Perkinput would update the finger locations progressively.

http://www.youtube.com/embed/Ot8_lObS1Lc?autoplay=1&start=30&end=113

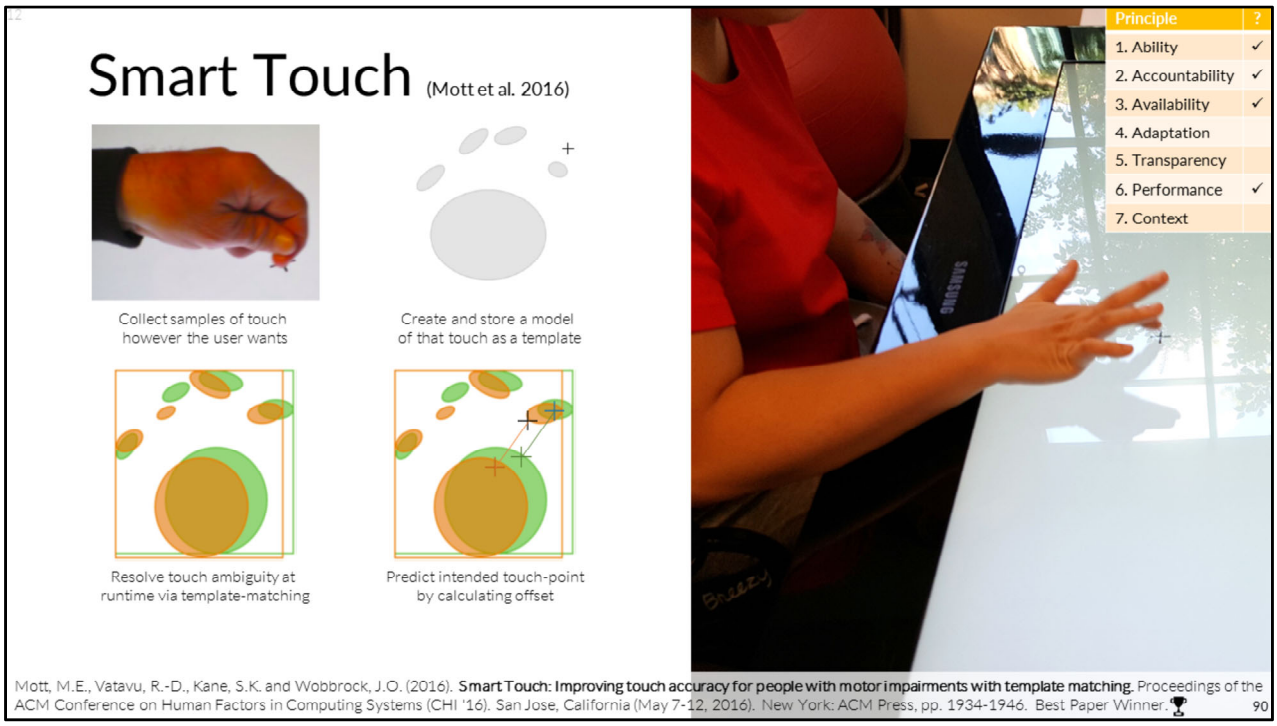
BrailleNote Touch™ by Humanware

see things. differently.



TouchBraille – the most natural way to type braille on a touchscreen
Instant calibration – virtually as fast as typing with 10 fingers on a keyboard
Virtual Keys find your fingers as you type

Many of Perkinput's ideas are now present in commercial products, such as the BrailleNote Touch by Humanware. Like Perkinput, this product allows for typing in Braille patterns on a touch screen, utilizes finger calibration, and tracks your fingers as you type.



People with various motor impairments touch screens in very different ways. What if we could make screens observe just *how* people touch them and then disambiguate that touch at runtime?

In *Smart Touch*, we built a touch model for each user consisting of a series of templates and various properties about them.

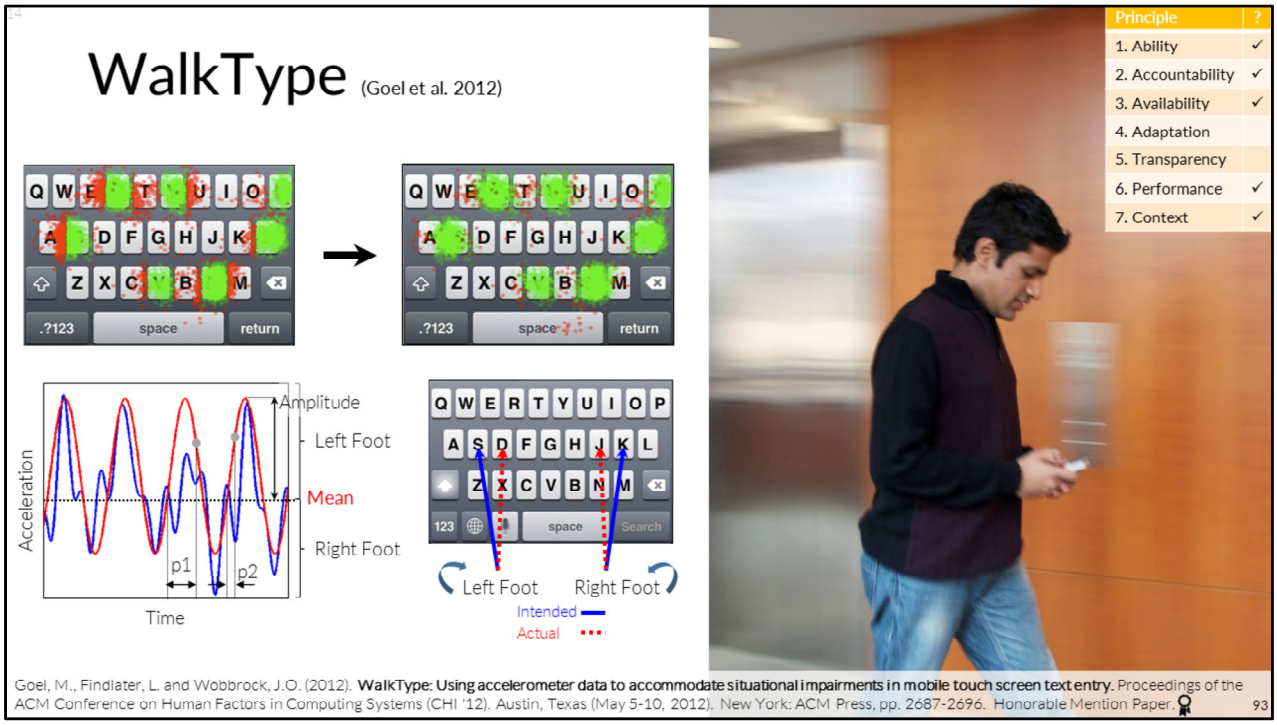
Smart Touch resolved touch locations that were 3x closer to intended targets than the native *land-on* or *lift-off* techniques common to most touch screens.

In this video, you can see the many different ways that people with motor impairments touch. Smart Touch is able to model those patterns using templates and then at runtime, compare against those templates to resolve intended touch points.

https://www.youtube.com/embed/AJQFfneNk5o?autoplay=1&start=15&end=24

See also:
https://www.youtube.com/embed/G-DmfUvxenM?autoplay=1

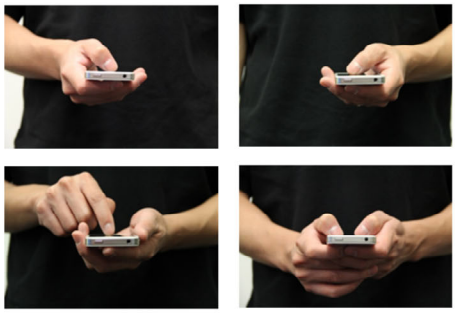
Now let’s look at a few projects explicitly directed towards situationally-induced impairments and disabilities.



WalkType was a project that used (1) touch interaction features like touch location, duration, travel, and time between touches, and (2) accelerometer features like amplitude and phase since the last tap, to train decision trees that improve the accuracy of key-presses on a mobile keyboard while the user is walking. We observed an "inward rotation" on each half of the keyboard based on which foot is moving forward and could remove that bias to make typing more accurate.

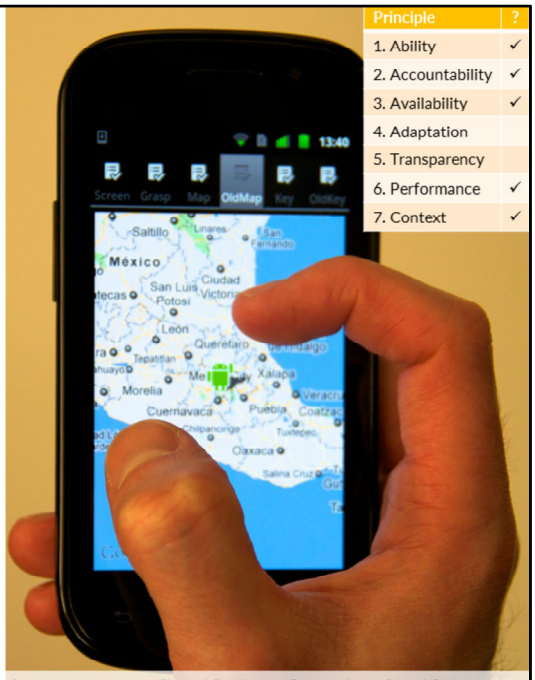
Typing speeds were about 12% faster, and error rates were reduced by almost 50%, with WalkType compared to a standard touch keyboard without walking sensing.

GripSense (Goel et al. 2012)



Grip detected via:

- Rotation of device
- Touch size
- Shape of swipes



Principle	?
1. Ability	✓
2. Accountability	✓
3. Availability	✓
4. Adaptation	
5. Transparency	
6. Performance	✓
7. Context	✓

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.

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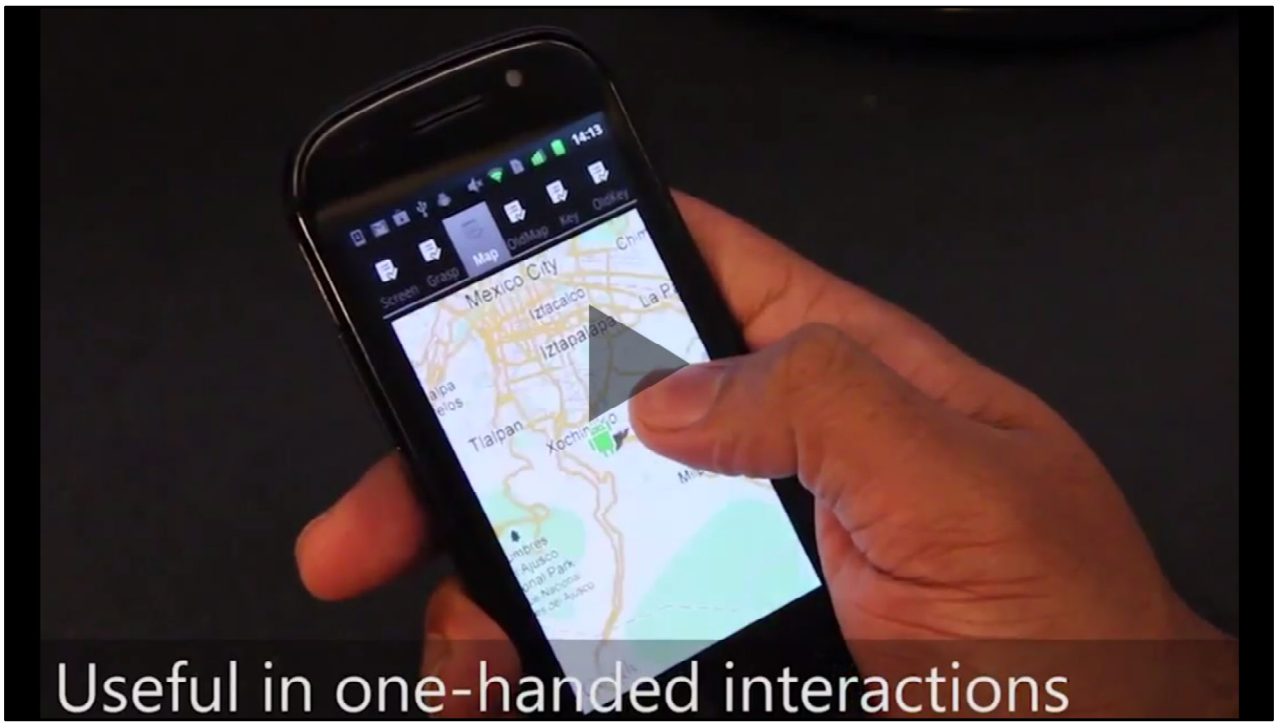
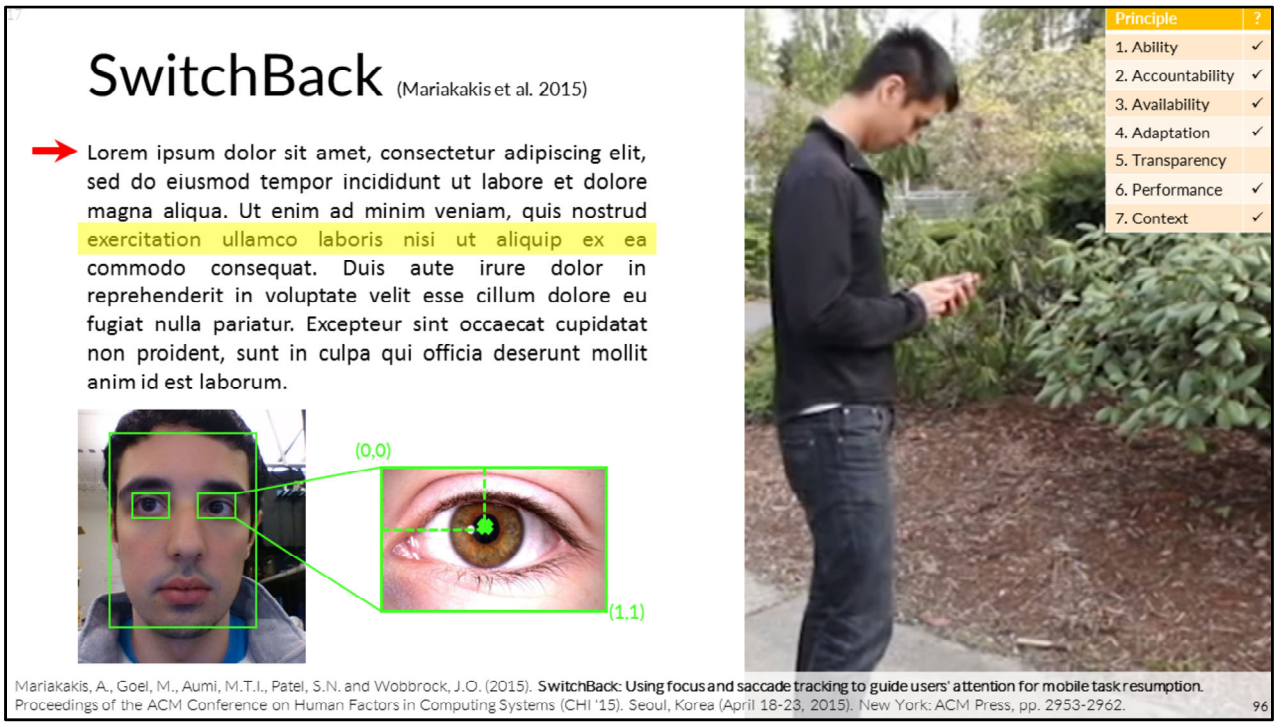
How many of us have tried to zoom with one hand like in the picture shown here? A situational impairment can come from how we hold a mobile device. Our devices currently are oblivious as to whether we are holding them with one hand or two hands, and if one hand, which hand we're using.

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." (A clever little hack!)



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



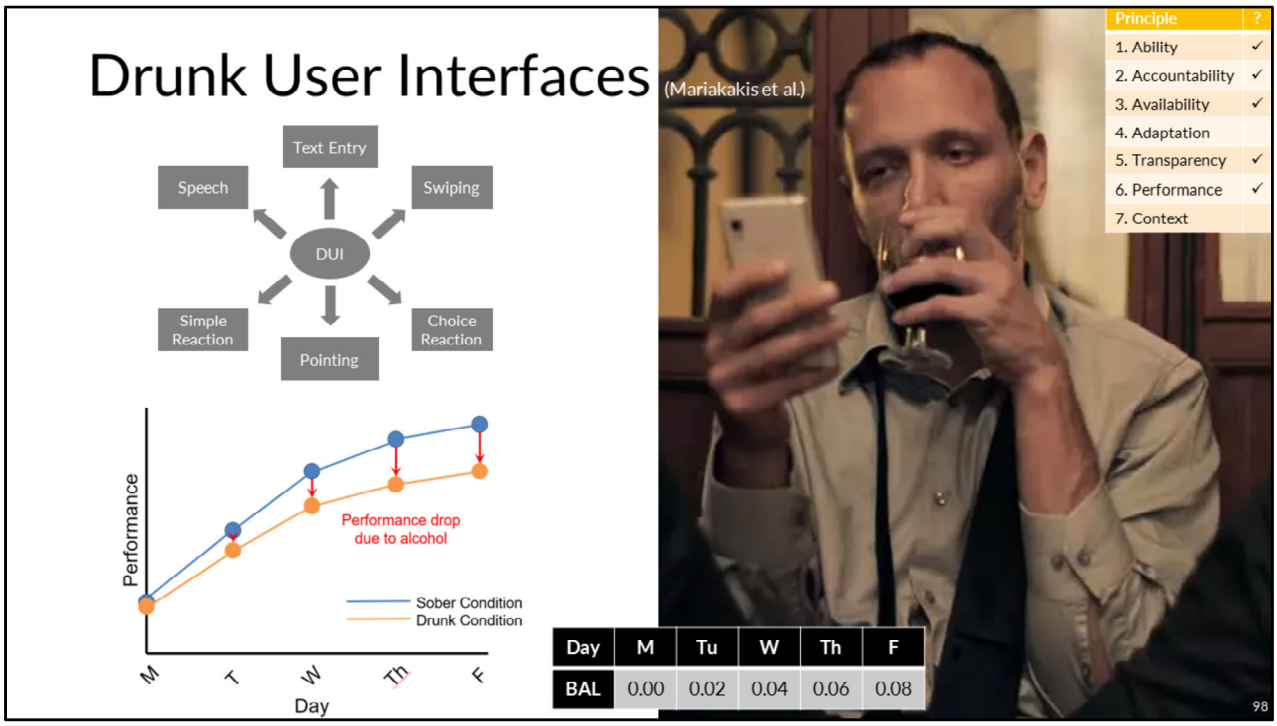
Input is only half the challenge when interacting while on the move. Output is also difficult.

We know from prior research (Oulasvirta et al. 2005) that people look away from their screens about every 4 seconds while mobile.

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 were on when we look back at the screen after looking away.

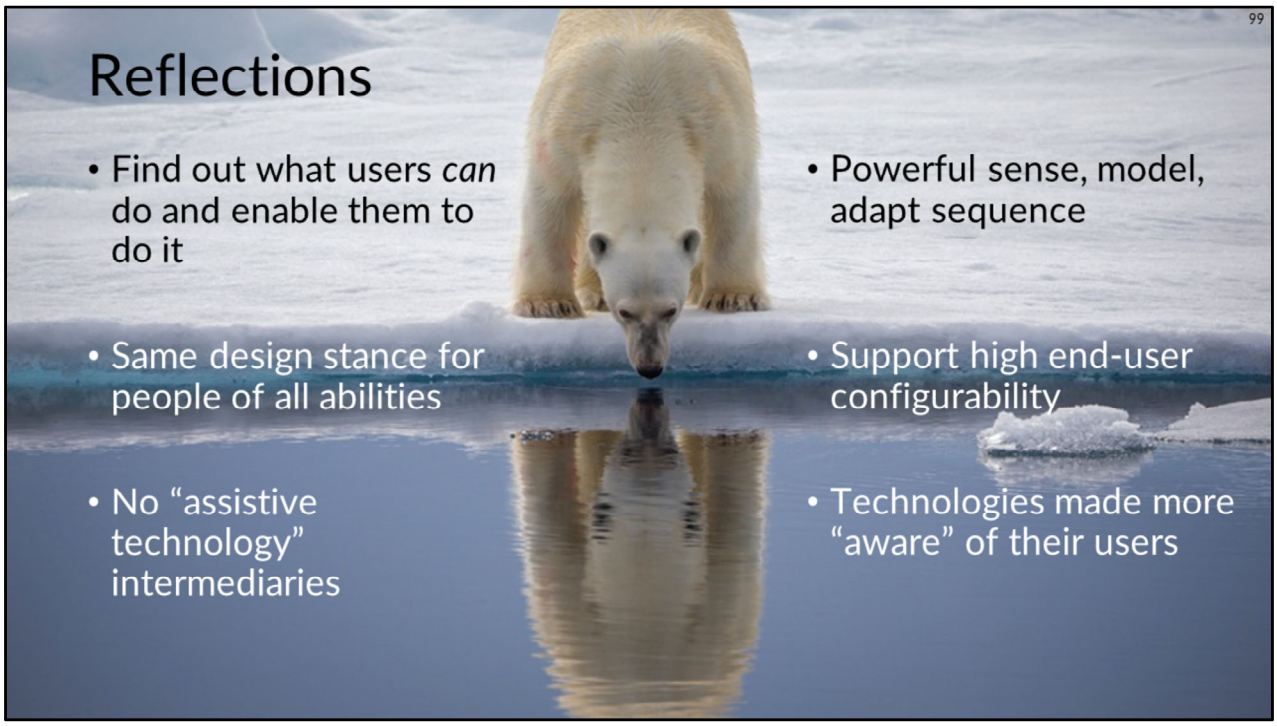
http://www.youtube.com/embed/uDsZXEZdLpY?autoplay=1&start=16&end=70



Here is a project of ours that is currently underway…

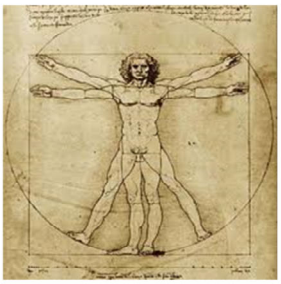
In *Drunk User Interfaces*, or *"DUI*," we're trying to see if we can reliably detect inebriation with smartphones through a combination of sensing and human performance tasks. We're currently running an experiment that systematically gets participants intoxicated at increasing levels, runs them through a battery of human performance tasks, and looks to correlate performance with ground-truth inebriation from a breathalyzer.

An example use case for DUI is that people could opt-in to lower insurance premiums if they agreed to use DUI after 10 pm before driving on Friday and Saturday nights. If they failed the test, then maybe their car wouldn't start, or their phone would call a loved one, or they'd be forced to try again in an hour.



In light of these and many other projects we have done, let's step back and offer some reflections.

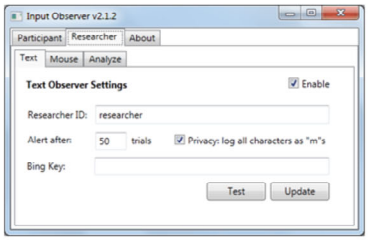
Future work



Generalized ability profiles?
(e.g., Vanderheiden's GPII)

Ability-based design for services?

Social, relational dimensions
(e.g., people helping people)



Implicit training?
(e.g., *Input Observer*, Evans & Wobbrock 2012)

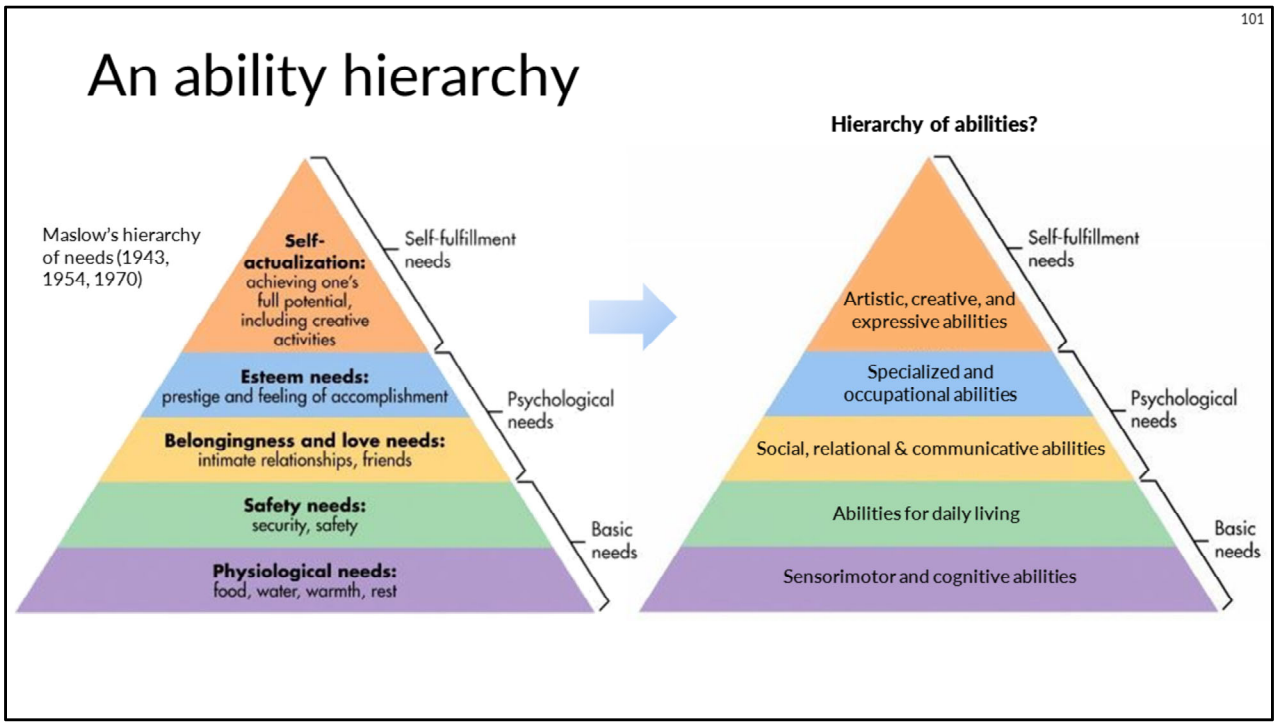
Here are some avenues for future work.

It would be great to explore *generalized* ability models, meaning models that are not specific to any particular application. Gregg Vanderheiden, who was the first SIGCHI Social Impact Award winner in 2005, is working on the Global Public Inclusive Infrastructure (GPII), which is trying to do just this (and more). Imagine if every system you ever used knew your ability profile and worked better for you because of it.

Another avenue for future work is to look at the social aspects of ability and disability, and recognize that people often help other people. Would there be ways of incorporating other users, groups of people, or communities in an ability-based fashion?

Ability-Based Design has thus far been mostly about interactive computing technologies, but could such an approach be used for Service Design? What would Ability-Based Design for Services look like?

In cases where ability models were built, a lot of explicit training was used. It would be great to get away from this, where ability models could be built just by ongoing observation of everyday technology use. There's a "cold start" problem here, but we have made some inroads in understanding human performance with another project we've done called the *Input Observer* from CHI 2012.



Everyone is probably familiar with Maslow's hierarchy of needs. It would stand to reason that for each level of need, there is a corresponding level of ability to meet that need. (Unsatisfiable needs, those that cannot even theoretically be met, are maybe not "needs" at all but wishes or dreams.)

So far we have looked mostly at sensorimotor and cognitive abilities, the lowest level of the hierarchy. VoiceDraw also enabled an artistic ability at the top of the hierarchy. And Perkinput used literacy, a communicative ability. So we've poked around this pyramid a bit today, but we could certainly explore many types of abilities up and down this hierarchy.

Earlier, you saw this vision I shared for Ability-Based Design. Well, I'd like to suggest that this is not just a vision, but a Grand Challenge. How can we make this statement true? What do we need to advance to achieve this?

"... as it always should have been."

"When society makes a commitment to making new technologies accessible to everyone, the focus will no longer be on what people cannot do, but rather on what skills and interests they bring to their work. That will be as it always should have been."

— Frank Bowe (1987)


Making Computers Accessible to Disabled People

January 1987

Finally, I'd like to close with a quote from an article in the January 1987 issue of the M.I.T. Technology Review, over 30 years ago. It was penned by the legendary Frank Bowe, a professor, activist, and one of our nation's greatest disability advocates. He was known as the "Father of Section 504," which eventually led to the Americans with Disabilities Act.

He closed his article with this: …

Notes:
https://en.wikipedia.org/wiki/Frank_Bowe
https://drmovement.wordpress.com/leaders-of-the-drm/frank-bowe/

SIGCHI Accessibility Community sigchi.org/communities/access

I want to encourage everyone in the audience to join the SIGCHI Accessibility Community, currently chaired by Jennifer Mankoff.
https://sigchi.org/communities/

Click the “Log in to Join” button there.

Acknowledgements

Shiri Azenkot, Jeffrey Bigham, Abigail Evans, Leah Findlater, James Fogarty, Batya Friedman, Jon Froehlich, Krzysztof Gajos, Mayank Goel, Susumu Harada, Alex Jansen, Shaun Kane, Julie Kientz, Richard Ladner, James Landay, Alex Mariakakis, Meredith Ringel Morris, Martez Mott, Brad Myers, Katie O'Leary, Shwetak Patel, Eve Riskin, Kristen Shinohara, Jessica Tran, and Daniel S. Weld.

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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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DESIGN USE BUILD

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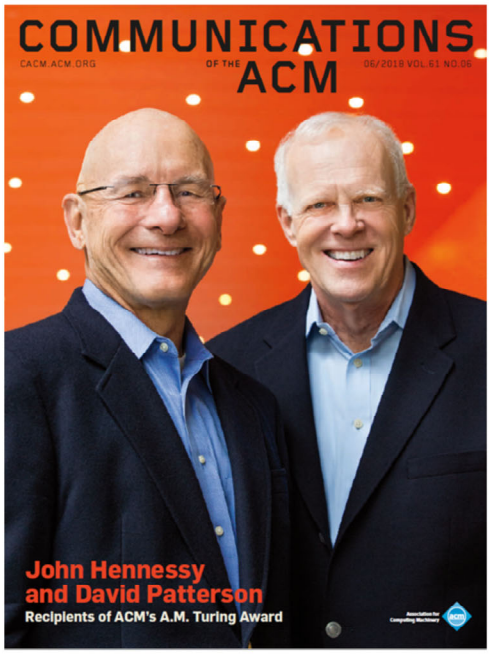
UNIVERSITY of WASHINGTON

MAD lab
mobile + accessible design

Thank you very much!

Q&A from CHI 2017:

- Meaning
- Social abilities, beyond one-user / one-machine?
- Service design?




contributed articles

DOI:10.1145/3148051

By focusing on users' abilities rather than disabilities, designers can create interactive systems better matched to those abilities.

BY JACOB O. WOBBROCK, KRZYSZTOF Z. GAJOS, SHAUN K. KANE, AND GREGG C. VANDERHEIDEN

Ability-Based Design

RECALL THE LAST time you took a trip out of town. Perhaps you were traveling to a conference far from home. Remember the many forms of transportation you endured: cars, buses, airplanes, and trains. Not only were you responsible for moving yourself over a great distance, you had to move your things as well, including books and baggage. Remember the cramped spaces, sharp elbows, body aches, and exhaustion. Feel again your desire to simply be at your destination with your possessions intact . . .

Such journeys remind us of our physical embodiment in the physical world, that much of our lived experience is fundamentally physical, and that we must contend with the world on physical terms. As computing professionals, we might be tempted to forget this, as our keystrokes summon data instantly from across the globe. But as humans, we still interact with that data through physical devices and displays using our physical senses and bodies. We and the world interact physically.

Civilization's story of technological progress is in no small part the story of an increasingly built physical environment, from the pyramids to roads to skyscrapers to sanitation systems. Much of our energy, collectively and individually, goes into moving and shaping material for such purposes, altering the physical landscape and our movement through it. Some of our most thrilling experiences come by way of changing our bodies' relation to that landscape: bungee jumping, skydiving, scuba diving, and riding a rollercoaster all provide radically new experiences for our bodies in the world.

As designers and builders of interactive systems for human use, we also play a central role in defining people's relationship to and experience of the physical world.[1,2,3,20] When we design things, we take mere ideas, things without form, and embody them in the world, whether simple sketches or cardboard mockups. They could be pixels on a screen or functioning digital devices. Regardless of the medium, to design and build things is to embody ideas that are then encountered and

» key insights

- Ability-based design is a new design approach for interactive systems that focuses on people's abilities in context, on what people can do, rather than on what they cannot do.
- Ability-based design scrutinizes the "ability assumptions" behind the design of interactive systems, shifting the responsibility of enabling access from users to the system.
- People's abilities may be affected not just by disabilities but by disabling situations; designing for abilities in context leads to more usable, accessible systems for all people.

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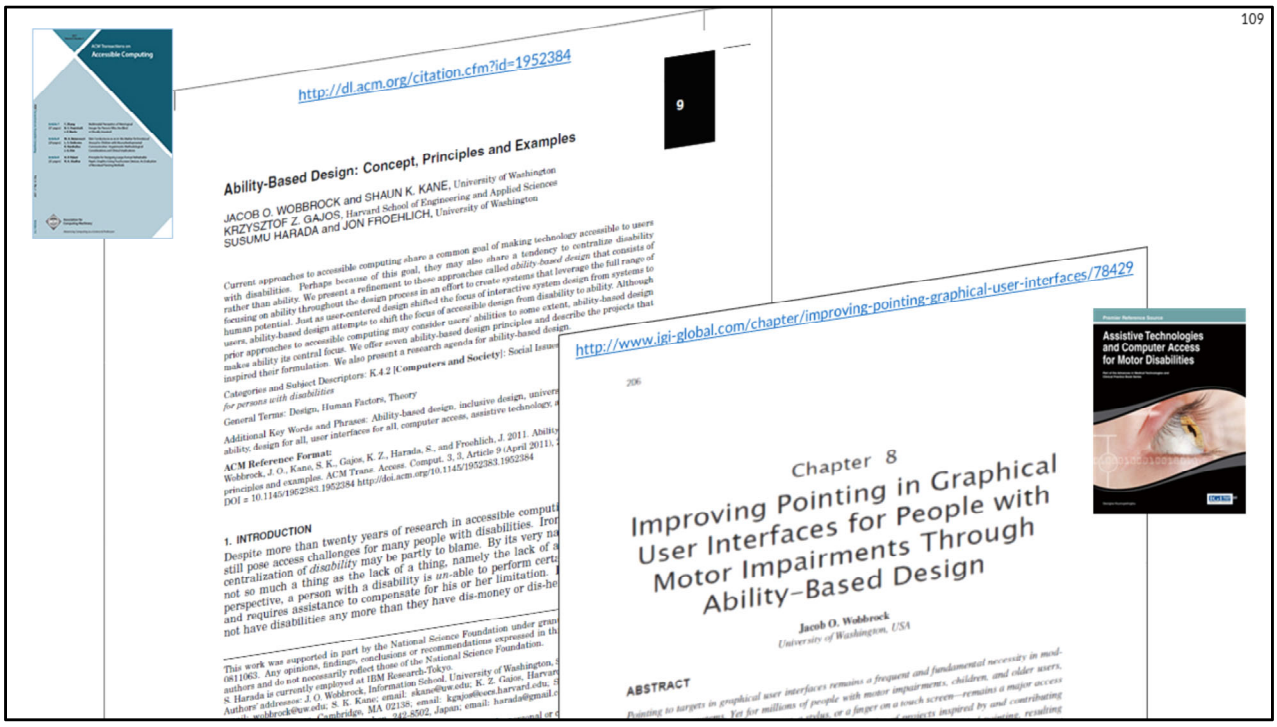
Wobbrock, J.O., Gajos, K.Z., Kane, S.K. and Vanderheiden, G.C. (2018). Ability-Based Design. Communications of the ACM 61 (6), June 2018, pp. 62-71.

https://dl.acm.org/citation.cfm?id=3148051



For anyone wanting to read more about these ideas, most are contained in our 2011 TACCESS article on Ability-Based Design and in a 2014 book chapter on applying Ability-Based Design to improving mouse pointing for people with motor impairments.

Wobbrock, J.O., Kane, S.K., Gajos, K.Z., Harada, S. and Froehlich, J. (2011). Ability-Based Design: Concept, principles and examples. ACM Transactions on Accessible Computing 3 (3), April 2011, Article No. 9. http://faculty.washington.edu/wobbrock/pubs/taccess-11.pdf

Wobbrock, J.O. (2014). Improving pointing in graphical user interfaces for people with motor impairments through ability-based design. Chapter 8 in G. Kouroupetroglou (ed.), Assistive Technologies and Computer Access for Motor Disabilities. Hershey, PA: IGI Global, pp. 206-253. http://faculty.washington.edu/wobbrock/pubs/igi-14.02.pdf