

# Supporting Learning for Individuals with Visual Impairment

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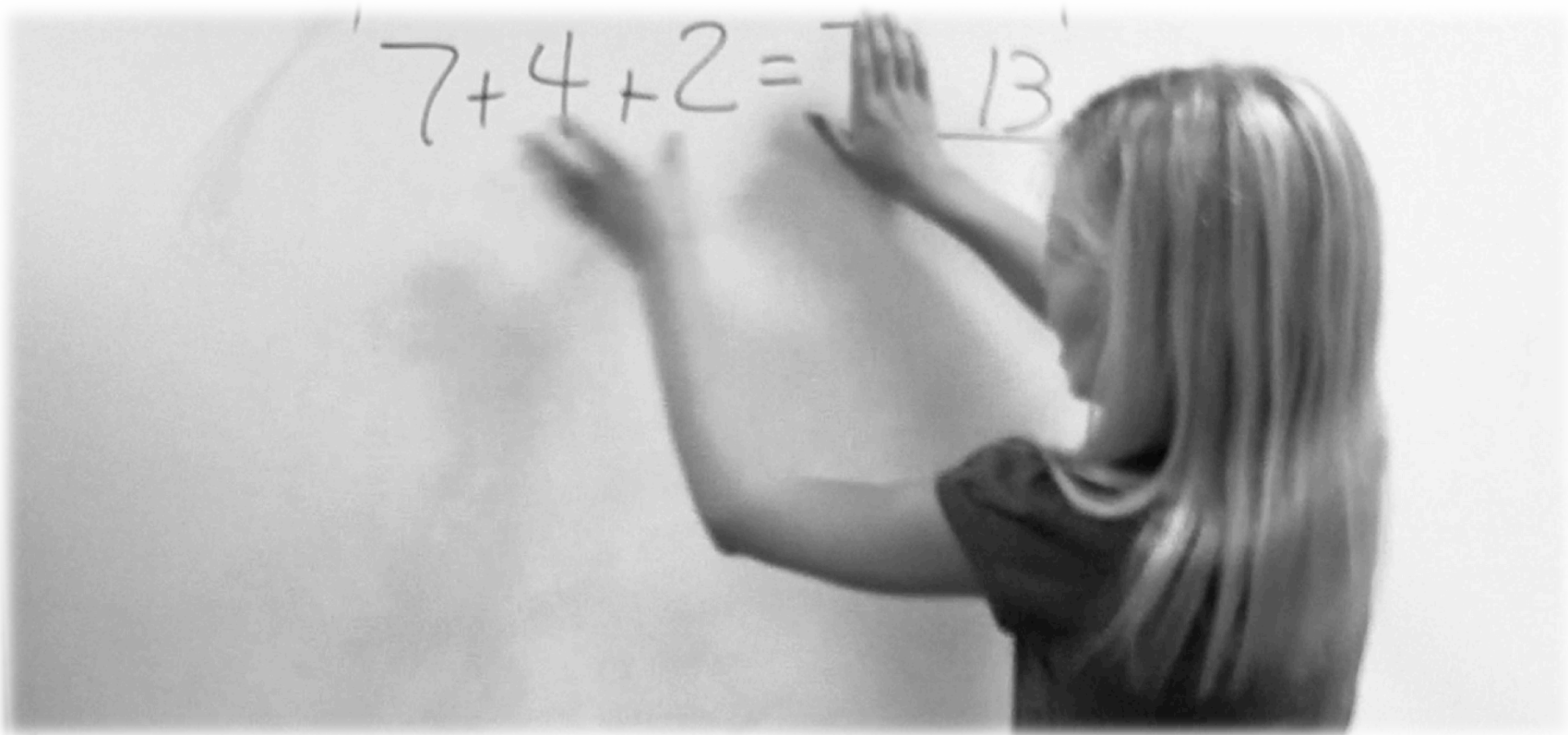


# Underlying Premise

- Humans live in a ‘cultural world’ designed for humans
- Humans are embodied beings (mind and body)
- Individuals with disability are ‘otherly enabled’ and have to overcome cultural designs grounded in expectations of embodiment



# Embodiment and Language





## Speech Example

S1 you know like those ;fireworks?

S2 well if we're trying to drive'em / out her<r>e #  
we need to put'em up her<r>e

S1 yeah well what I'm saying is we should\*

S2 in front

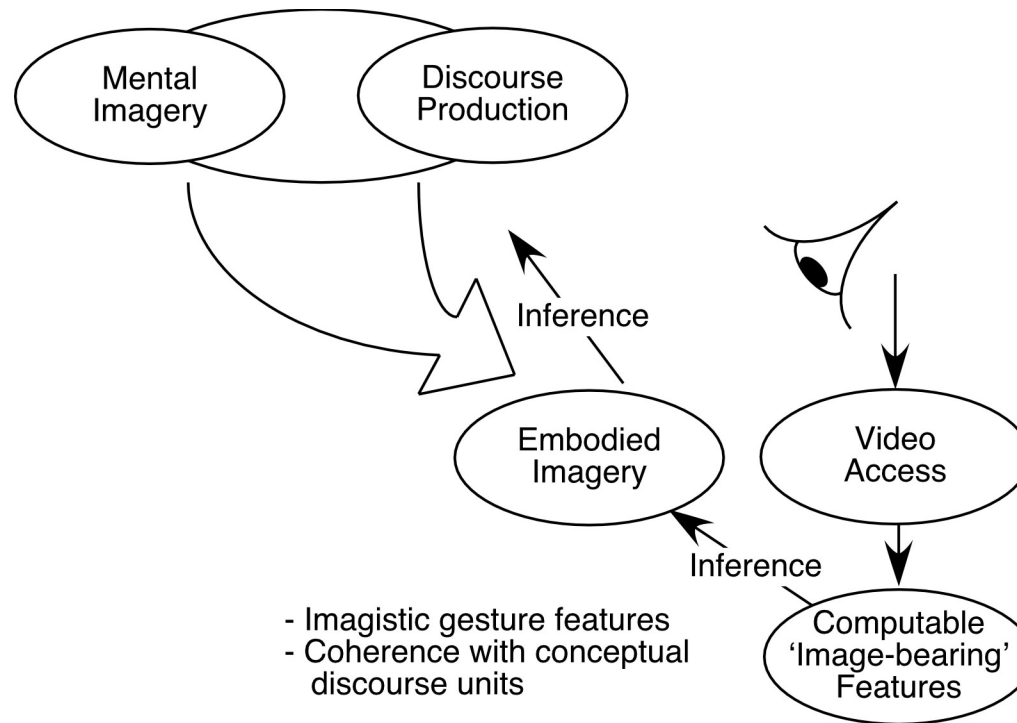
S1 we should do it\* we should make it a lin<n>e  
through the room<m>s / so that they explode  
like here then here then here then here



# Multimodal Language Example



# Co-Generation of Gesture and Speech



Gesture/Speech Framework: (McNeill 1992, 2000, 2001, Quek et al 1999-2003)



# Embodiment: Thinking and Speaking

- Embodiment shapes Language
  - Laterality of human form
  - Symmetries and oscillatory processes of human structure & movement
  - Opportunities of spatial organization
- The mind appropriates embodied processes for language and thought
- Temporal cohesion between gesture and speech reveals the unfolding of thinking and speaking



# Two-Projects

Will show impact of this thinking in 2 projects

- Supporting mathematics instruction discourse for Individuals with Blindness or Severe Visual Impairment (IBSVI)
- Developing of e-readers for IBSVI



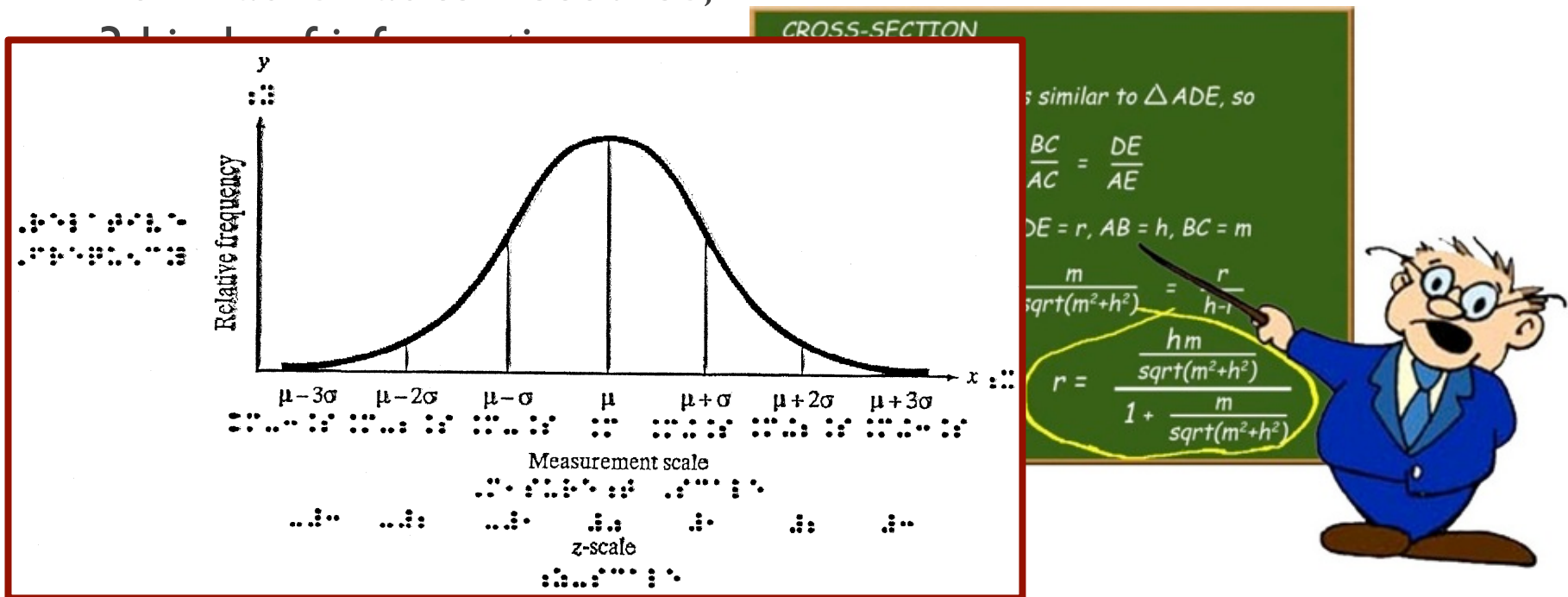


# Pointing is Gesture

- Pointing allows us to borrow space and imagery from the immediate surrounding for embodied language production
- Temporal cohesion is maintained between pointing and speech for expression of thought
- Pointing and pointing uptake must be part of expressive act, not an extraneous effortful action

# Mathematics Instruction for the Blind

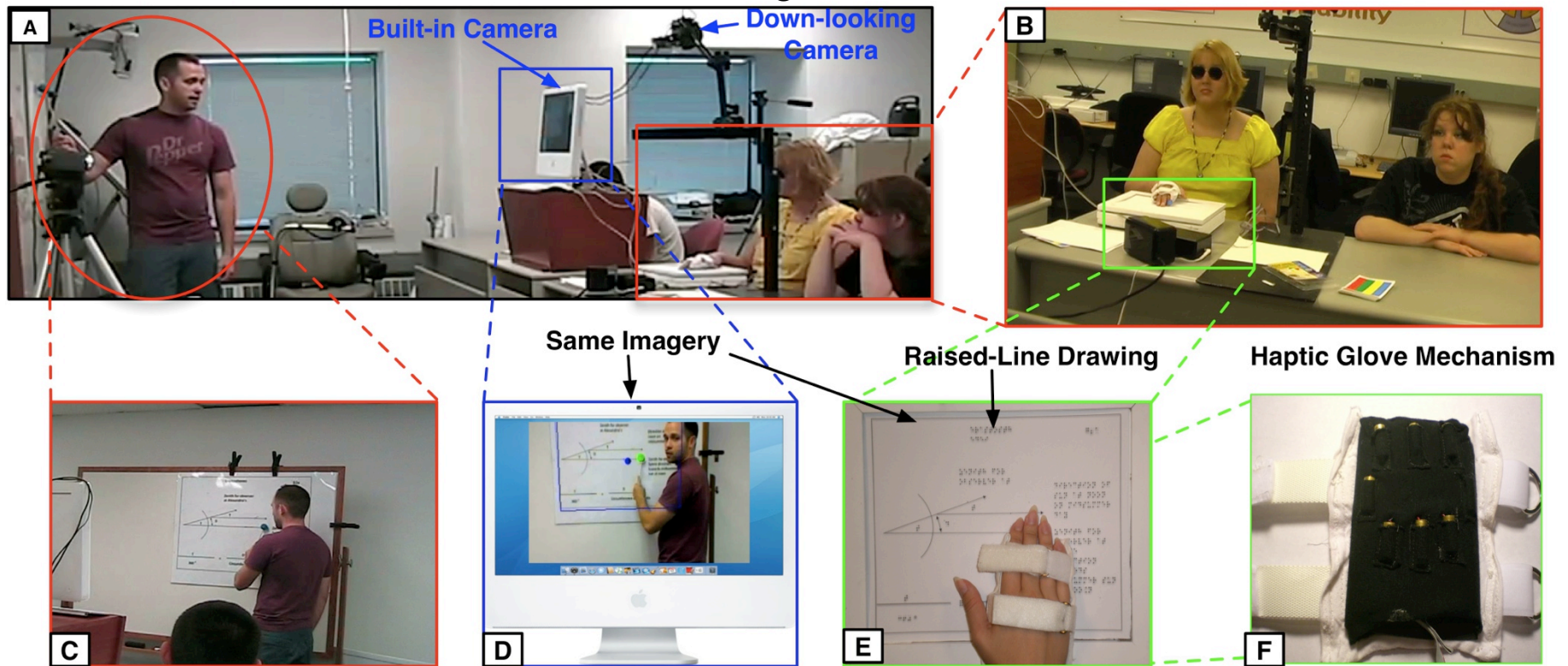
- For mathematics discourse,



Individuals with Blindness or Severe Visual Impairment (IBSVI) do not have access to this!

# The Haptic Deictic System (HDS)

Embodied Behavior Tracking



Embodiment Awareness  
for the Instructor

Embodiment Awareness  
for the Student

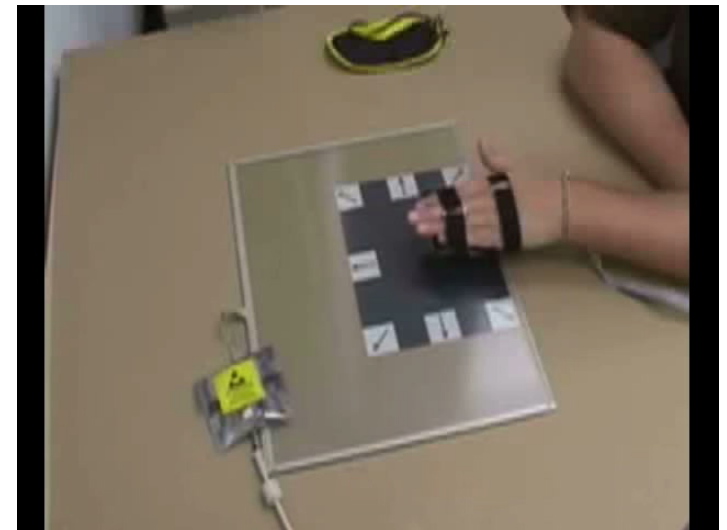


# Developing the Technical System

- **Phase 1: Haptic Glove Development**
  - Iterative design and test to produce glove design
- **Phase 2: Discourse Support**
  - Phase 2a: Developed and tested discourse support system
  - Phase 2b: Game for Embodied Skill Training
- **Phase 3: Mathematics Instruction**
  - On to Inclusive Mathematics Instruction ...

# Phase I: *Haptic Glove Design*

- Iterative Design-Prototyping-Testing
- Perception-action studies determined:
  - Glove supports navigation
  - Glove does not interfere with fingertip reading
  - User can **navigate, listen to speech & read with fingertip** simultaneously



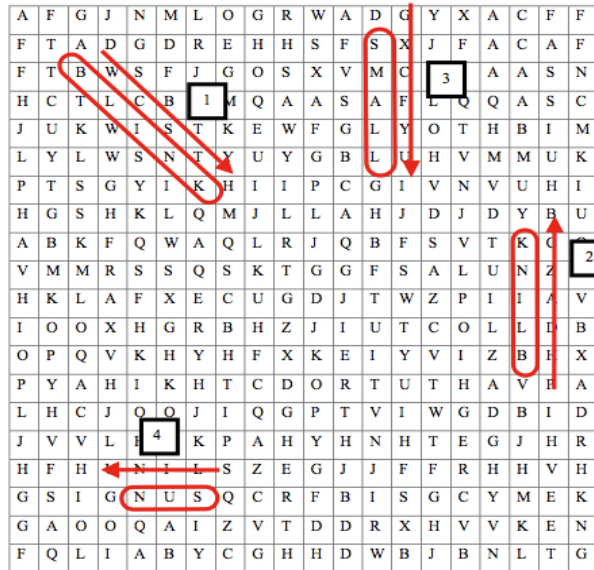
## Phase 2a: Developing Full Discourse Support System

- Full deployment of system with bi-directional awareness
- Questions:
  - Can device support fluid conversation while engaging in joint cognitive problem-solving?
  - How do users adapt to the technology?

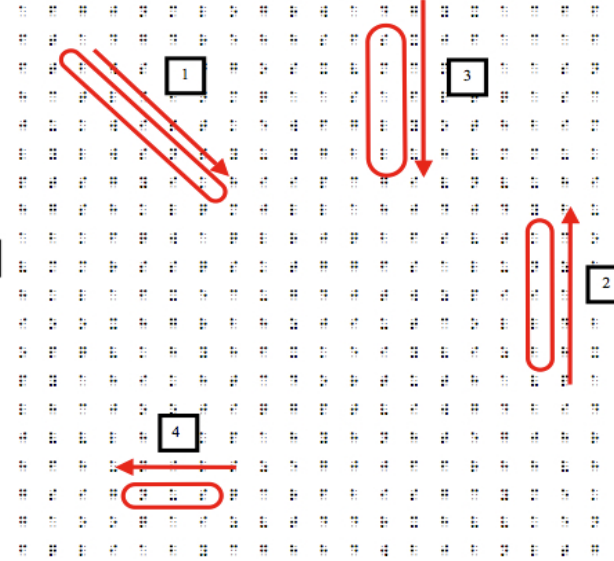




# Testing Discourse: Phrase Charade Study



Blink Blink Small Sun – Twinkle Twinkle Little Star



Blink Blink Small Sun – Twinkle Twinkle Little Star

- The guide helps the follower to solve the charade.
- The puzzle consists of well known phrases, like: “Twinkle twinkle little star” that are encoded as clue phrases like “Blink blink small sun”.

# Early Charade Study

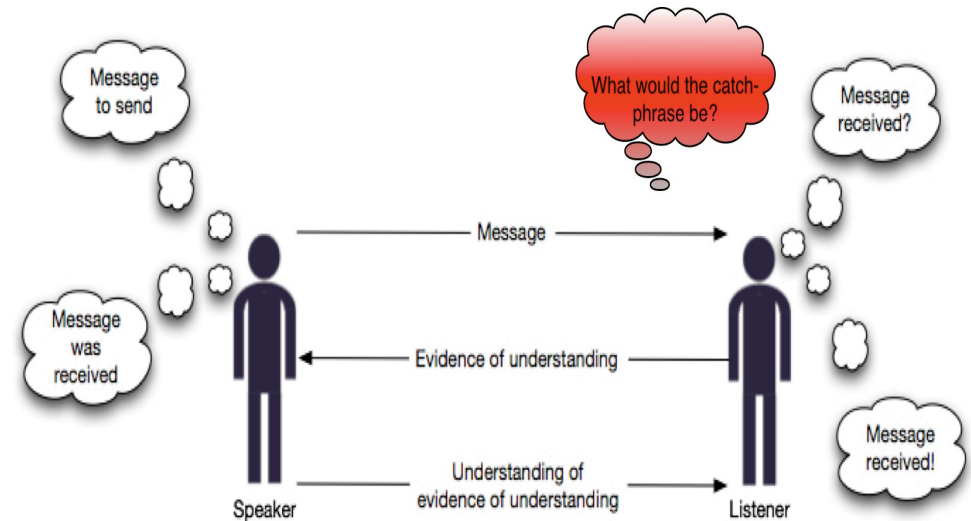


Figure based on Clark's Common Ground Theory

- Subjects could solve puzzle
- One third of the discourse time was about the interaction (device, navigation instruction etc.) and not on the problem



# Phase 2b: Game Engagement as Training

**Training while having fun**  
**A game for the blind**

This is Agent Smith of the Agency of Impossible Missions (AIM). Your services are needed at this time. Dr. Evil has stolen all of the launch codes of our nuclear arsenal. With such codes he can destroy any city in the world. Your mission, if you decide to accept it, is to disarm the launch sequences as they are detected. The first launch sequence detected is for New York City. You have 2 minutes to find the codes and disarm them. Go!

## Approach:

- Game to encourage skill acquisition
- Computer game & stationed it at the Office for Disabilities Services at Wright State University

## Results:

- Improvements for all participants
  - 45% - 62% speed increase
  - Increase in accuracy as the game became more difficult
  - All 5 reached level 2, 3 got to level 3
- Long durations of use:
  - No desensitization detected
  - After game sessions of 30-60 mins, participants said they could play 45 mins or more longer



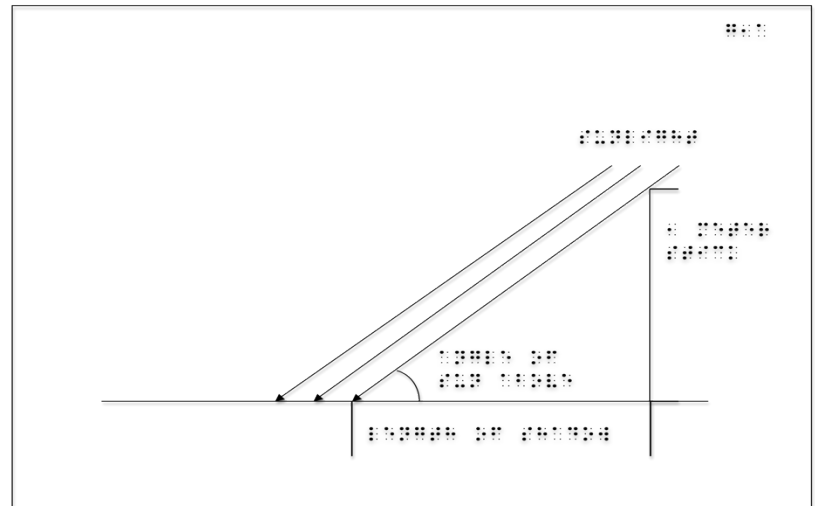
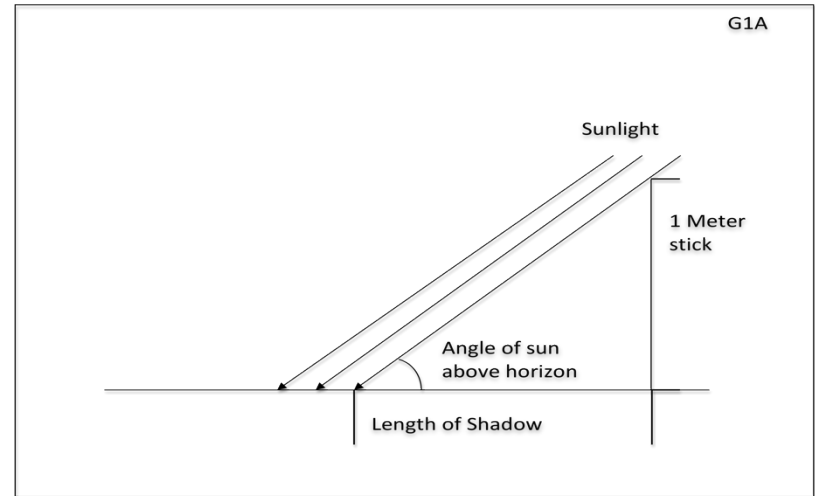
## Second Phrase Charade

- Participants solved charade 3x faster
- No discussion of technology
- No reference to pointing task itself
- All discourse was directed at problem and playful speech



# On to Mathematics Instruction

- Two 3-session curricula
  - (A: Eratosthenes computation of Earth radius & B: Trigonometry)
- Participants grouped in all sighted and inclusive-instruction classes



	Curr. A (T1)	Curr. B (T2)
Sighted	s16, s17, s18, s19	s20, s21, s22, s23
Blind w/ System	b1, s1, s2, s3 b2, s4, s5, s6	b3, s7, s8, s9 b4, s10, s11, s12 b5, s13, s14, s15
Blind w/o System	b3, s7, s8, s9 b4, s10, s11, s12 b5, s13, s14, s15	b1, s1, s2, s3 b2, s4, s5, s6



# Situated Language Analysis

- To determine ‘opportunity to learn’
- David McNeill’s Growth Point Analysis:
  - Whether instructor & student are able to share the same ‘idea unit’
  - Student’s hand may arrive **during** idea unit, or **at transition** before next unit
- Herbert Clark’s Common Ground (*Presentation-Acceptance Model*)
  - CG based on **Evidence** (*Immediate co-presence*) or **Assumption** (*Locatability assumption*)
  - Three conditions: **R**esolved, **U**nresolved, **P**robably Resolved

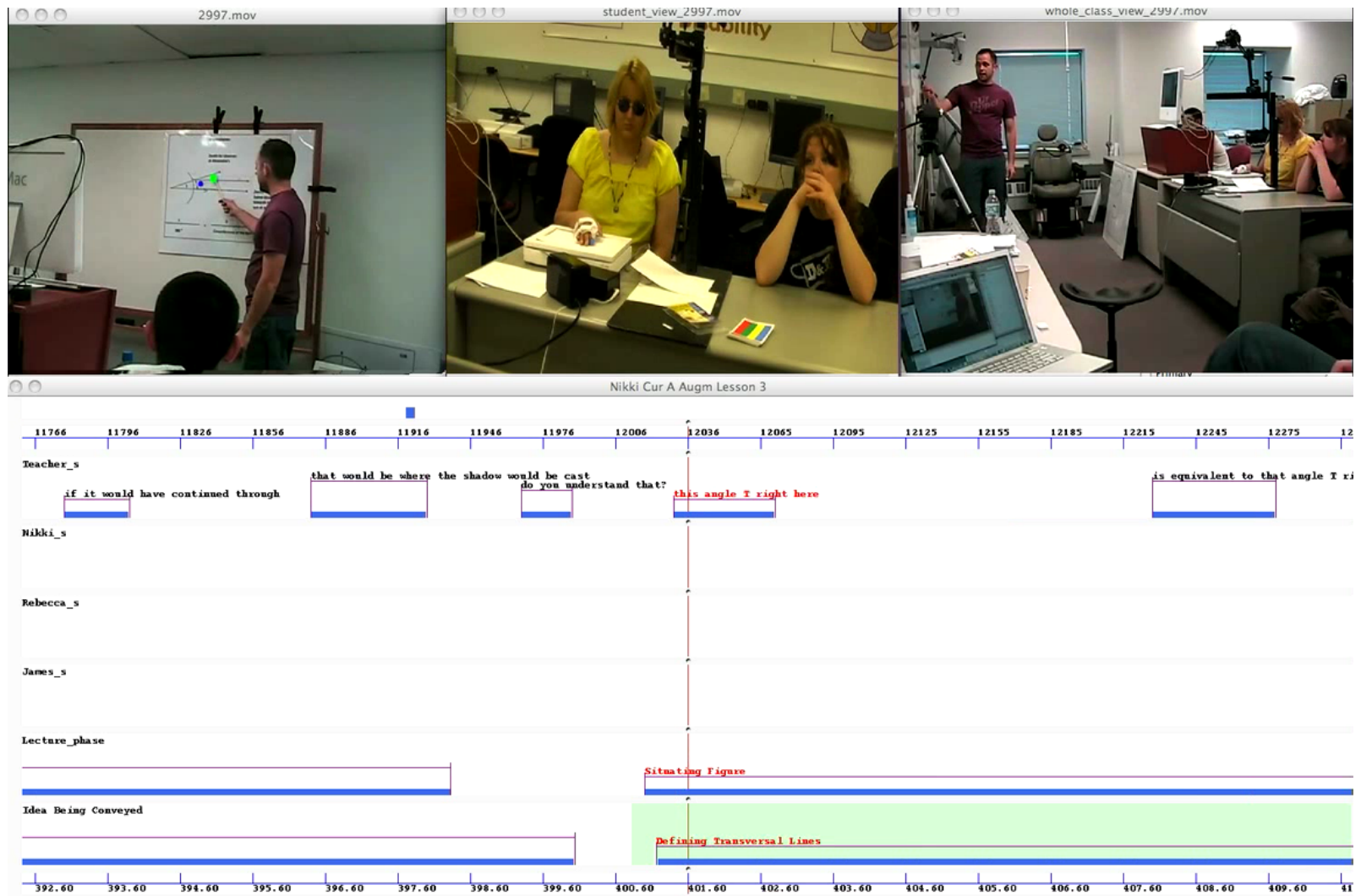


# Summary of Lecture Fluency Measures

Measure	A+B	A	B
Words per Turn (WPT)	Fewer words per turn w/ HDS (Sig. Diff)	Fewer words per turn w/ HDS (Sig. Diff)	Fewer words per turn w/ HDS (Trend)
Duration of Instructor's turn (DIT)	Inconclusive	Inconclusive	Inconclusive
Hand Positioning Events (HPE)	Fewer HPE w /HDS (Sig. Diff)	Fewer HPE w /HDS (Sig. Diff)	Inconclusive
Focus on lesson's objectives (TLO)	<b>More</b> focus w/ HDS (Trend)	<b>More</b> focus w/ HDS (Sig. Diff)	<b>Less</b> focus w/ HDS (Sig. Diff)
Deictic expressions (DE)	<b>More</b> deictic expressions w/ HDS (Sig. Diff)	<b>More</b> deictic expressions w/ HDS (Sig. Diff)	<b>More</b> deictic expressions w/ HDS (Sig. Diff)



# Inclusive Learning Setting with HDS



# Inclusive Learning Setting without HDS



Cur A non Augmented Olivia Lessons 1, 2 and 3





# Results Summary

## ■ Situated Analysis

- Both Growth Point & Presentation-Acceptance analyses show IBSVI have opportunity to learn (access to relevant material)
- Both show opportunity depends on communicative skill of instructor

## ■ Fluency Analysis

- Data shows fluency improvement
- Fluency gains depends on instructor's skill





# Inclusive Mathematics Instruction for the Blind

- Collaborative across HCI, CS, psycholinguistics, special education
- Demonstrated importance of gesture uptake
- Developed analysis techniques to assess opportunity to learn
- All parties in inclusive classroom benefit:
  - Students with Blindness or Severe Visual Impairment: Access, decreased self-awareness
  - Sighted students: pace of class, overall instruction
  - Instructor: classroom awareness, feedback, pacing



## Conclusion

- Humans appropriate embodied resources for language and thought
- Pointing (deixis) is an important species of gesture
  - Pointing allows us to borrow space and imagery from the immediate surrounding for embodied language production
  - Temporal cohesion must be maintained between pointing and speech
  - Pointing and pointing uptake must be part of expressive act, not an extraneous effortful action
- In IBSVI pointing uptake must be sufficiently automatic
- Demonstrated Haptic Deictic System that supports mathematics instructional discourse
- Presented analysis approaches to assess opportunity to learn
- All parties benefit

# E-Reader for the Blind

(STAAR: Situated Tactile Audio Annotator and Reader)

- Books and pages are information design for embodied humans with visual spatial ability
- Walter Ong (1982) literature designed for aural consumption is fundamentally different from current literature
- Since Guttenberg, visual layout has become the dominant organizational structure

## look who's talking

# JASMINE LEE

AUSTRALIA'S RUBIK'S CUBE CHAMPION  
EXPLAINS THE METHOD AND MADNESS BEHIND  
THE WORLD'S MOST FRUSTRATING PUZZLE



**"People who get under 15 seconds would know 100 algorithms just for the last layer. I know about 30."**

### What time do we need to beat to become world champion?

The official fastest time is just under 12 seconds and that's a lot faster than me. But it's not like you just go up there and do it once, there's a whole round of grand slams that you have to get through first, so it's about consistency.

### Twelve seconds. A freak. How far behind the Freak are you?

[Laughs] My best time is 23 seconds.

### So do competitors try to hobble each other's hands at competitions to get an edge?

People want to win, but one thing I found at my very first competition was that everyone was also very friendly and wanted to show each other their algorithms and tricks. Even the day of the comp, the top two people in the world will be telling each other their secrets and algorithms — it's all very friendly. I think they're so happy about just being able to talk about cubing with another person.

### What the hell is an algorithm?

It's a sequence of moves. So, just say you have done a third of the cube and you want to finish it by swapping all the edges, there are a series of set moves, algorithms, that can do that without stuffing up the rest of the cube.

### What do tube passengers think of you fiddling with a suspicious device on your way to work?

They just ignore me. It's like it's not happening. I would be happy to talk about it if anyone wanted to. I'll do it in the pub a lot too.

### Shouldn't you have a beer in your hand?

I drink wine. And I can do it with one hand.

### Is it addictive? I mean, do you find yourself fiddling with something else if you don't have your cube with you?

[Laughs]

### What?

No, nothing. I think the sort of person who is into cubing is also going to be into finger tricks. Like, you know, those people who spin pens around their fingers and stuff? And also, you'll find a lot of cubers are musicians.

### According to my calculations, professor, there are a quintillion different variations to the cube. So what's the shortcut?

There are actually 43 quintillion variations.

### Yeah, that's what I meant. Quintillions.

And there are loads of different ways of solving it, so, to get faster, you need to learn lots of algorithms and you need to have really fast fingers. The people who get under 15 seconds would know 100 algorithms just for the last layer. I only know about 30.

### What's your favourite type of cube?

The standard, original three-by-three model

has to be my favourite. I can do most of the other puzzles as well, like the magic and the clock and the four-by-four cube and the five-by-five. Most cubers can do them all.

### So what's the lamest one?

I reckon the Rubik's Magic. It was known as Rubik's Link The Rings in Oz. You know, that one that's flat and has rings that you have to link?

**Yeah, that one is shit. I got it for Christmas once, in about 1987, and broke it in five minutes. Cheap fishing wire all tangled up over the Christmas wrapping it came in. Bitch of a thing.**

Yep, yep, that's the one. That's the lamest.

### Has anyone painted each side of their head a different colour for the comps?

No, nothing that crazy. But I'm thinking of painting each of my nails different colours for my next comp.

### Have you ever been tempted to just peel the stickers off and rearrange them?

Of course, because when you're a speedcuber the stickers wear out really quickly so you have to replace them. Like, I just had to replace all my orange stickers because that's the colour that wears out the fastest. I don't know why.

### Come on, you know what I mean. Tell us about cheatin'.

No. Never.

### Thrown one across the room?

No.

### What's with the Hamleys toy store gig tomorrow?

It's in celebration of the 25 year anniversary of the cube and I'll be appearing with the UK speedcubing champ, Dan Harris. We'll be doing demos and stuff and maybe having a competition.

### Are you going to kick his arse?

No, he's a lot faster.

**We'll get you up there. We'll spike his drink.**  
He doesn't drink alcohol.

### That's the point.

— SEAN MAHER  
Rubik's Cube's 25th birthday is at Hamleys, 188-196 Regent St, EC1, on Tuesday, July 26 from 10am. A special Rubik's cake and party will be on offer.

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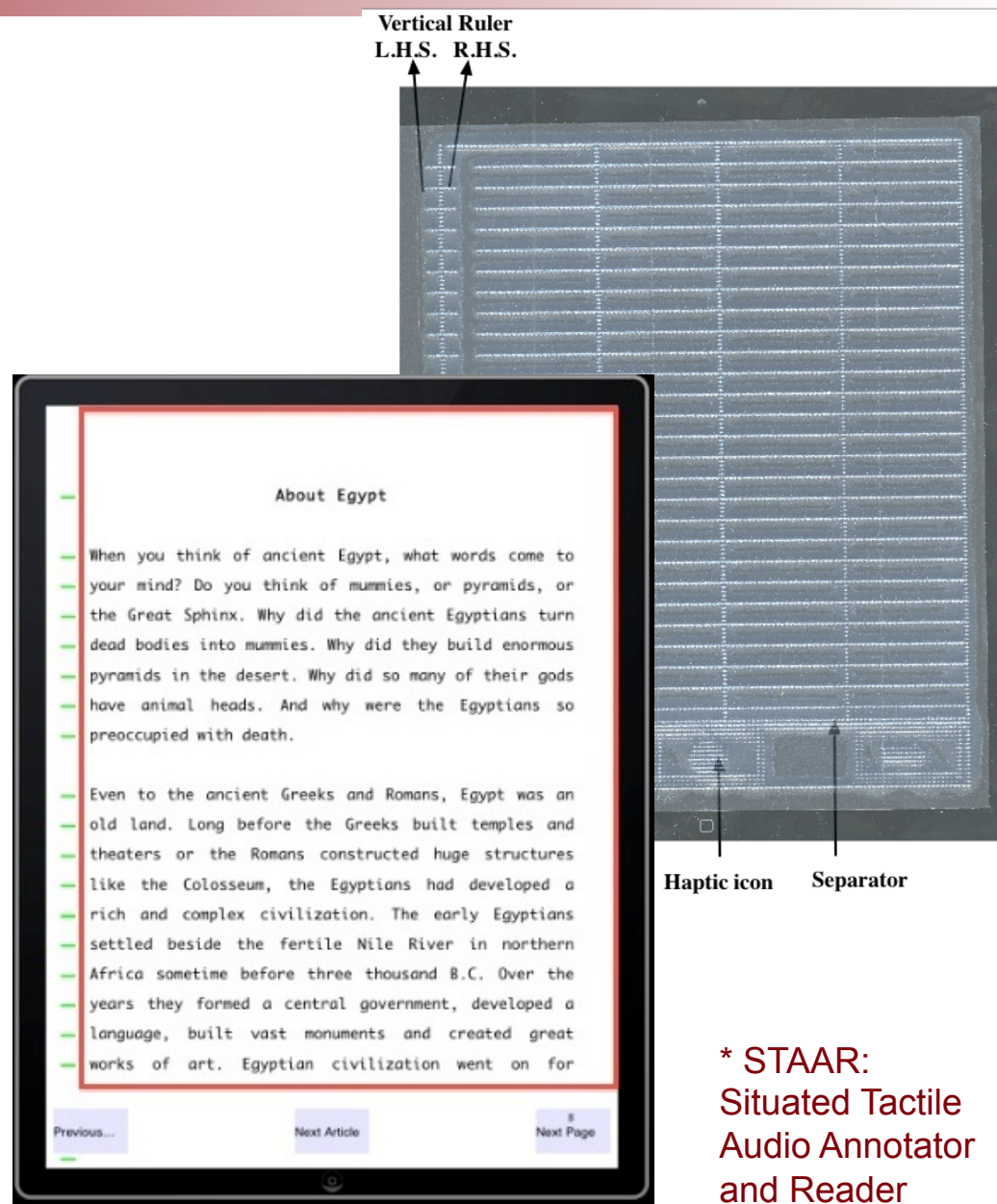
# Reading for IBSVI

- State-of-art
  - Braille – literacy and portability problems
  - Audio Readers – obliterates space
- Visually-dominant technology threatens to widen the gap

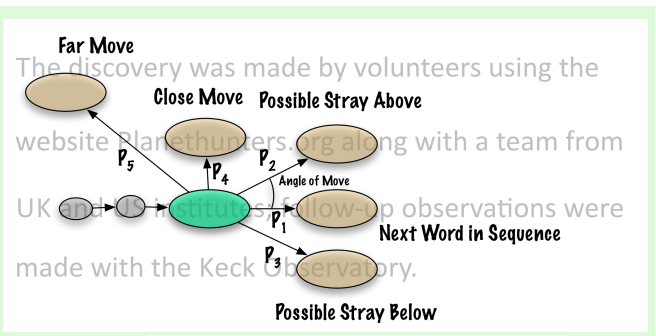
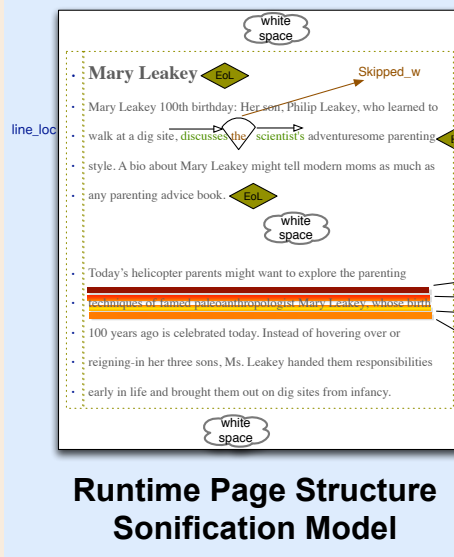
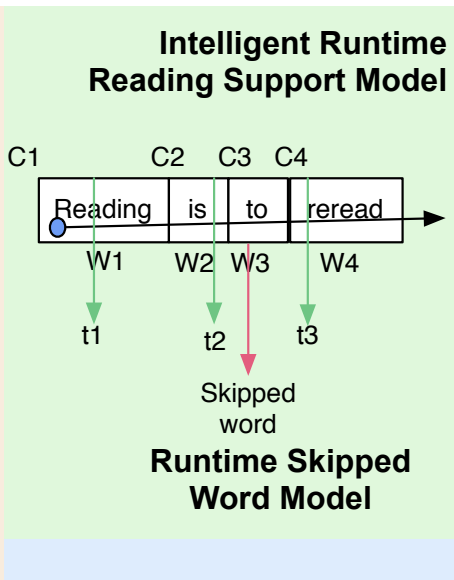
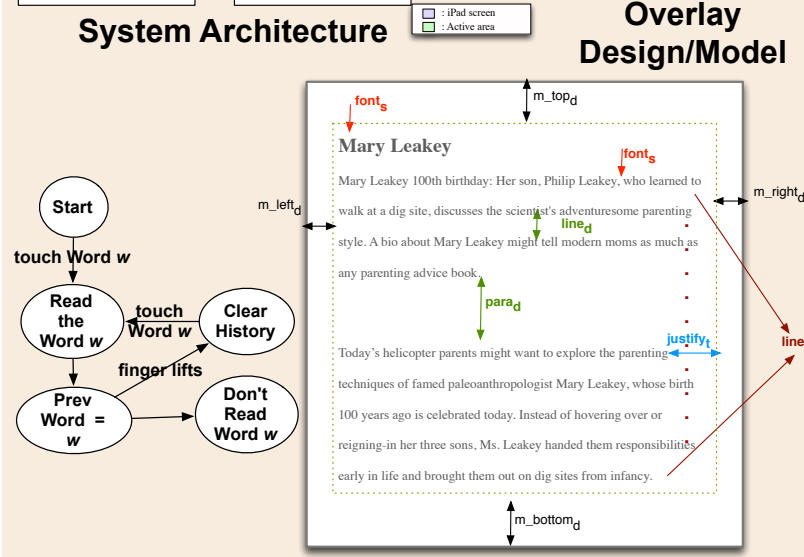
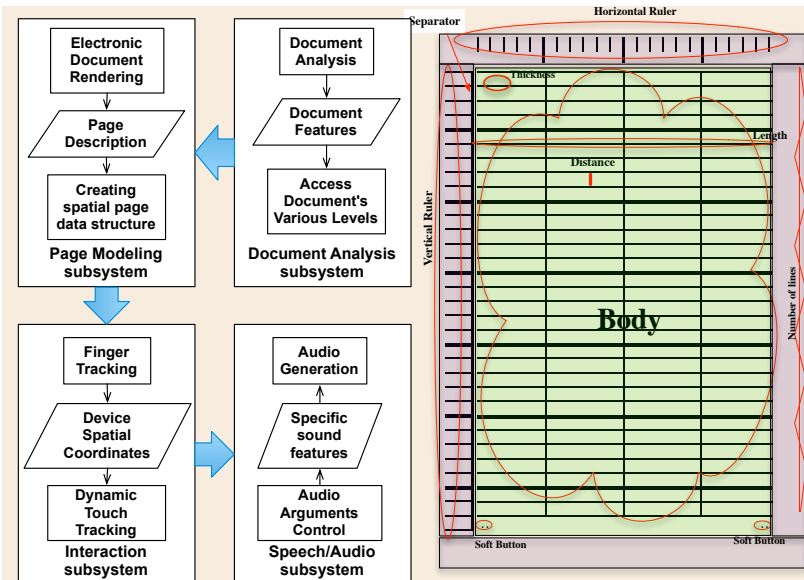


# STAAR Reader

- STAAR augments *iPad* with tactile overlay for landmarking
- Text is read as it is touched
- User fuses spatial (touch) and aural (words sounded) information
- STAAR supports self-paced active reading and re-reading
- The devil's in the design details

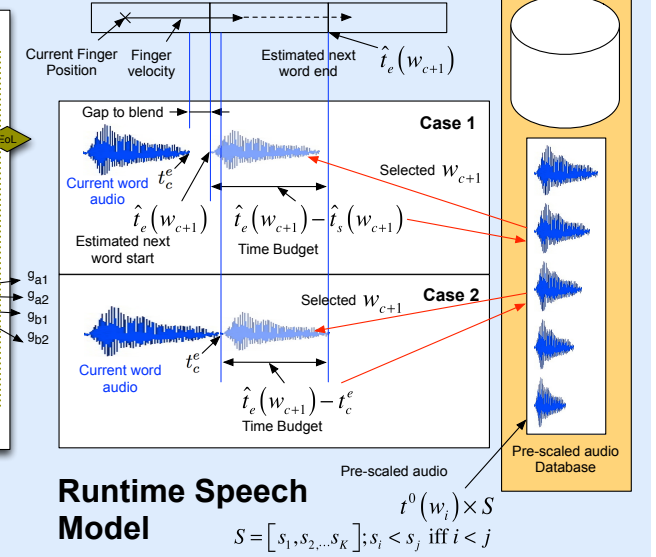


# Models and Systems



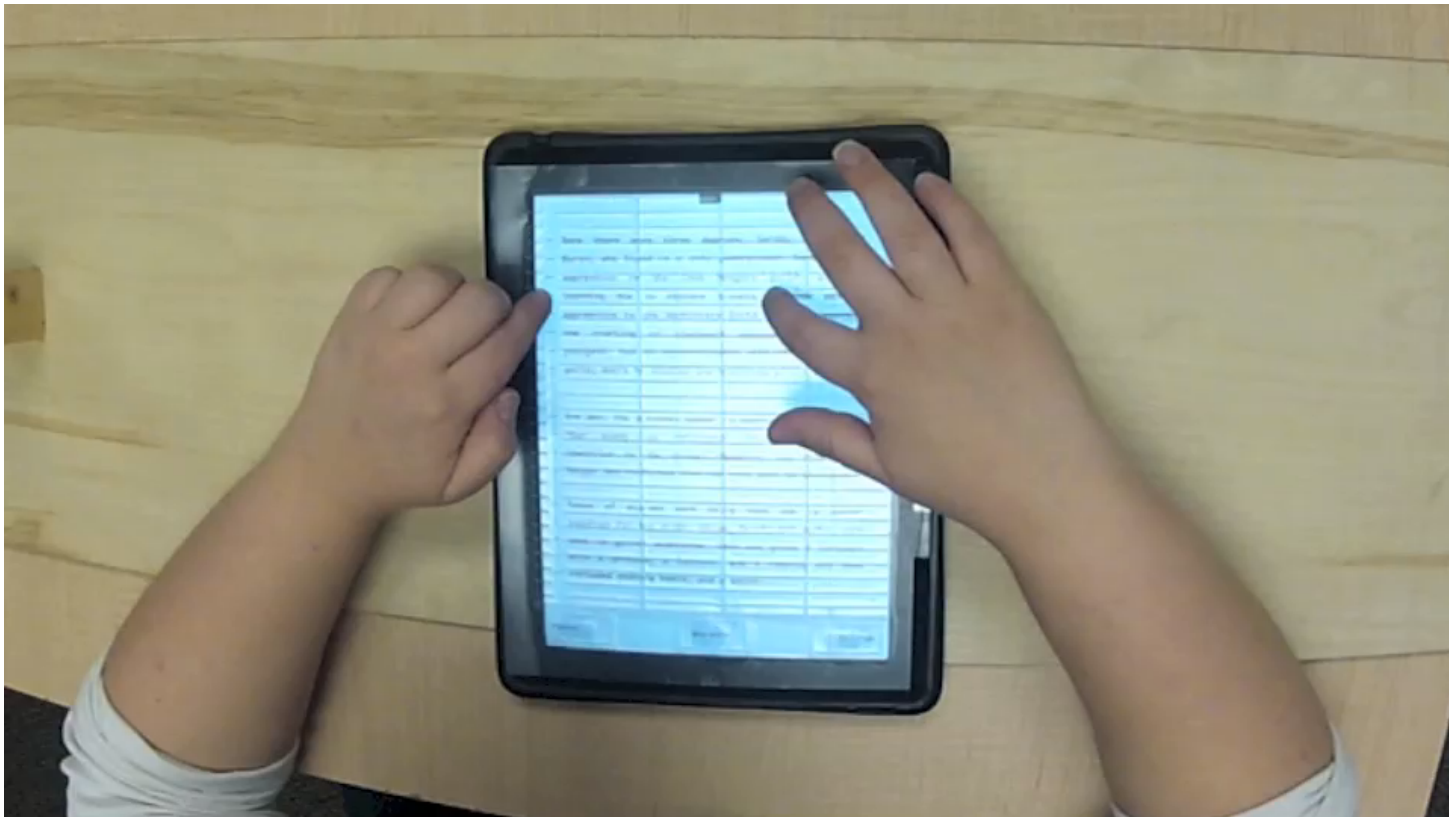
The discovery was made by volunteers using the website [Planethunters.org](http://Planethunters.org) along with a team from UK and US institutes; follow-up observations were made with the Keck Observatory.

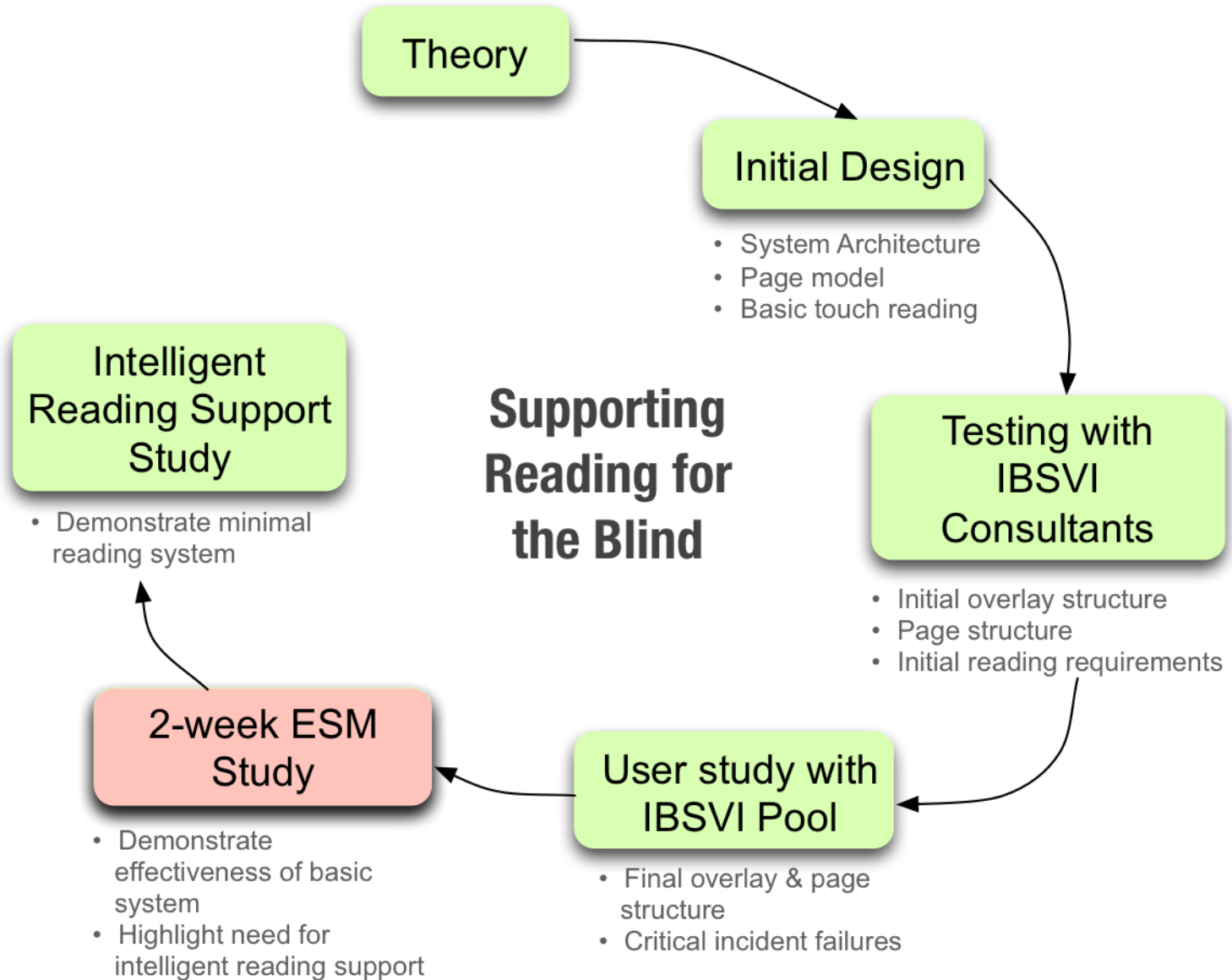
Above line sonic gutter level 2  
 Above line sonic gutter level 1  
 Below line sonic gutter level 1  
 Below line sonic gutter level 2





# STAAR with Overlay









# Line Straying Problem

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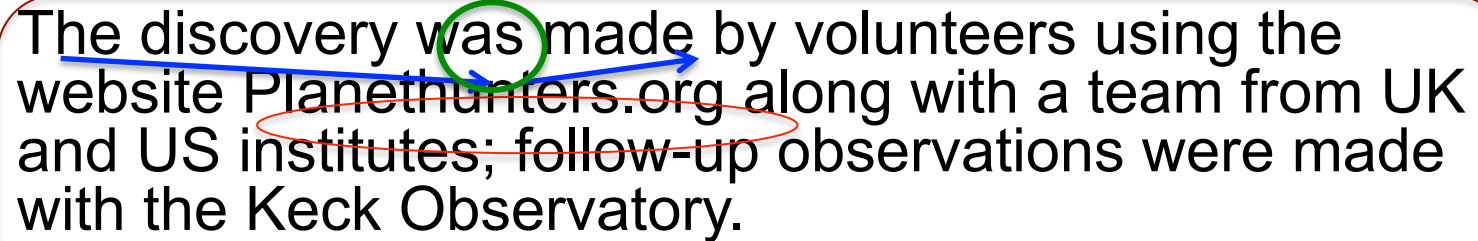
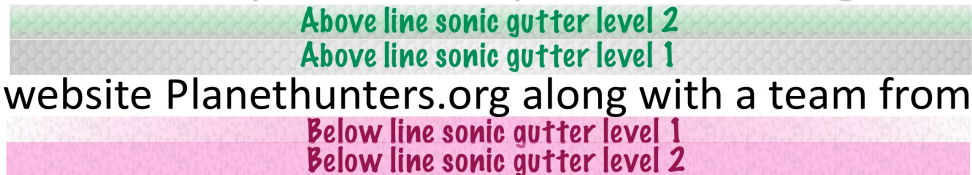


Illustration for the line straying problem.

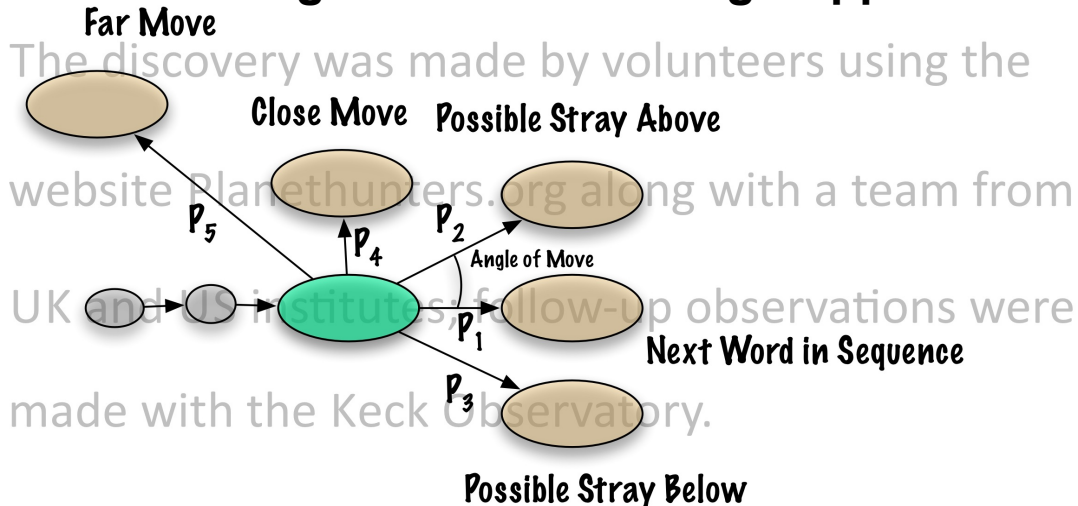
# Reading Support

## Sonic Gutter

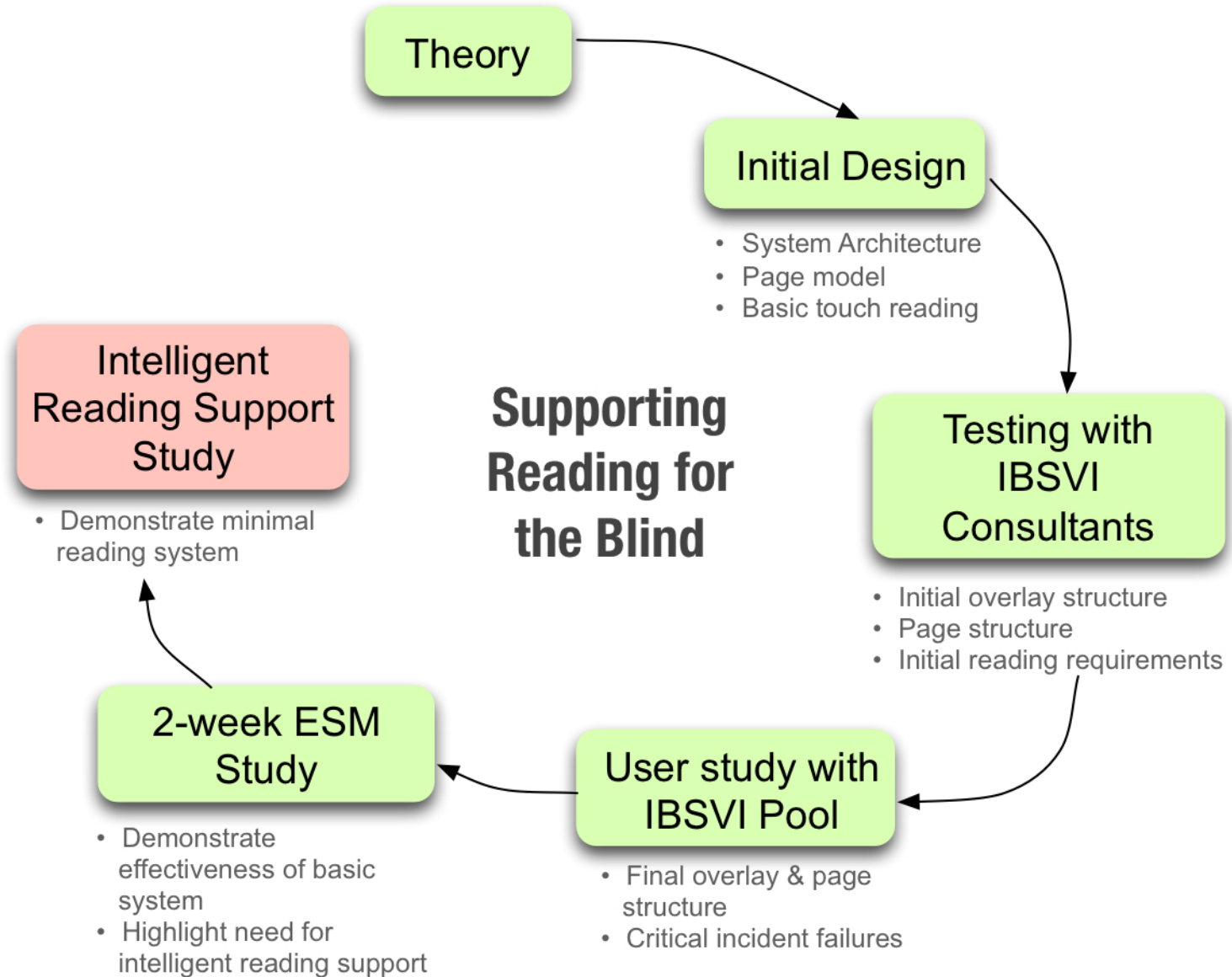
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## Intelligent Active Reading Support



**Effect:**  
**Dynamically**  
**fatten the line**  
**being read**





# Intelligent Reading Support Study

- Goals are to evaluate:
  - *Effectiveness*: Ability to answer questions
  - *Efficiency*: Reading & Re-finding time
  - *Spatial perception*: Page structure understanding
- Within subjects 2x2 study design:
  - Overlay (with or without)
  - Active Reading Support (Simple or Intelligent)
- Participants:
  - 10 IBSVI: ages 18 to 77,  $\mu = 50.8$  (SD=15.75) 5 F, 5 M
  - Total Blind: 6; Born visually impaired: 7; Legally blind: 4
  - 8 participants read Braille, 2 have touch devices
- Data was collected via:
  - Experiment video
  - Post-experiment questionnaire



# Intelligent Reading Support Study: Results

- In all three:
  - *Efficiency* (reading speed, refind time)
  - *Effectiveness* (question answering)
  - *Preference* (confidence in reading, ease of use)
- Overlay + Intelligent ARS:
  - Minimal effective design configuration
  - Outperforms Sonic Gutter and Basic STAAR system ( $p < .05$ )
- Page Structure:
  - STAAR supported effective strategies for page structure understanding (e.g. semantic idea identification, short lines, spatial exploration)



## Summary: *E-Reader for the Blind*

- Reading is not the same as interaction
- Stepwise incremental approach allowed us to determine the minimal effective design
- Details of design choices and implementation are critical to the success of the system
- Spatial access to the page enables self-paced reading: comprehension, refinding, page-structure



## Conclusion

- Recognition of challenges faced by IBSVI owing to cultural design and expectations uncovers rich research opportunities
- Research begins with understanding these challenges with the help of members of the target population
- HCI, disabilities and technology research must be tightly linked
- Research needs to go the extra step of careful validation with IBSVI population



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