Cognition in visualization

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Englebart quote

“Visualizing Argumentation 2003”

“ For five decades I have been driven by an intuitive certainty that computer supported argumentation could increase humankind's collective problem-solving capabilities to a degree that was (is) greatly unappreciated, and that its explicit pursuit should become one of society's high-priority, ‘grand challenges’."

http://opencourse.org/Collaboratories/eh/eh-wiki/FrontPage

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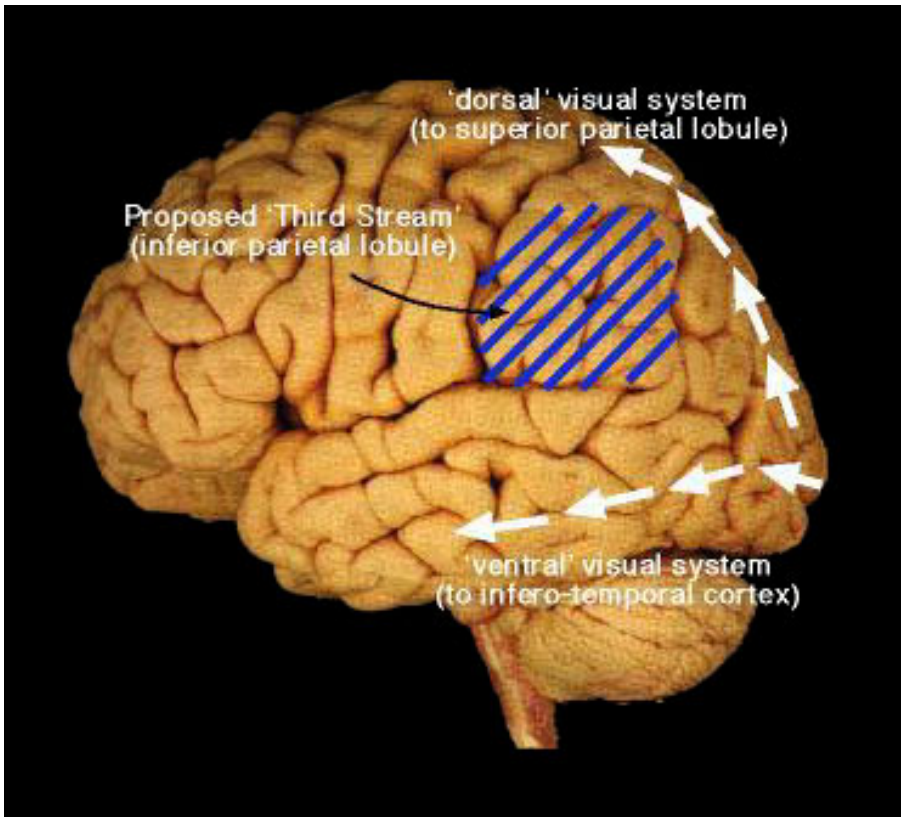
NVAC Recommendation

- **Develop a supporting science (theory and models) for visual analytics.**

This science must be built on integrated perceptual and cognitive theories that embrace the dynamic interaction between cognition, perception, and action. It must provide insight on fundamental cognitive concepts such as attention and memory. It must build basic knowledge about the psychological foundations of concepts such as "meaning," "flow," "confidence," and "abstraction."

Moore’s law and human evolution

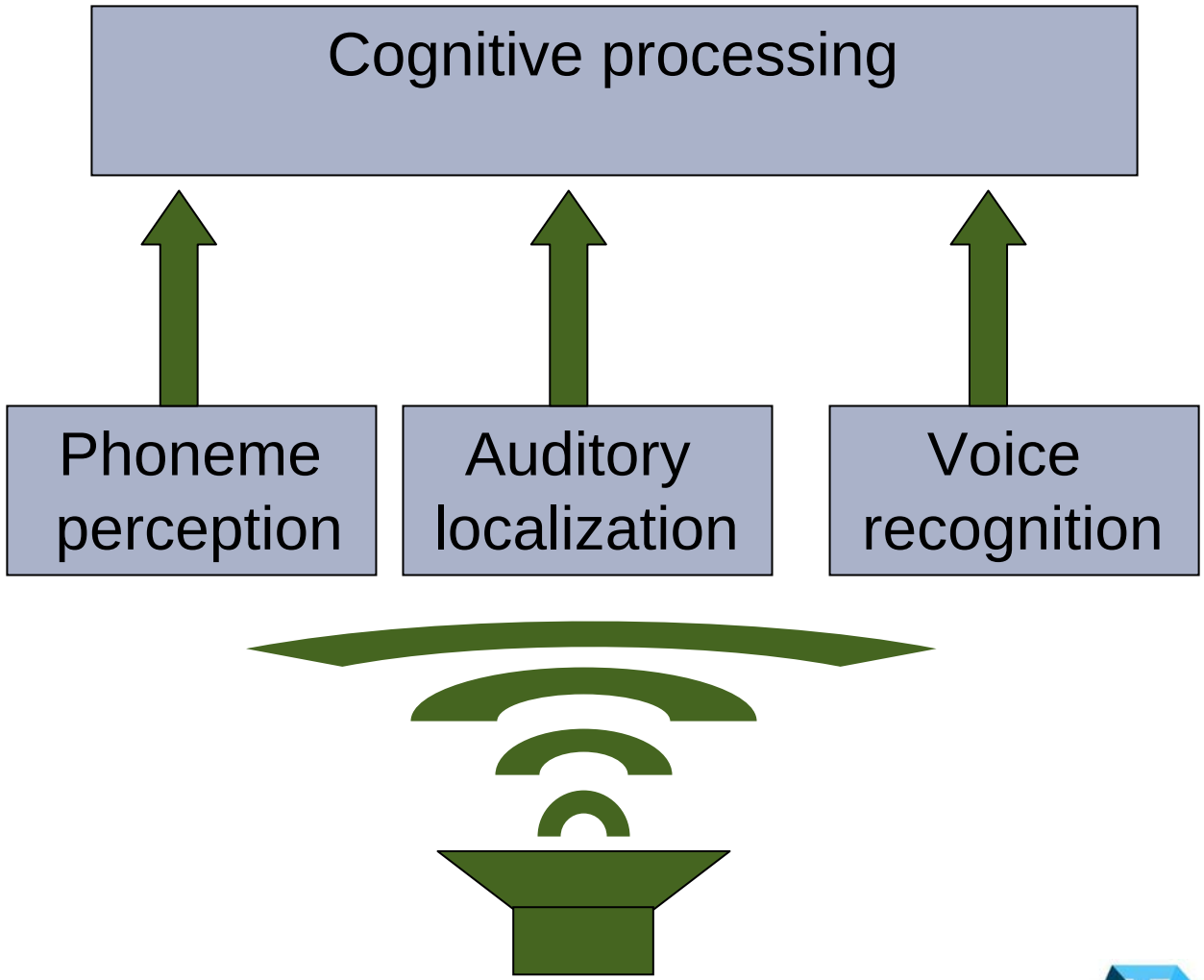


- Transistor density doubles every 18 months
- Disk density doubles every 12 months
- Brain volume doubles every 3 x10^7 months

My View

- Mine Psych/Cogsci literature, techniques
- Understand Cognitive Architecture
  - Cross modal effects
  - Perception in scenes, not labs
  - Perception/action/cognition loops
- Parameterize CA for individuals to tune for
  - Age
  - Expertise
  - Culture…
- Study effective interaction… wherever

Cognitive Architecture example (Fodor)



Cross-modal Speech Perception

QuickTime™ and a
Cinepak decompressor
are needed to see this picture.

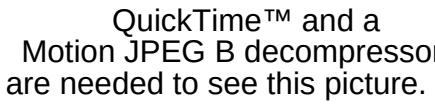
The McGurk Effect: McGurk & MacDonald 1976

Illusory Conjunctions in Multimodal Environments

Example: Movie theatre

- The McGurk effect (face influences sound)
  - Dubbed movie
- The ventriloquist effect (vision captures sound location)
  - Sound seems to come from actor

Shams, Kamitani, & Shimojo 2002



Shams, Kamitani, & Shimojo 2002

QuickTime™ and a
Motion JPEG B decompressor
are needed to see this picture.

Look at cross-modal effects, adaptation

- Individual senses adapt to display
- Sensory modalities calibrate each other: haptics, vision, sound
  - Observed actions calibrate visual space (space constancy)
  - Vision calibrates hearing for the location of a multimodal event
  - Sound calibrates vision for the time of a multimodal event
- Result is an after-effect: remapping of auditory (visual, haptic) space
- Recalibration by pairing (Epstein, ‘75)

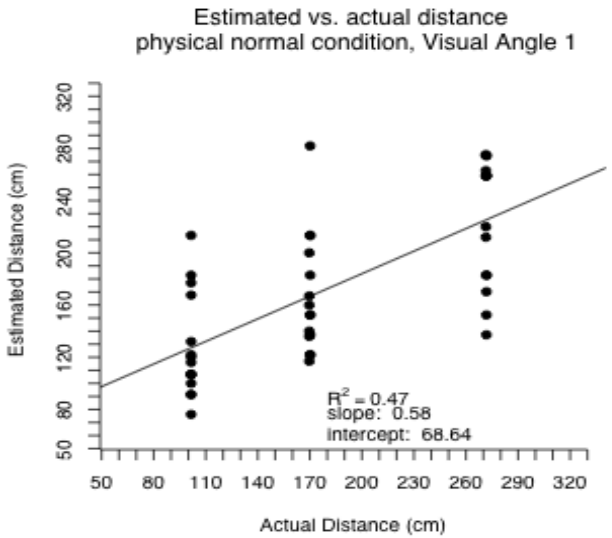
Immersive CAD

- Collaborative CAD (D.Kasik, Boeing)
  - "We want to derive more value for 3D model data outside engineering to minimize rework and maintain version consistency. Examples: 3D for assembly instructions, animation for maintenance procedures, bids from suppliers."
- Design review (R.Smith, GM)
  - "For a smaller number of individuals.. some features are seen to be inappropriately large or small, they may appear at the wrong distance, the three-dimensional space inside the vehicle may appear distorted…"

Stereo CAD studies (Hoskinson/Akai)

- No stereo display psychophysics in literature!
- Can people make VR distance judgments?
- Can people discriminate between VR object distances (criterion-free test)?
- Can people set a VR object at a real distance?

Exp 1: Depth estimation real vs. virtual



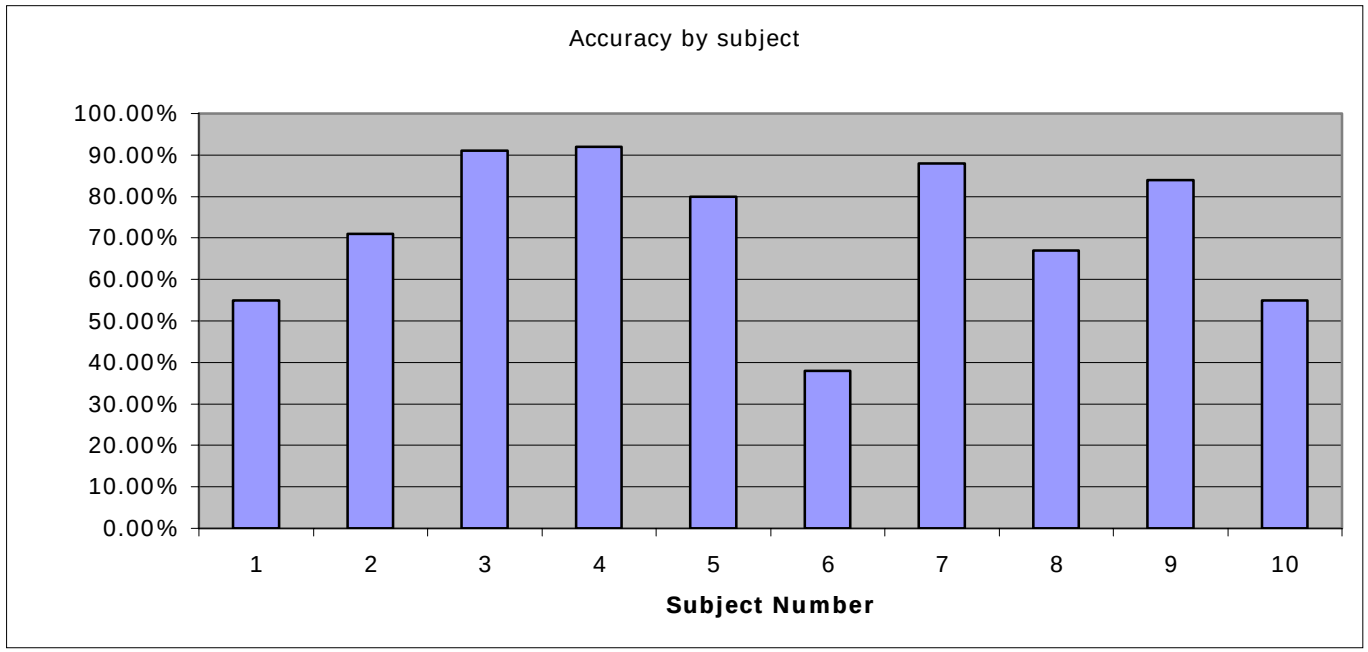
- Despite evocative impression of depth, depth judgments are terrible
- Supports GMR's observations

Stereo CAD studies (Hoskinson/Akai)

- Can people make VR distance judgments?
- Can people discriminate between VR object distances (criterion-free test)?
- Can people set a VR object at a real distance?

Exp 2: 2x2AFC size/distance

- Analysis presented at Vision Sciences 05
- Big individual differences between subjects, but consistent across trials



Stereo CAD studies (Hoskinson/Akai)

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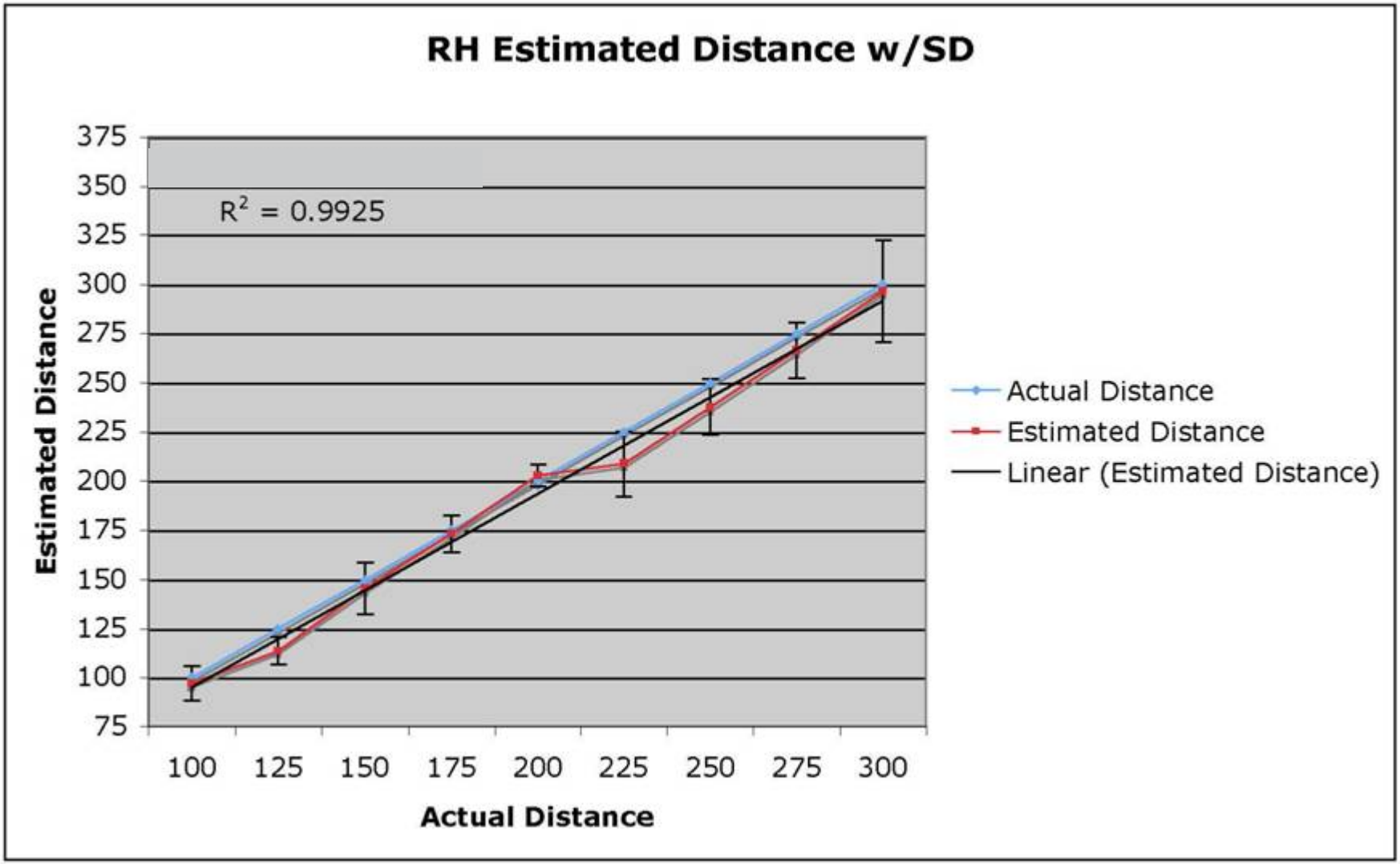
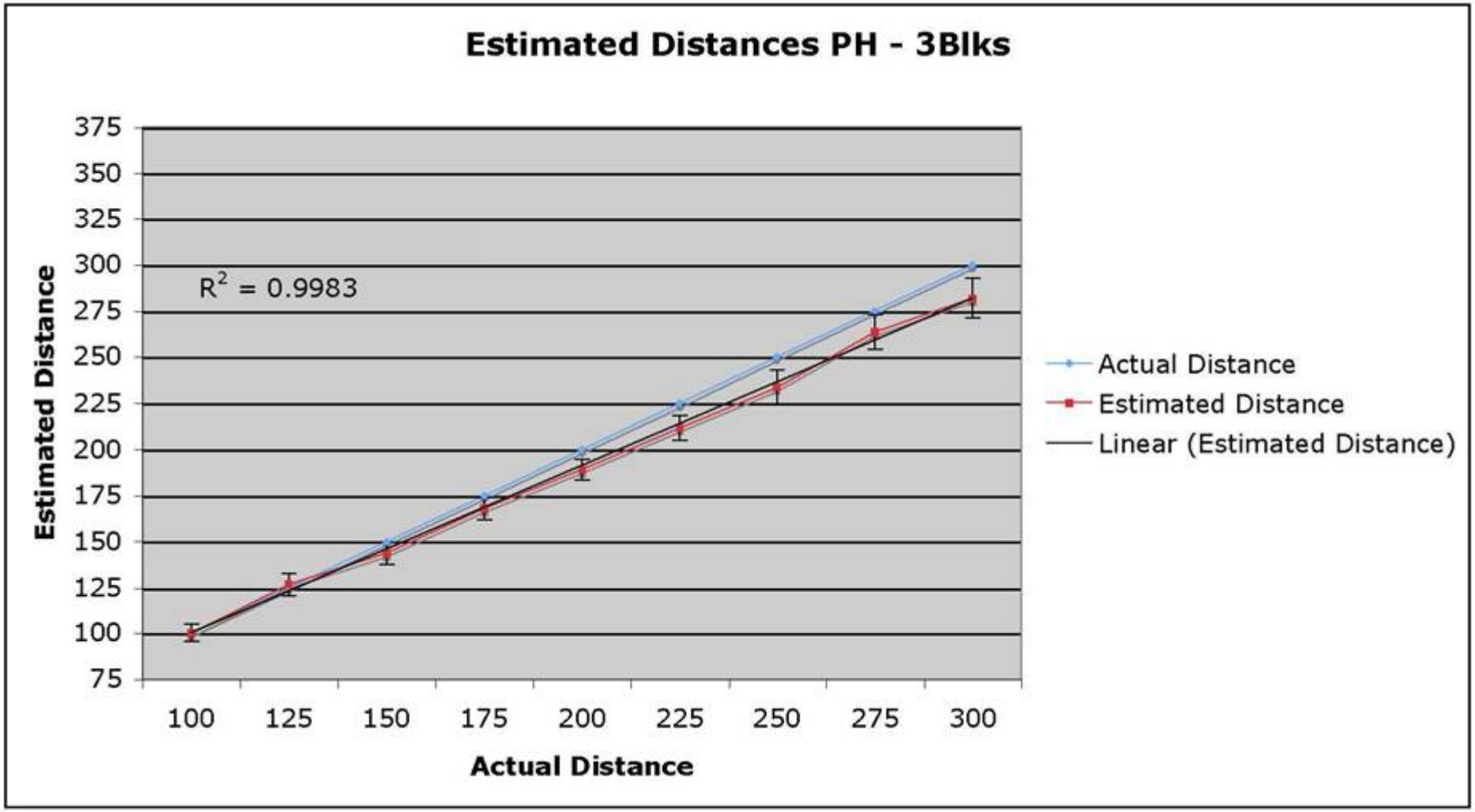
Exp 3: Adjust virtual -> real



Exp 3: Adjust virtual -> real



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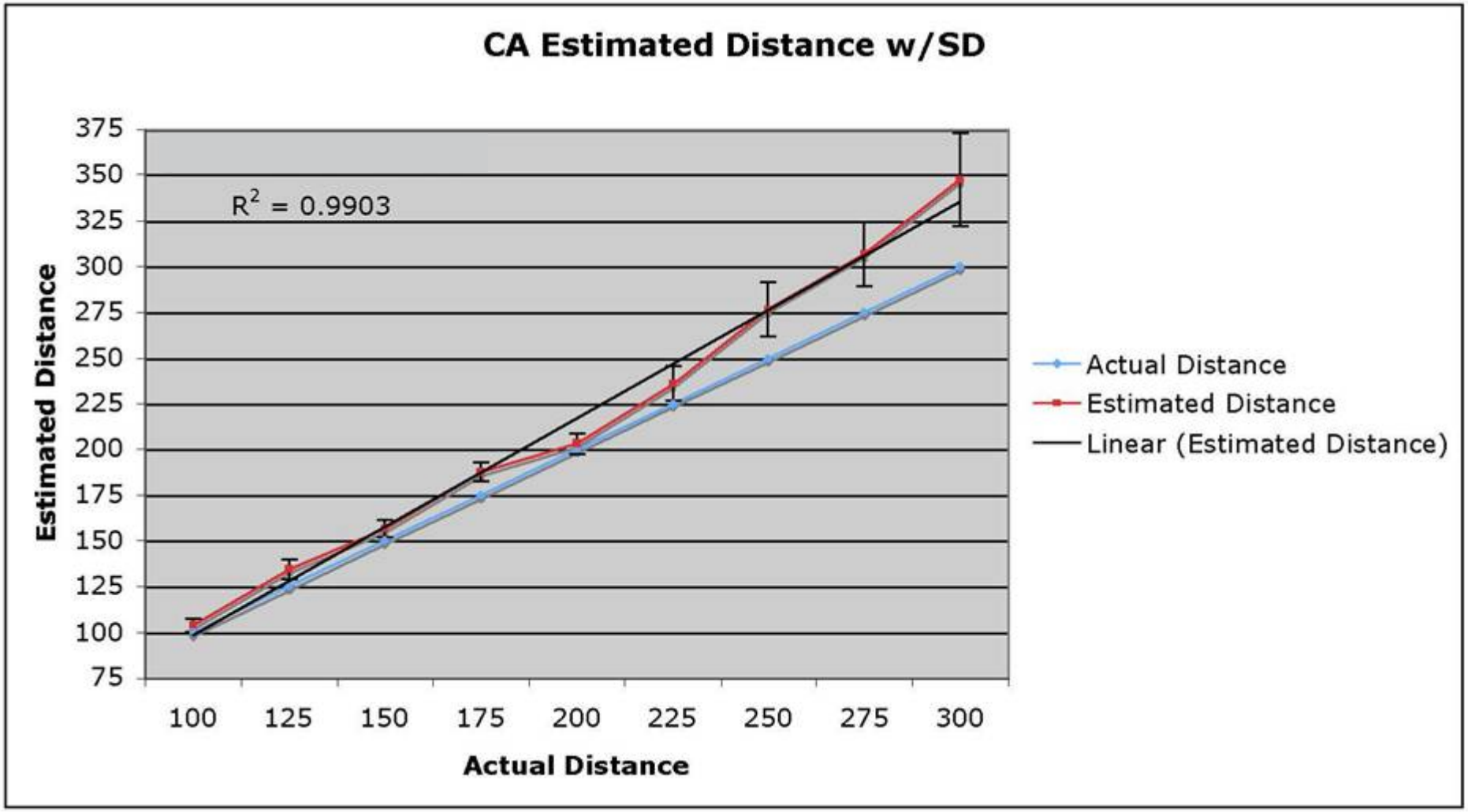
Exp 3: Adjust virtual -> real



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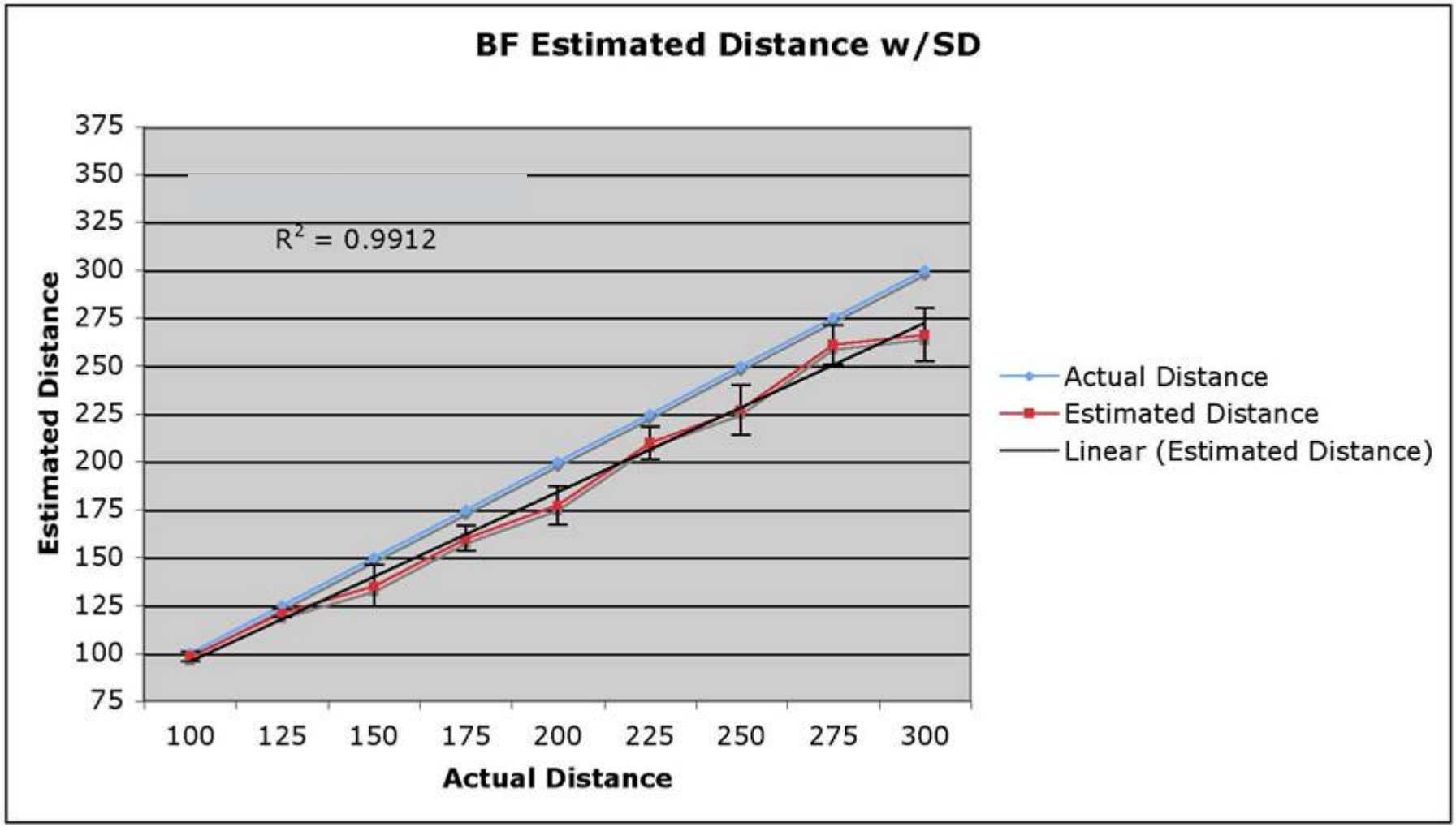


Explanation?

- Despite evocative sensation of depth, metric judgments in VR are generally bad (exp1), and differ greatly between individuals(exp2)
- Some situations provide enough support for consistent performance, but not overall accuracy (exp3)
- Can we fine tune VR for their “personal equations”?

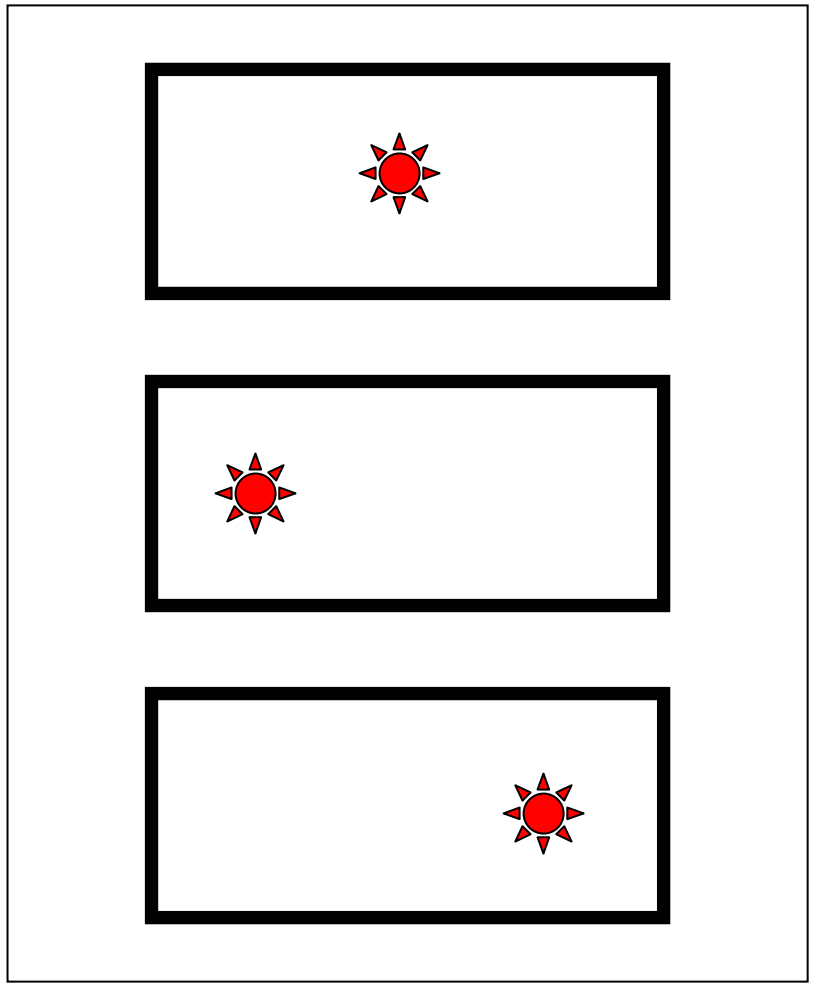
Perception and action Study: Pointing in Large Displays (Po)

Tell me where the target is

Point with no feedback

Point with visual feedback (cursor)

Point with delayed visual feedback



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Findings

1. Can you tell if a target is on the left or right?

   3 out of 7 males, 7 out of 7 females made errors

2. Can you point to it with no visual feedback?

   6 out of 10 who failed #1 were correct

3. Are you better with a (simulated) laser pointer?

   Out of 6 who point accurately in 2, all fail

4. Will pointing accuracy be affected if visible pointer lags pointing?

   3 of the 6 who failed #3 succeed

Predicted by 2 visual systems hypothesis

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Perception/action/cognition loops

- Move beyond looking at systems
- Study optimal human performance
  - Tight perception/action control loops
  - Highly interactive collaboration
  - Complex control device with high control intimacy

Performance analysis (Kaastra)

QuickTime™ and a
H.263 decompressor
are needed to see this picture.

Musical performance analysis interface

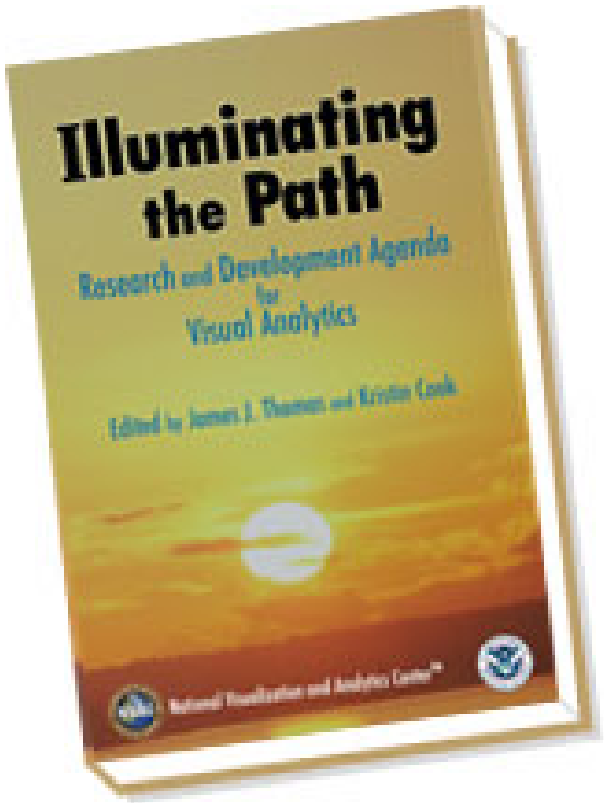
- HCI-style language analysis
- Gestural language analysis
- Motion analysis
- Breath and motion
- Empirical studies
  - Introduce lags, etc

MoCap (Tooka)

“Thick Description” + Math models

- How information from multiple senses is integrated to give rise to trans-modal mental events
- Perception/action patterns, sequences, rhythms
- Coordination between users
- Biosignals

Visual Analytics



1. Grand Challenges
2. The Science of Analytical Reasoning
3. Visual Representations and Interaction Technologies
4. Data Representations and Transformations
5. Production, Presentation, and Dissemination
6. Moving Research into Practice
7. Positioning for Enduring Success

http://nvac.pnl.gov/agenda.stm

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