A New Way to Get Around: Experimental Investigation of Non-Speech Navigation Interfaces

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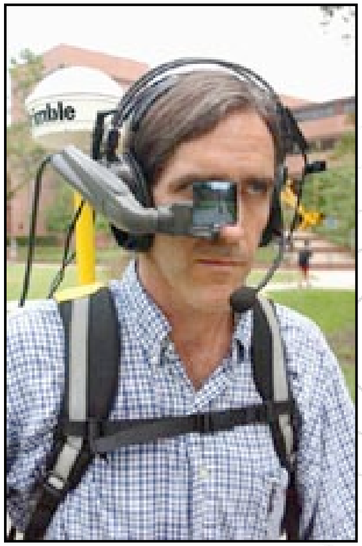
Navigation by Visually Impaired

- Permanent visual impairment
  - e.g., macular degeneration, diabetic retinopathy
- Temporary inability to see
  - e.g., firefighters in smoke-filled building

Technological Support

- Augment, not replace, environment
- Spoken directions most common
  (with/without GPS)
- Collision avoidance
  (infrared most common)
- Recently integrated with GIS
  (but not blind- or pedestrian-specific)
- Sometimes integrated with visual display



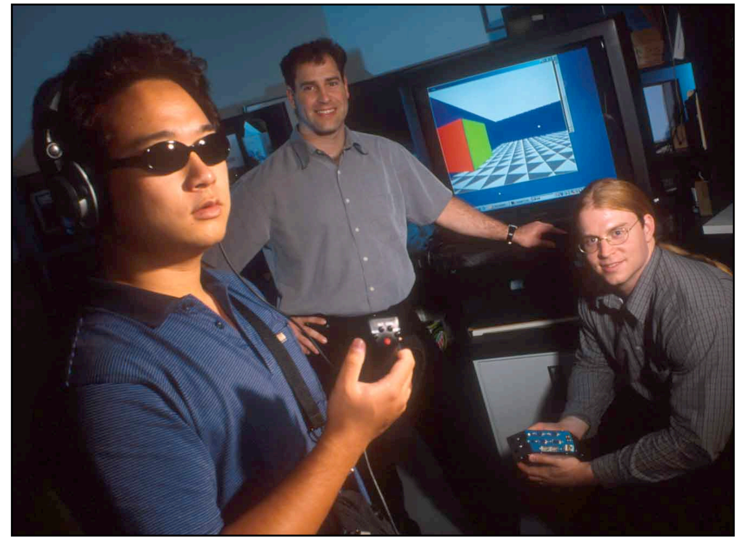
Design Decisions

- Tracking technology
  - GPS, inertial, IR, RF, others
  - Sensor fusion required
- Speech vs. non-speech output
  - Primary navigation cues
  - Auxiliary information
- Input device(s)?
  - Speech, twiddler, keyboard, Braille

Benefits of Non-Speech Audio

- Faster
  - Briefer sounds possible, even with speeded speech
- Does not interrupt speech channel
  - Necessary when speaking, or using radio/phone
- Can be sound-engineered
  - Spectrum and loudness can be matched to listening environment
  - Sets of sounds ("themes") can be developed

SWAN: System for Wearable Audio Navigation



- Navigation tool for those who cannot look or cannot see
  - Accessibility applications
  - Military applications
- Wearable computer
  - CharmedIT, Twiddler
  - InterSense InertiaCube2
  - GPS, IR, RF, & other tracking tech
  - Sensor fusion

SWAN Auditory Display

- Navigation Beacons
  - Spatialized audio beacons form a path which can be followed
- Objects & obstacles
  - e.g., a desk in the hall; phone booth
- Surface Transitions
  - e.g., sidewalk to grass; start of stairway
- Location
  - e.g., lecture hall; intersection; office

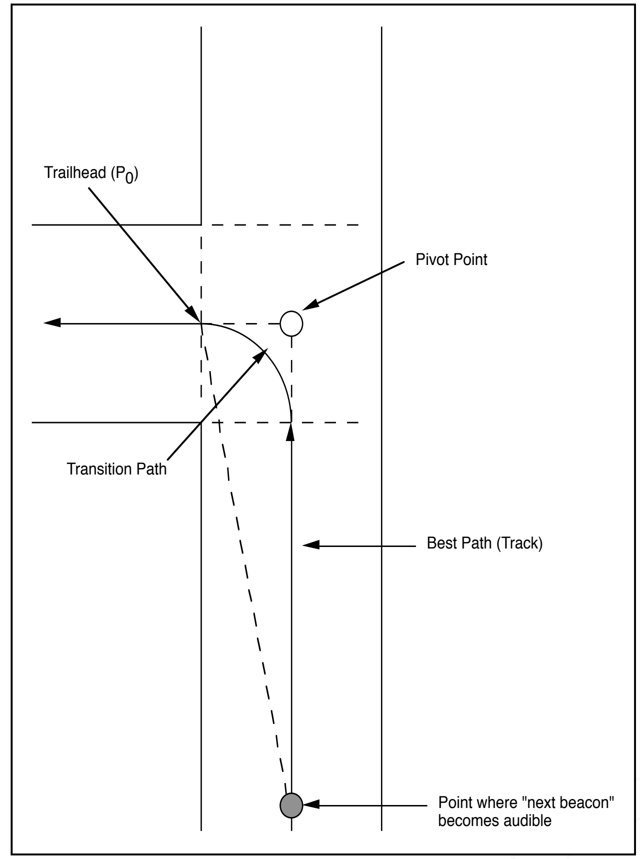
Spatialized audio earcon

- Annotations
  - e.g., "Puddle here whenever it rains"
  - e.g., "Ramp on left side of entrance"

Recorded speech or TTS

Evaluation

- Do they help the user safely accomplish specific tasks?
  - Navigation effectiveness
  - Situational awareness
  - Movement speed, efficiency
  - Comfort, satisfaction
  - Safety



Experiment 1

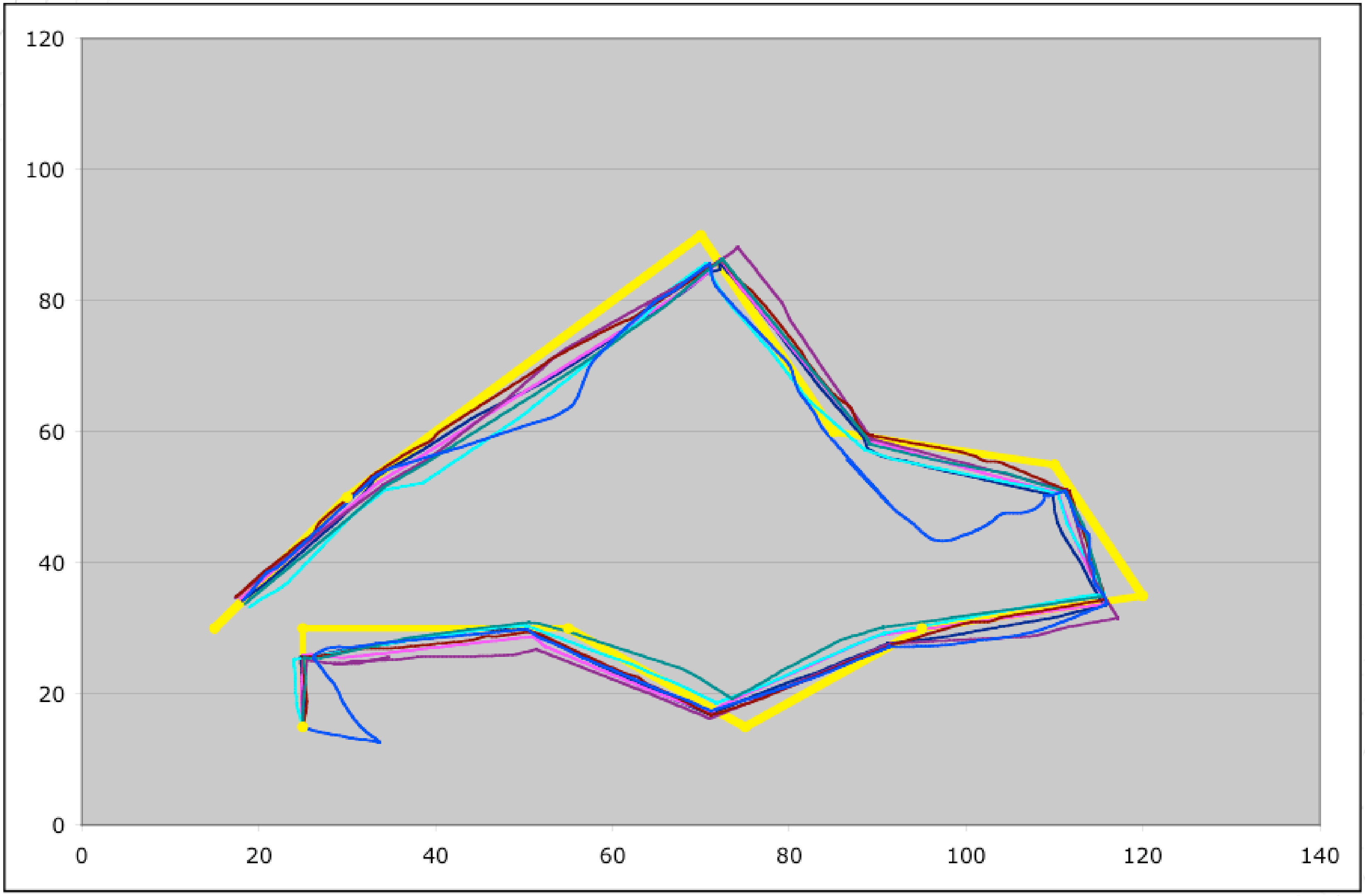
- 36 Participants
  - Georgia Tech students
  - Age range: 18-30; mean: 20.6
  - Males: 27 ; females: 9
  - Normal/corrected-to-normal vision & hearing
- 3 maps (simple, medium, difficult)
- 3 beacon sounds (noise, ping, tone)

Results

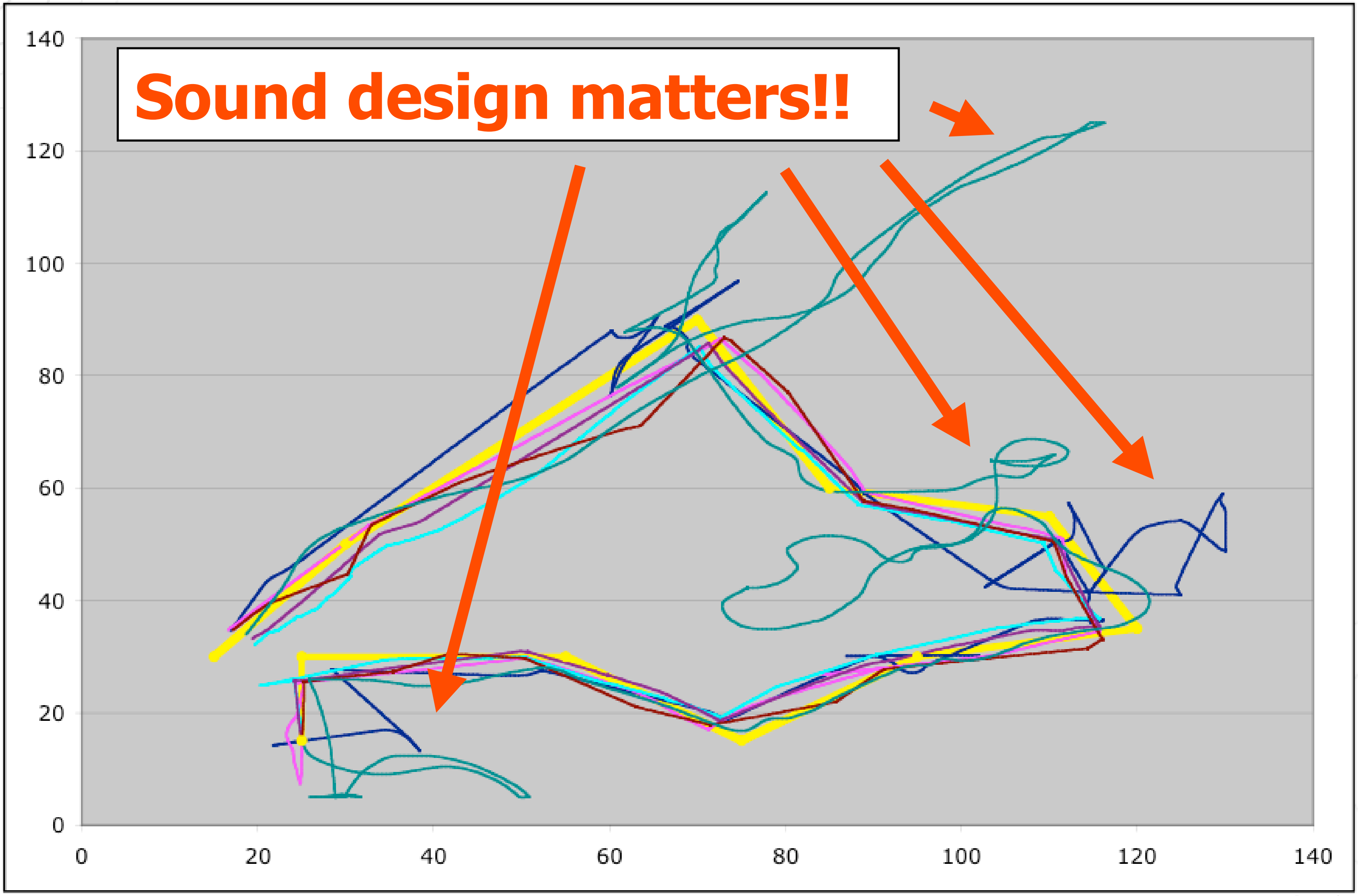
- Different beacon sounds lead to more effective navigation
  - Sound design matters
- Practice effects
  - Studies need to address long-term usage
- Capture radius effects
  - Sound design interacts with task requirements

More…

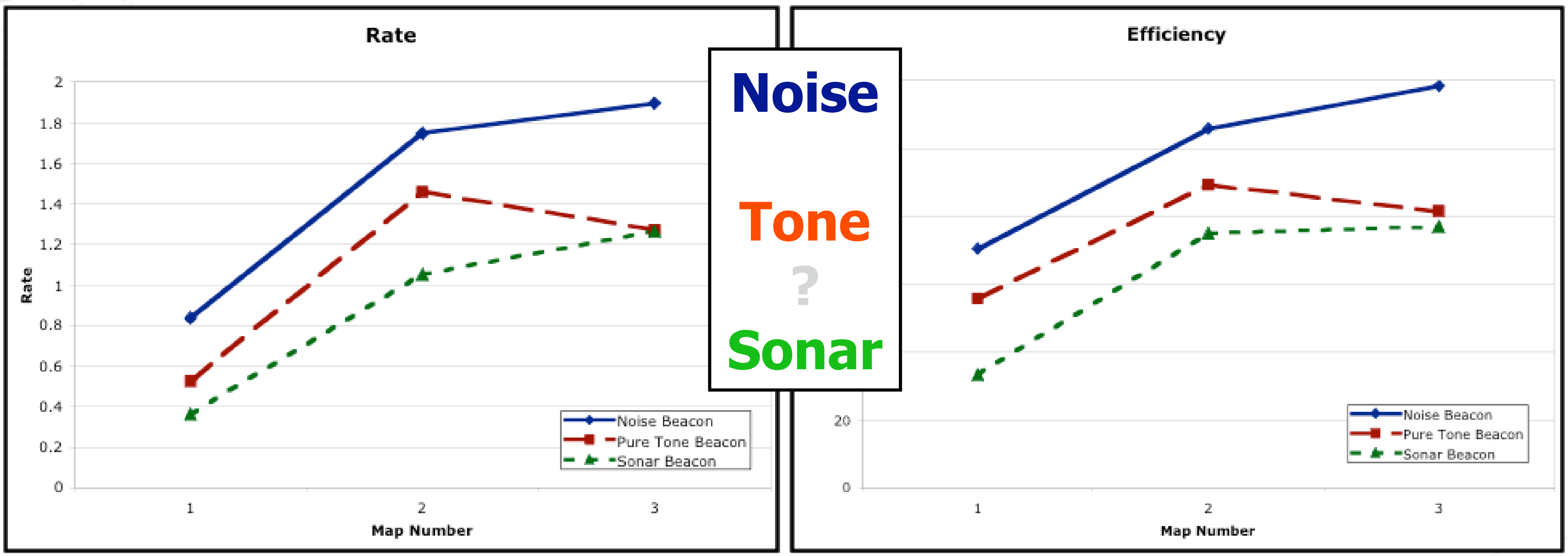
Good Beacons (noise burst)



Poor Beacons (pure tone)



Movement Rate & Efficiency

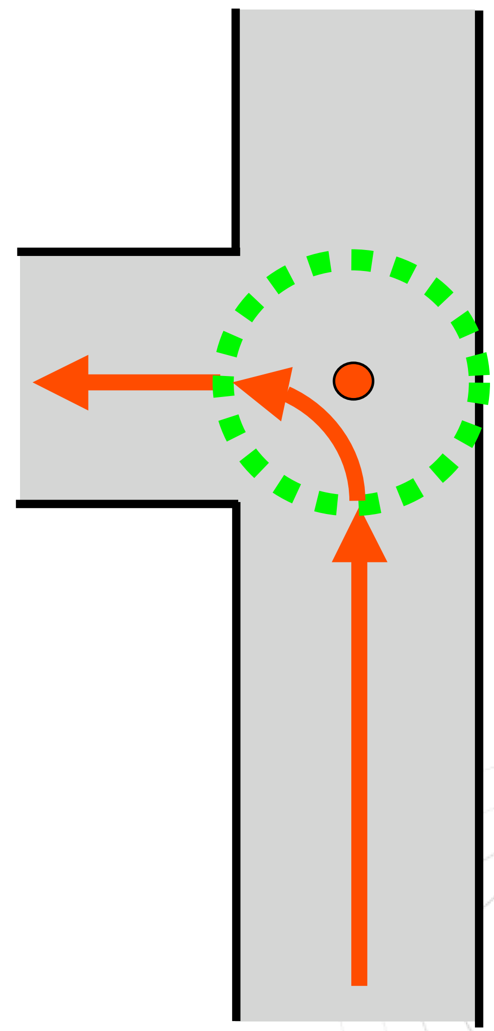


Practice

Practice

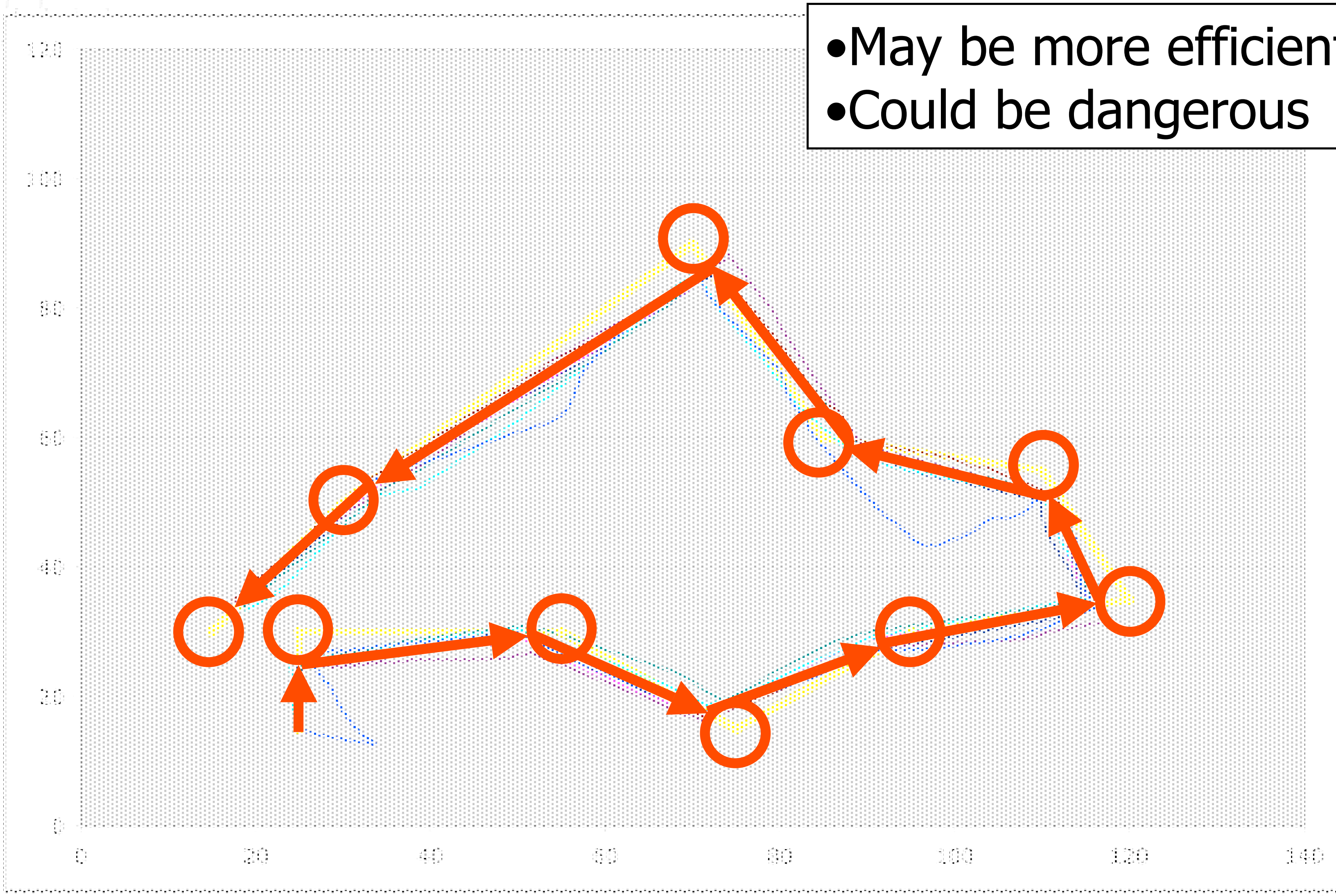
Effect of “Capture Radius”

- Capture radius = distance from the waypoint that the “next beacon” sound begins (= 5 meters)
  - Intended to allow for more natural walking around corners and turns
  - In reality, you likely never exactly reach waypoint, so c.r. is required
- Participants in the study “bounced” off edge of capture radius
  - Artifact of movement technique (not walking)



"Bouncing"

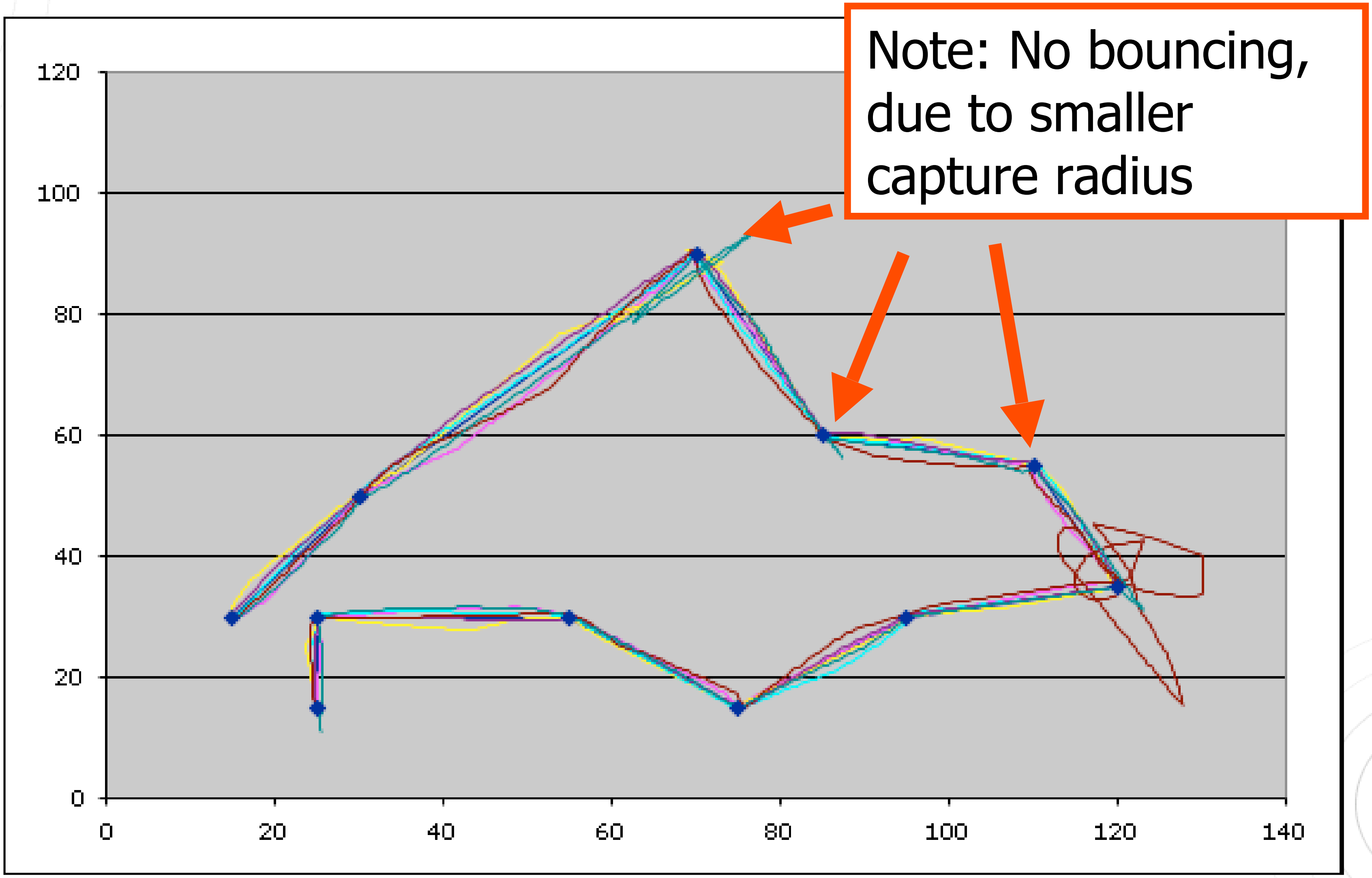
- May be more efficient
- Could be dangerous



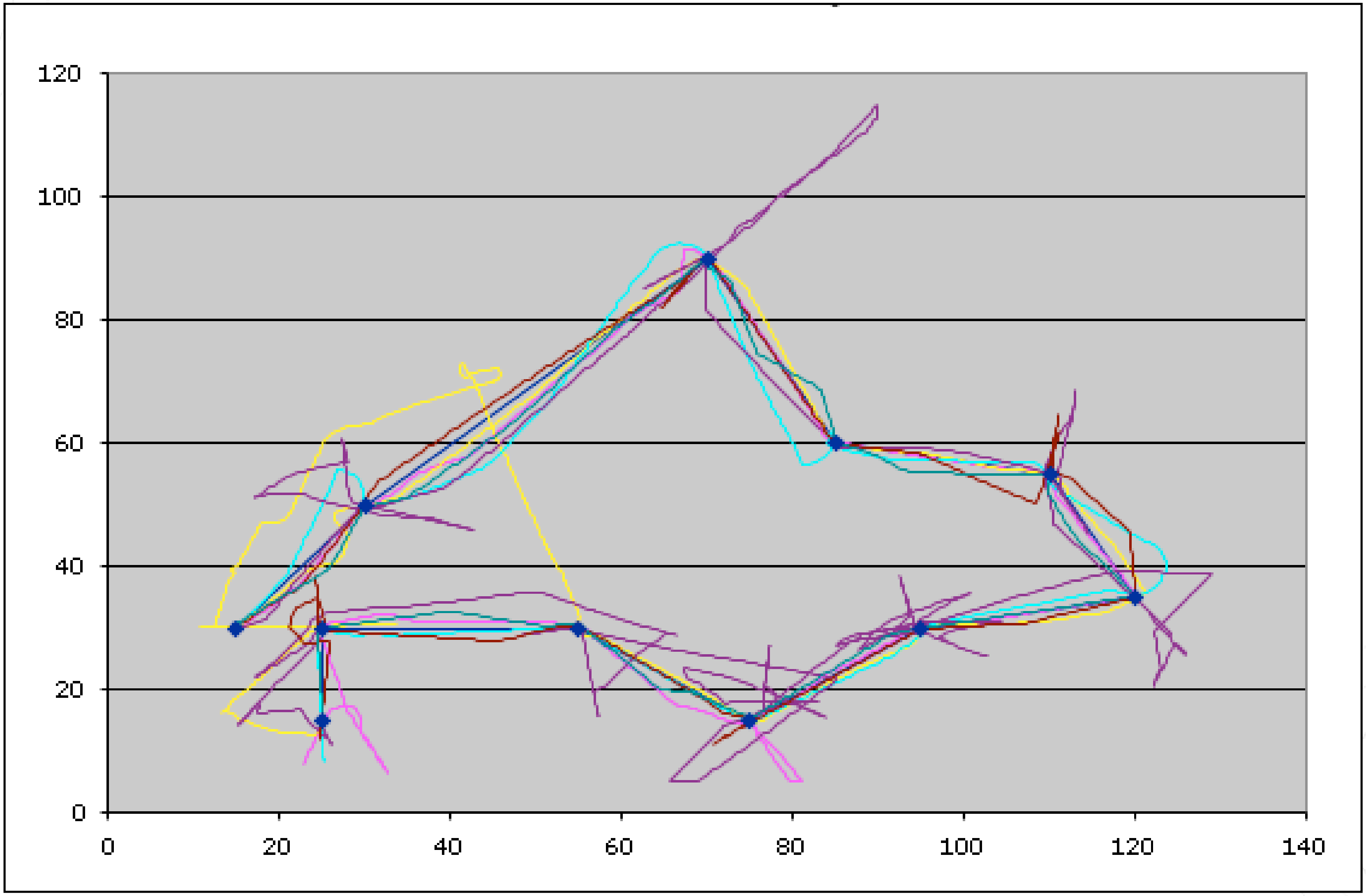
Experiment 2

- 36 Participants (new)
  - Age range: 18-28; mean: 20.9
  - Males: 21 ; females: 15
  - Same subject pool
- Same beacon sounds & maps
- Capture radius set to 30 cm

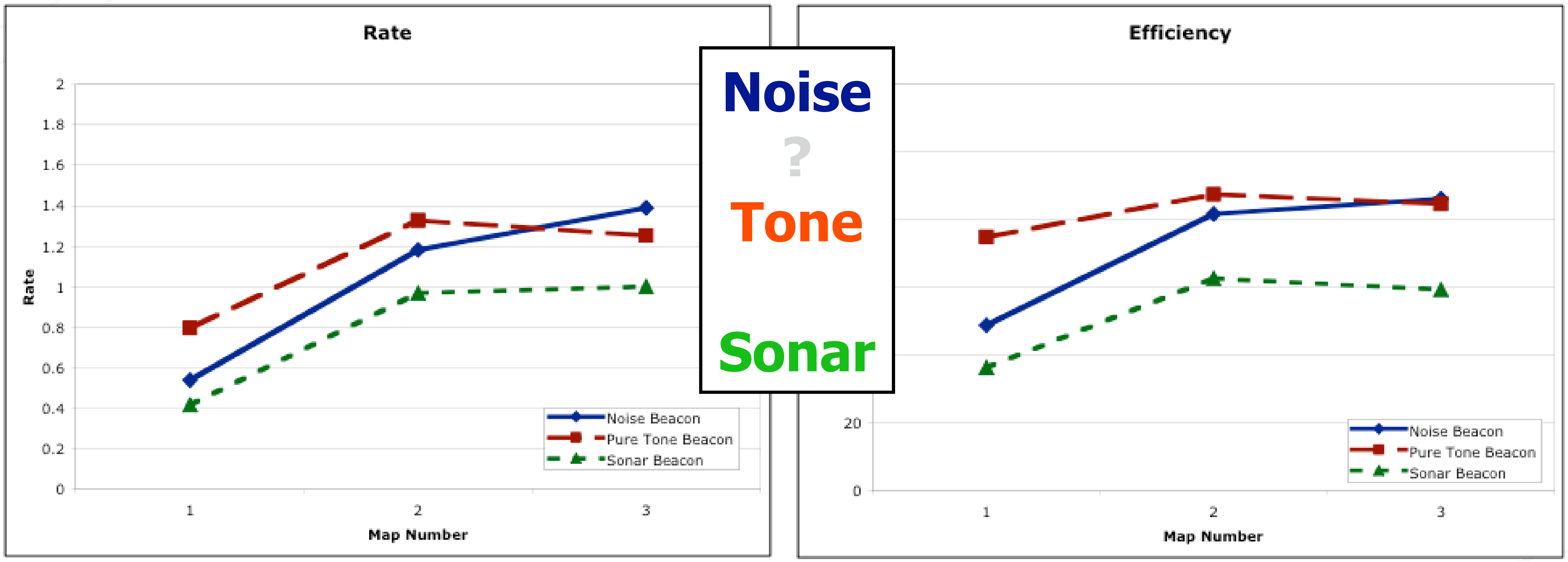
Medium beacon (pure tone)



Poor beacon (sonar ping)



Practice Effect



Practice

Practice

Summary

- Non-speech beacons can be very effective
- Beacon sound design matters for navigation accuracy
  - Experimentation required
- Practice effects may change initial “findings” of effectiveness
- Realities of task affect sound design
  - Capture radius must be considered

Ongoing Work

- Participants (!)
  - Blind, blindfolded (simulated smoke)
- Implementations
  - Sound designs, information augmentation
- Individual Differences
  - Do all listeners respond the same?
- HRTFs
  - Individualized HRTFs vs. simple stereo
- Training
  - Clearly there are practice effects. Can we speed up the learning through training?

Thank you!

Questions…?

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