Effects of Table and Seat Position in a Simulated Restaurant

William J. Bologna, Au.D., Ph.D., CCC-A

Director of Towson Auditory Simulation Lab (TASL)

NCRAR Seminar Series

7/11/24

TOWSON UNIVERSITY

Towson Auditory Simulation Lab (TASL)

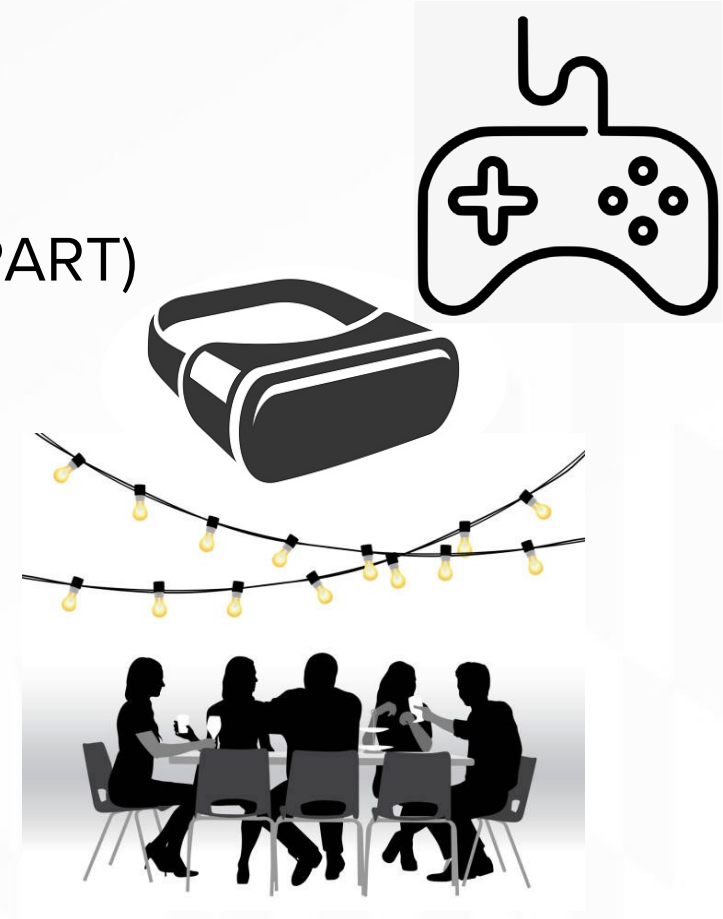
Overarching goal is to create innovative new approaches to assessment and rehabilitation in audiology

Gamified tests of speech understanding in noise

- iPad applications, Portable Automated Rapid Testing (PART)
- Virtual reality simulation

Positioning strategies in realistic environments

- Simulated restaurant environments
- Listener can “move” through the environment
- Evaluate efficacy of aural rehabilitative training



Real World Problem: Speech in Noise

Difficulty understanding speech in noise is very common

- Even among individuals with normal hearing thresholds[1]

Background noise is a difficult problem for hearing aids and cochlear implants to address[2,3]

- Understanding speech in noise involves more than just audibility[4]

Improving communication in noise is an important clinical goal

[1]Beck et al., 2018; [2]Xia et al., 2017; [3]Choi et al., 2023; [4]Ruggles et al., 2018

Clinical Problem: Near-Normal Audiogram

TOWSON UNIVERSITY

Many patients with near-normal hearing report difficulty in noise

- Not necessarily good candidates for amplification (not audibility issue)
- Some evidence of benefit from low-gain hearing aids[1]

Good candidates for positioning-based training

- Positioning strategies are free
- Can supplement over-the-counter amplification
- Focus on the situations where they are reporting difficulty
- Help them stay engaged and active in crowded social environments

[1]Davidson et al., 2024

Clinical Problem: Aural Rehabilitation

TOWSON UNIVERSITY

Positioning strategies are a component of traditional aural rehab

- Based on intuition and acoustics (sit in the corner of the room)

- Little evidence on whether these strategies work in the real world, or if patients use them effectively

- Mostly delivered to patients informally through counseling

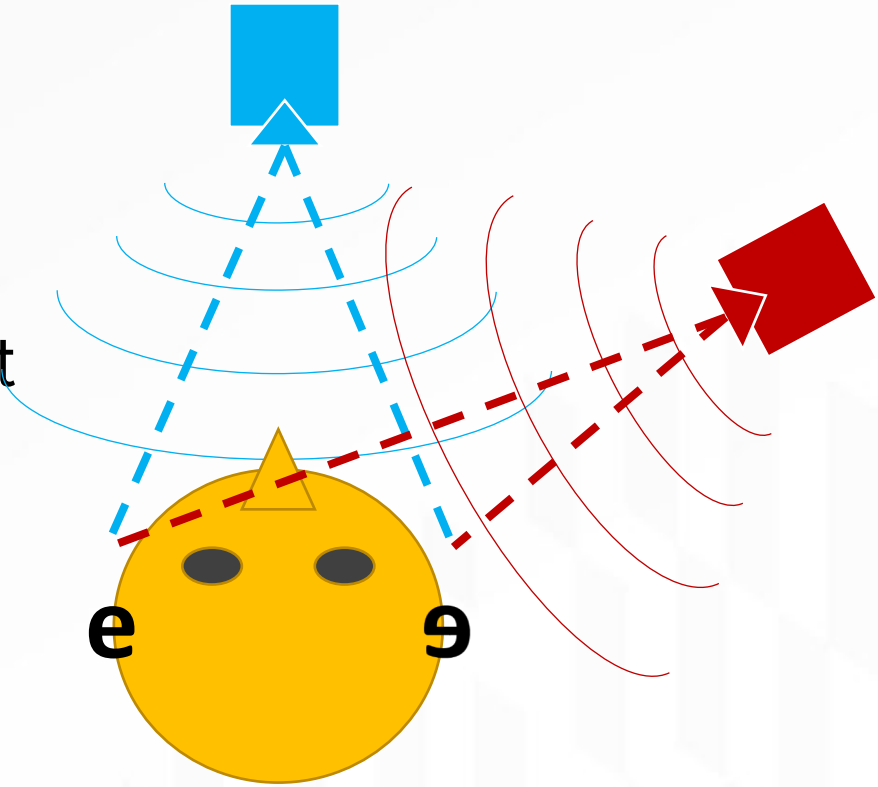
Spatial Hearing

In the real world, sounds arrive at our two ears at slightly different times and intensities

- Depends on the angle of the sound source relative to the listener

Sounds from the right arrive at the right ear slightly *sooner* and slightly *louder* than the left

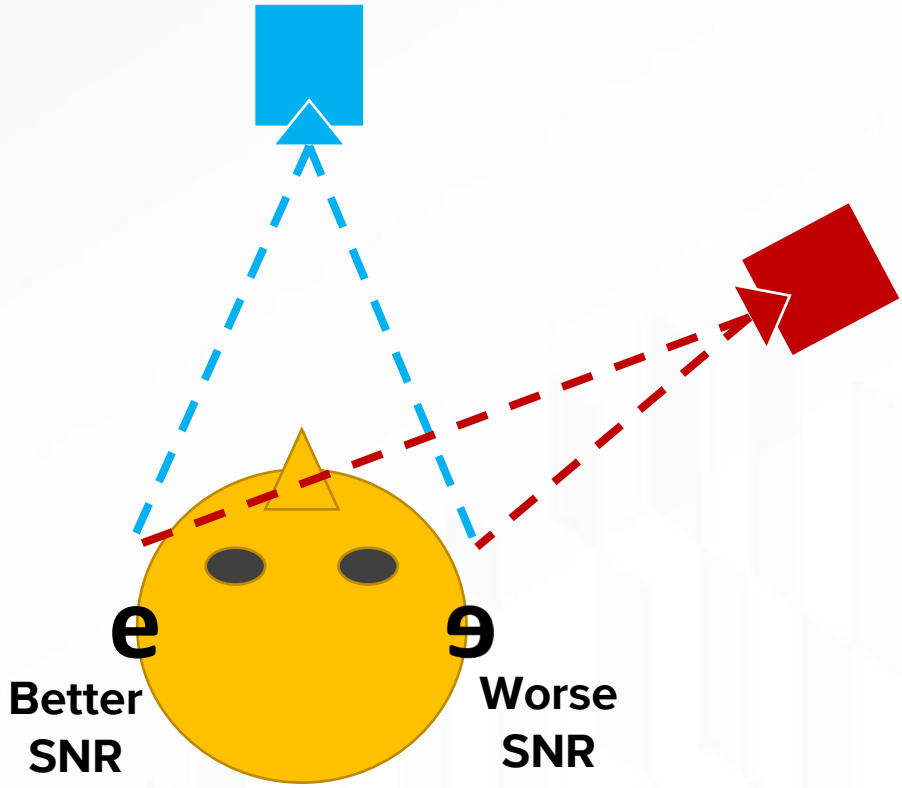
Sounds from directly in front arrive at both ears at the same time and intensity



Better Ear Listening

When maskers are not symmetrical, one ear will have a better SNR than the other

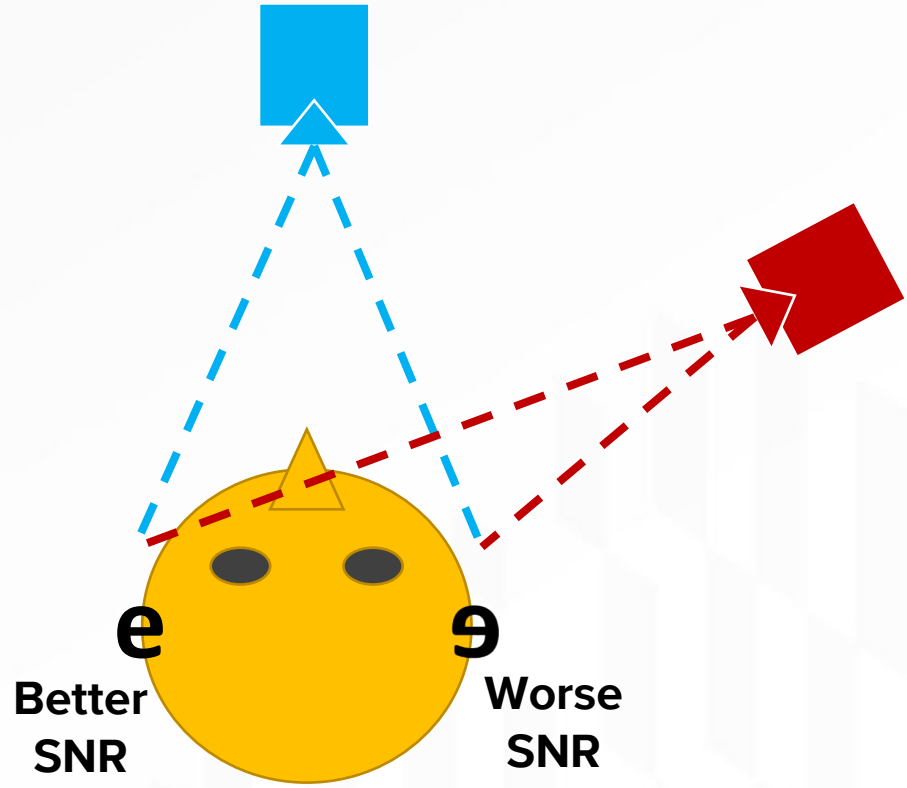
Listeners naturally use better ear listening to understand speech in realistic noisy environments[1]



[1]Best et al., 2015

Head Turns

- When maskers are not symmetrical, one ear will have a better SNR than the other
- Turning the head slightly toward the masker maximizes SNR in the better ear[1]
- Most listeners, even hearing aid and cochlear implant users, are poor at using head turns to maximize better ear listening[2]

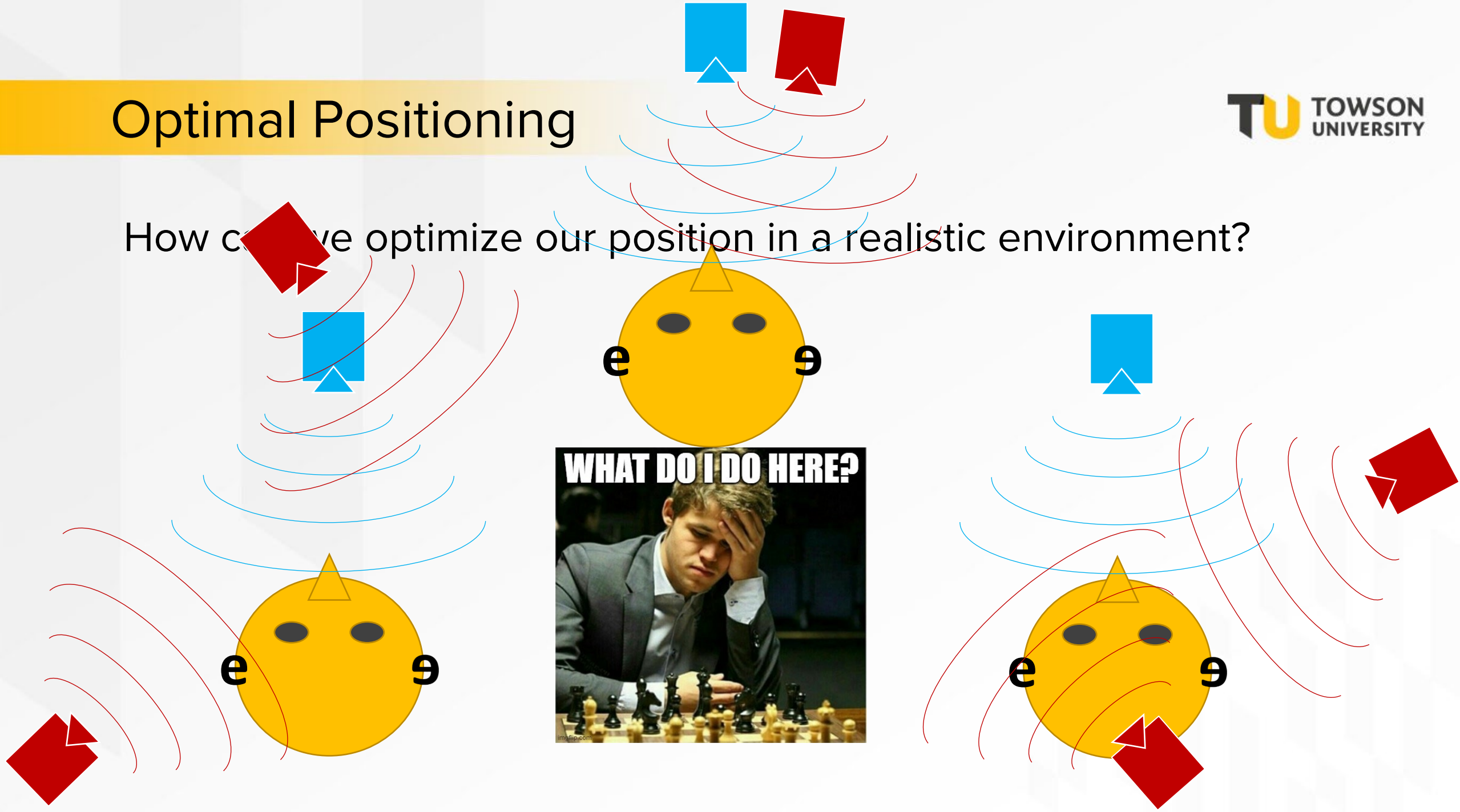


[1]Grange & Culling, 2016; [2]Grange et al., 2018

Optimal Positioning

TOWSON UNIVERSITY

How c ve optimize our position in a realistic environment?



Purpose of Positioning Research

TOWSON UNIVERSITY

Learn more about how position affects speech understanding and other aspects of communication (listening effort)

Identify generalizable positioning strategies that are effective in many different environments

Determine if behavioral training for better spatial positioning may improve speech understanding in noise for patients

- What type of patient benefits most from positioning strategies training?

Start Simple – Café Acoustica

TOWSON UNIVERSITY

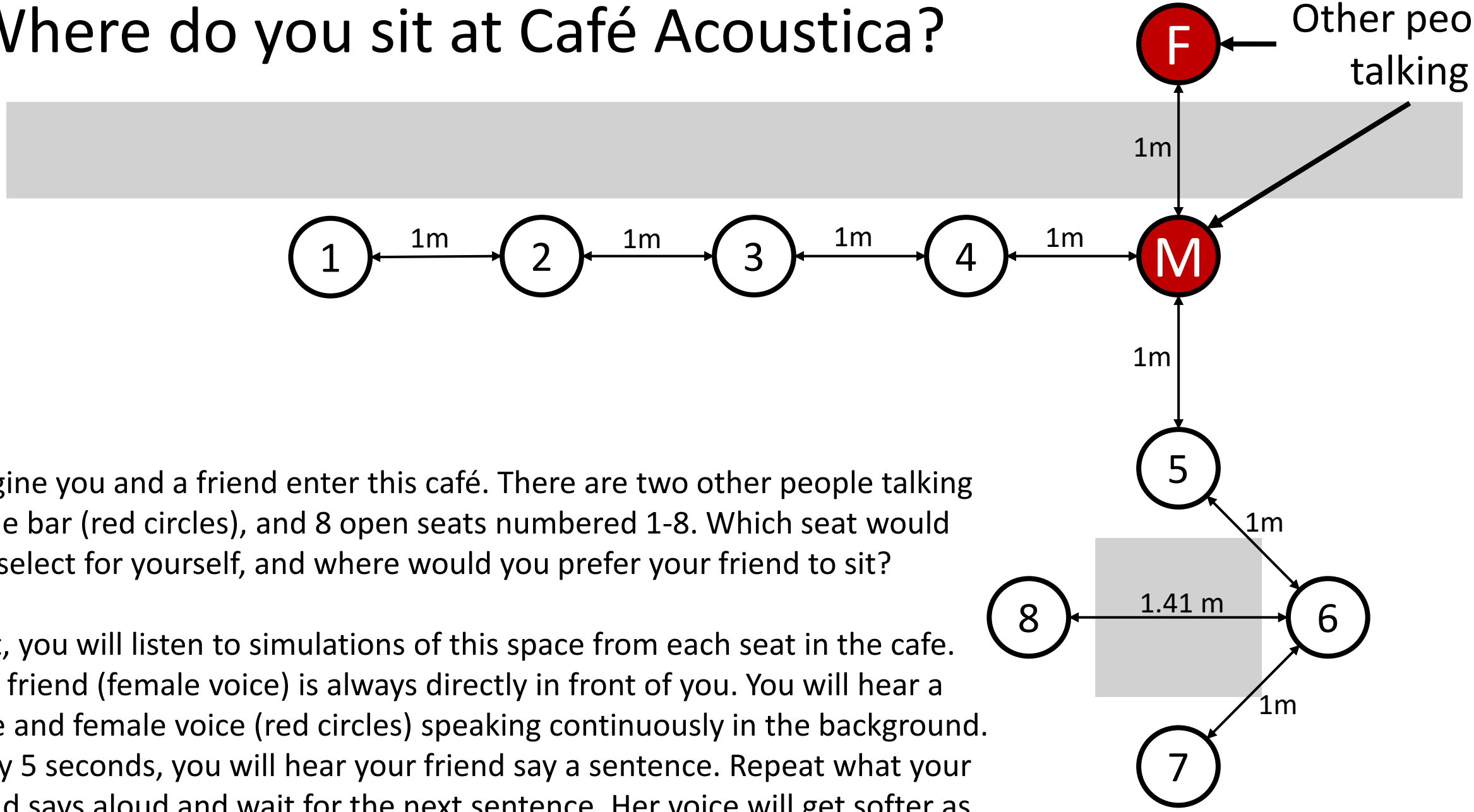
Effects of position in a simple environment with two competing talkers

- Is speech recognition facilitated by greater distance from maskers?
- Facilitated by angular spatial separation of target and maskers?

Positioning preferences of listeners in this simple environment

- Do they choose advantageous positions for themselves and for their conversation partner?

Where do you sit at Café Acoustica?



Imagine you and a friend enter this café. There are two other people talking at the bar (red circles), and 8 open seats numbered 1-8. Which seat would you select for yourself, and where would you prefer your friend to sit?

Next, you will listen to simulations of this space from each seat in the cafe. Your friend (female voice) is always directly in front of you. You will hear a male and female voice (red circles) speaking continuously in the background. Every 5 seconds, you will hear your friend say a sentence. Repeat what your friend says aloud and wait for the next sentence. Her voice will get softer as the test continues, so try your best and guess if you're not sure.

Method – Café Acoustica

TOWSON UNIVERSITY

- All Talkers individually rendered using 3D Tune-In Toolkit[1]
  - Intensity changes based on distance to listener
  - Binaural cues based on generic head-related transfer function
  - Anechoic simulation (no walls or reverberation)

- Two masker talkers (one male, one female) calibrated to be speaking at 70 dB SPL at 1m
  - Concatenated BKB sentences from lists 1-5

- One target talker (different female voice) that starts at 70 dB SPL and decreased by 3 dB after every 2 sentences (70-49 dB SPL)
  - BKB sentences from lists 6-21

[1]Cuevas-Rodriguez et al., 2019

Method – Café Acoustica

21 younger adults with normal hearing

Ask them where they would prefer to sit

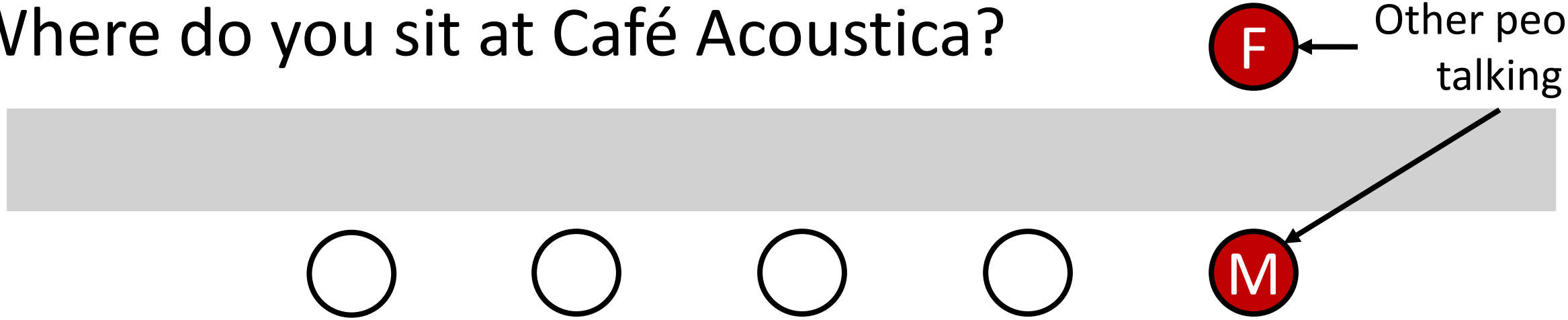
- Position for themselves plus their conversation partner

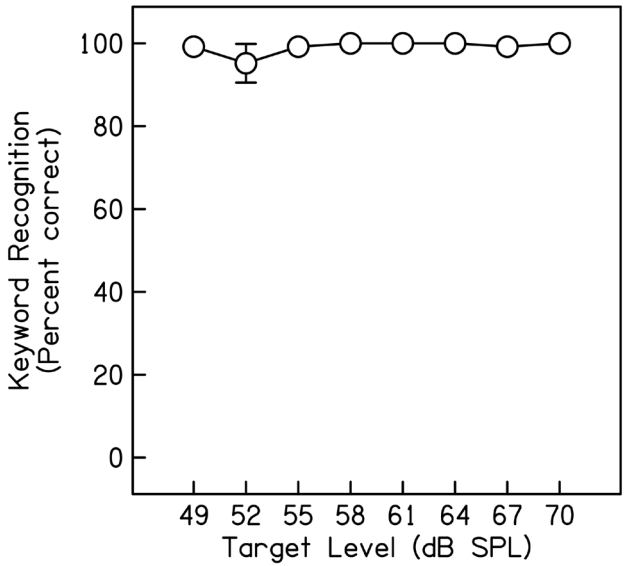
Measure keyword recognition in each position

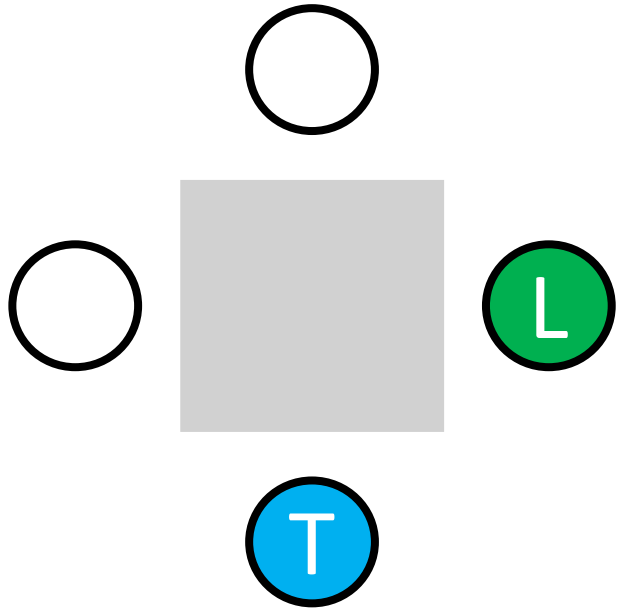
- One list of BKB sentences at decreasing target intensity levels

Ciara Houlihan,
Graduate Student
Researcher

Where do you sit at Café Acoustica?

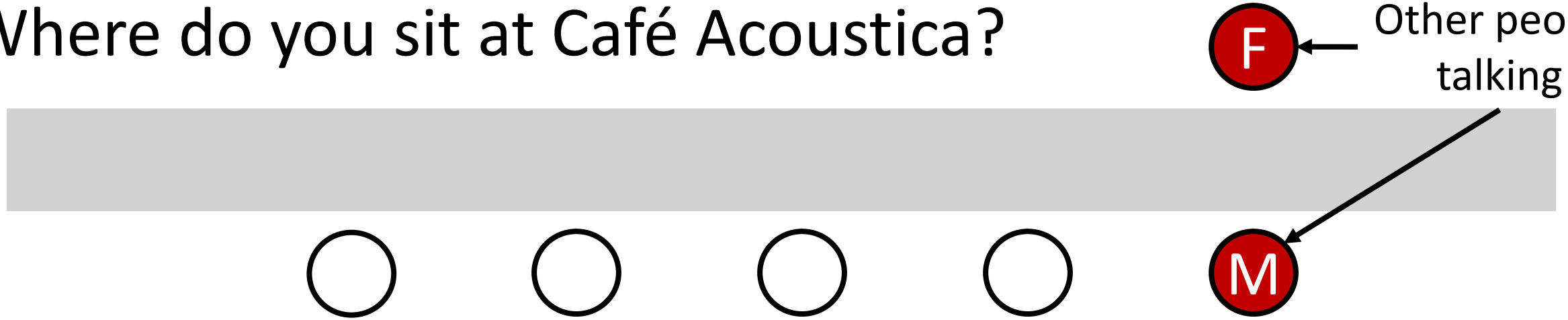


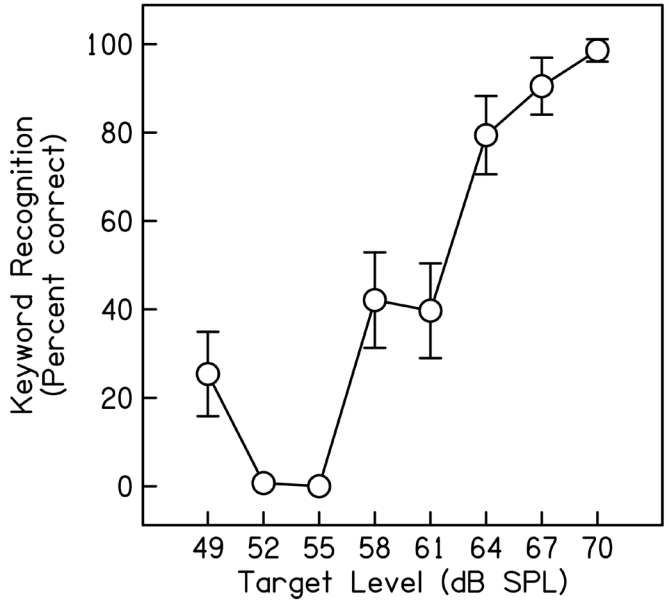


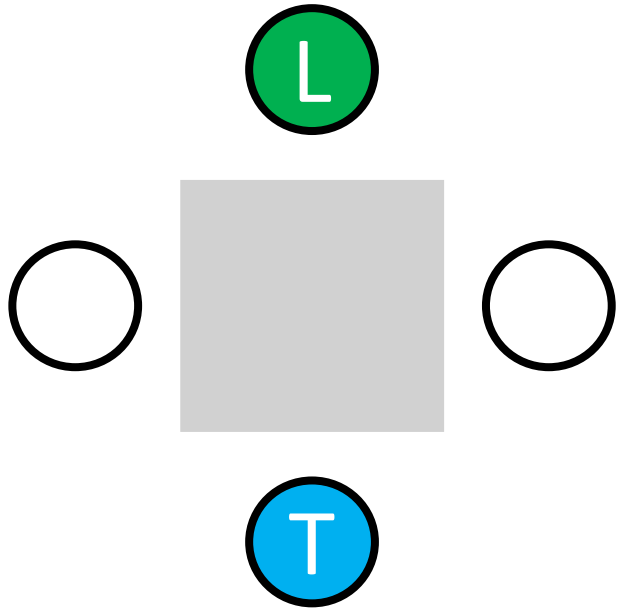


0/21 would choose to sit here

Where do you sit at Café Acoustica?

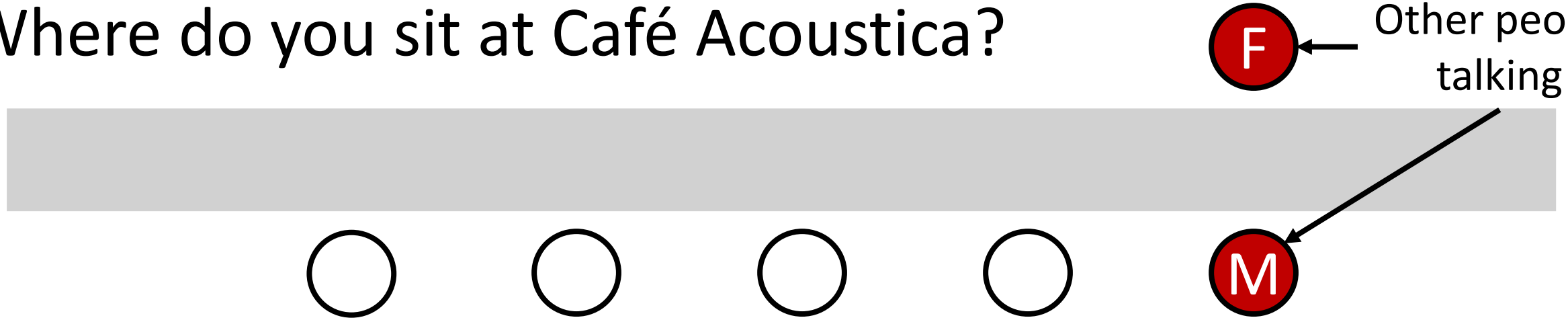


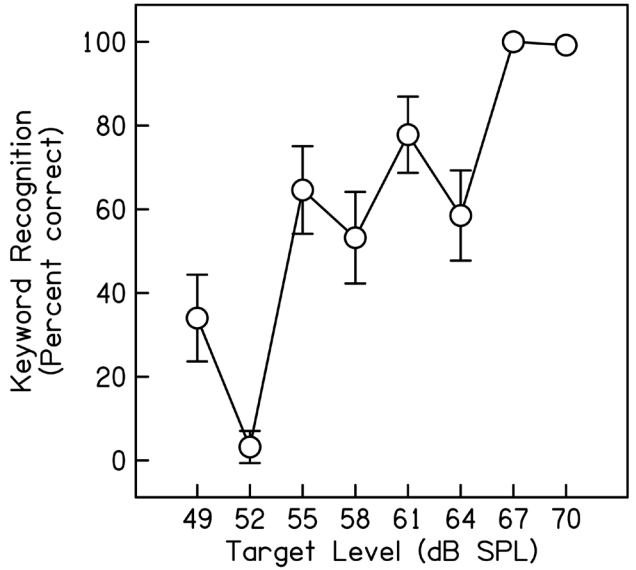


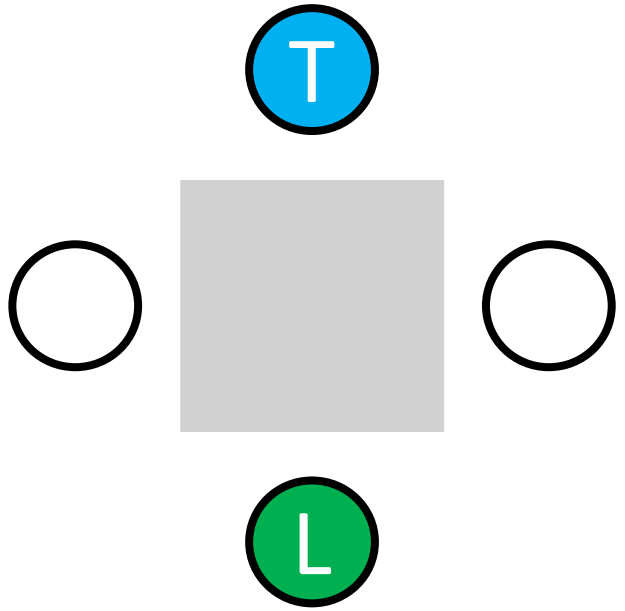


0/21 would choose to sit here

Where do you sit at Café Acoustica?

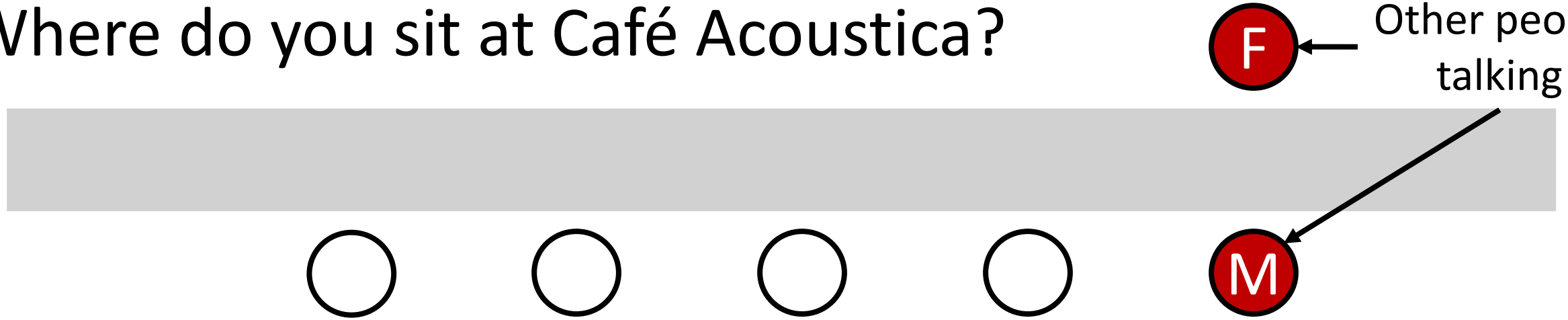


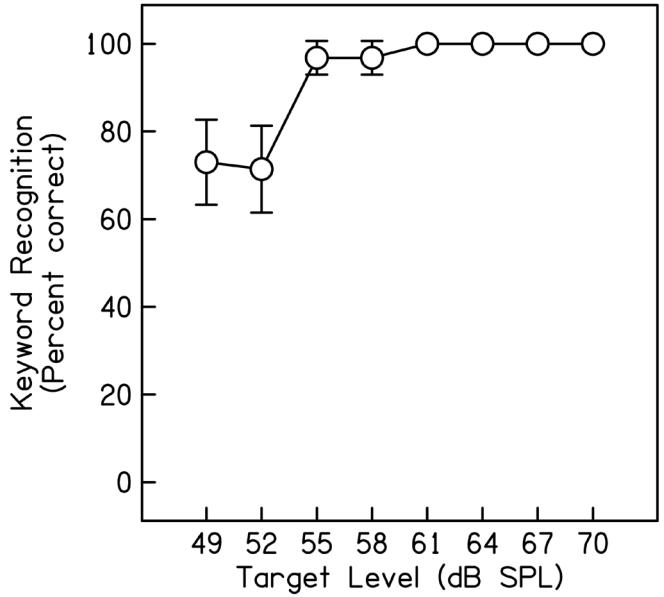


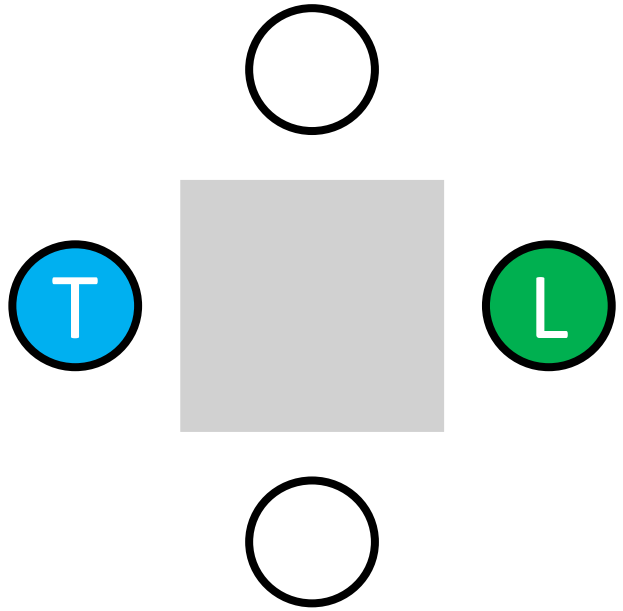


1/21 would choose to sit here

Where do you sit at Café Acoustica?

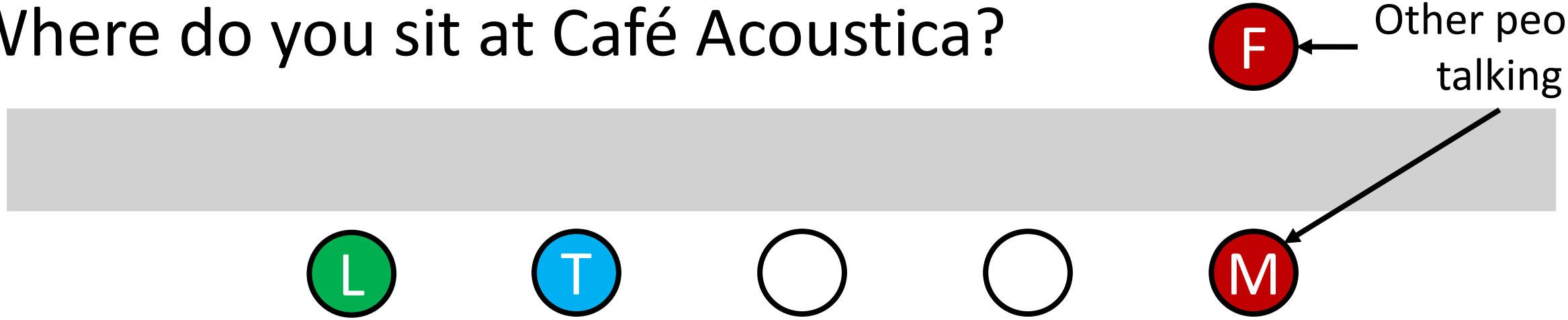


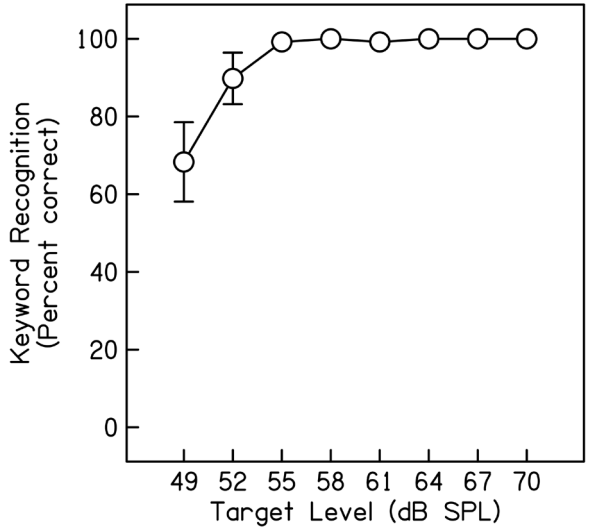


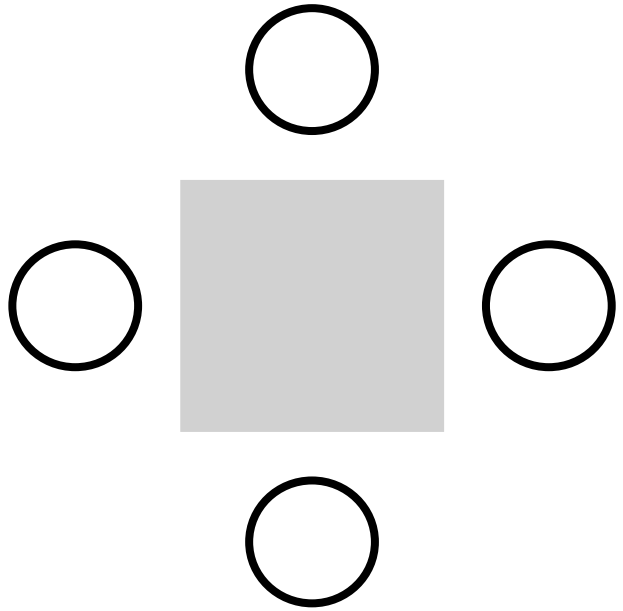


1/21 would choose to sit here

Where do you sit at Café Acoustica?

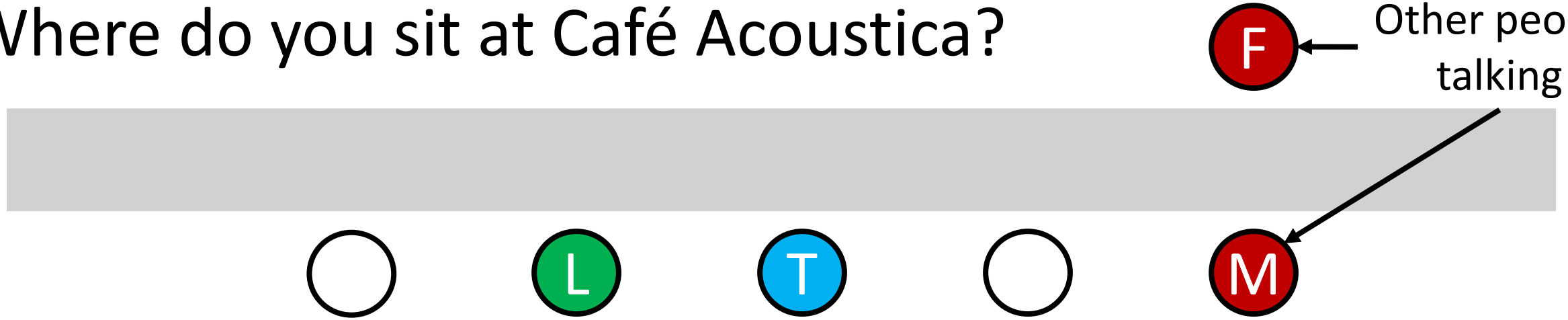


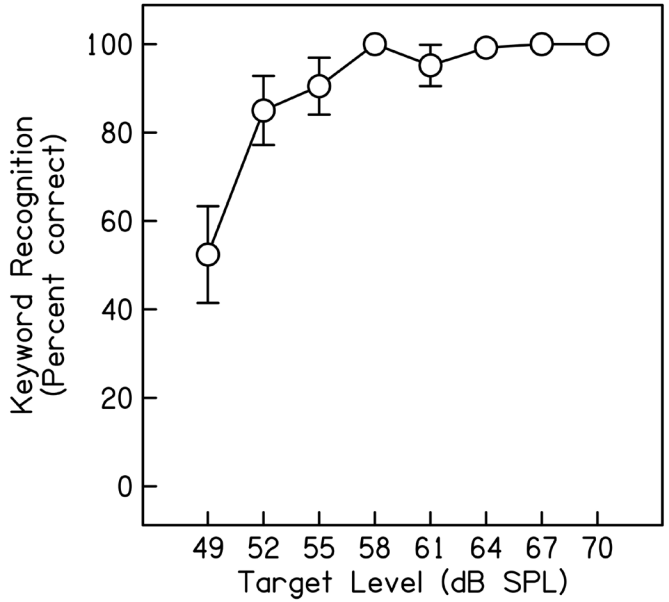


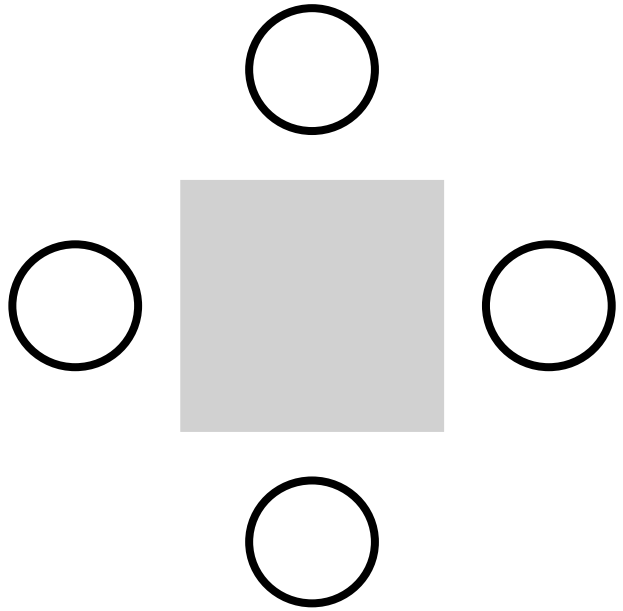


8/21 would choose to sit here

Where do you sit at Café Acoustica?







2/21 would choose to sit here

Conclusions – Café Acoustica

Demonstrated two different effects of position on speech recognition in a simple environment with two competing talkers

- Positions farther from maskers are better than closer to maskers
- Positions that offer angular spatial cues are better than ones that do not

Younger adults chose a good seat, but not the optimal seat

- Younger adults prefer to sit at the bar

Limitations – Café Acoustica

Lots of ceiling effects

- Not seeing the full psychometric function
- Two competing talkers was too easy
- Positioning effects small for younger adults with normal hearing

Preference data was limited to one data point, collected before testing

Increase Complexity…

Address these limitations in a new environment

- Restaurant with 10 competing talkers
- Fix issues with “frozen” maskers (nonlinearity in data)
- Adaptive testing to generate full psychometric functions

More diverse patient populations

- Older adults, with and without hearing loss
- Younger adults with hearing loss

Research Questions – Restaurant

TOWSON UNIVERSITY

Effects of table and seat in a complex environment with ten competing talkers

- How are positioning effects influenced by age and hearing status?

Positioning preferences of younger and older adults with normal or impaired hearing

- Do they choose advantageous table and seat?
- Does their preference change after testing?

Simulated Restaurant

Simulated restaurant with 4 tables, each with 3 seats (green)

A: Across from target

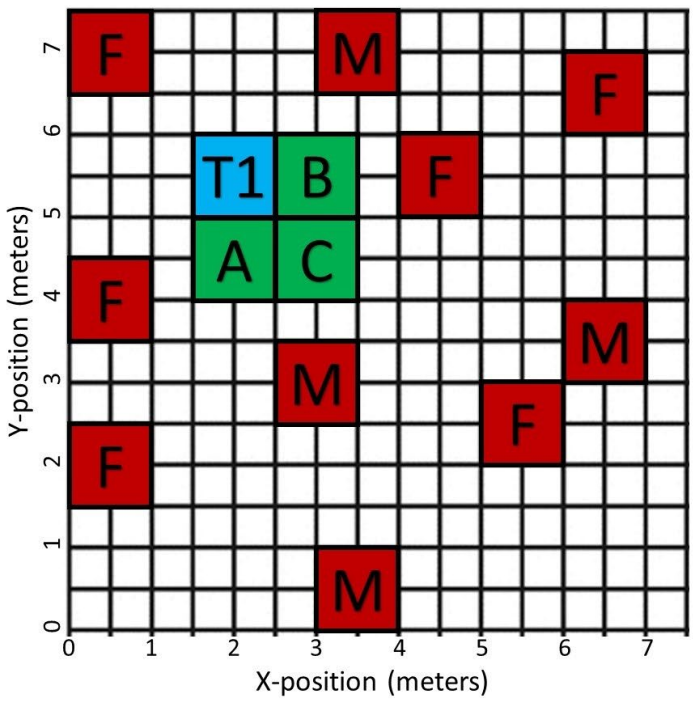
B: Beside the target

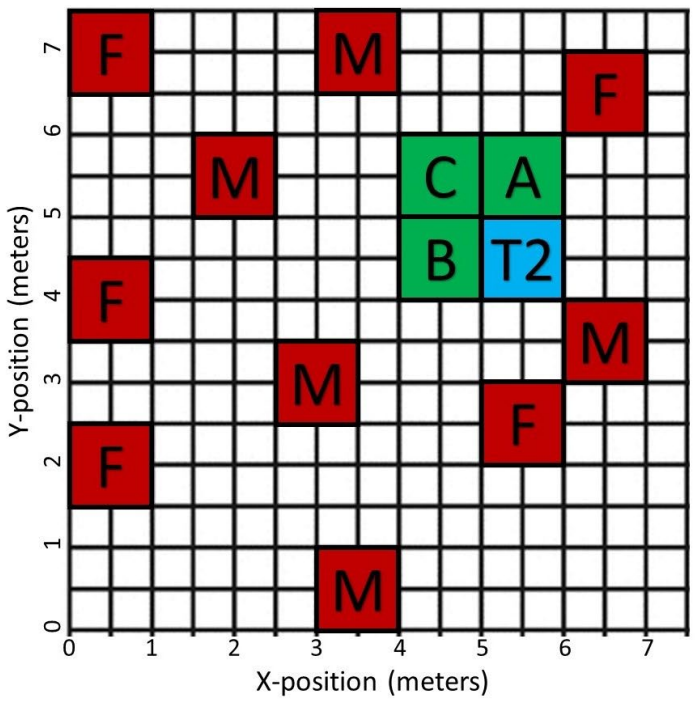
C: Corner opposite target

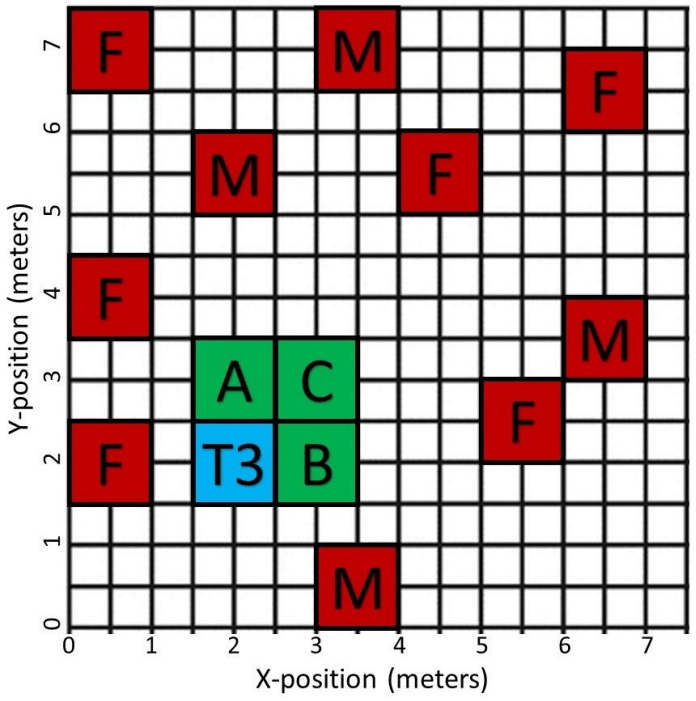
All Talkers individually rendered using 3D Tune-In Toolkit[1]

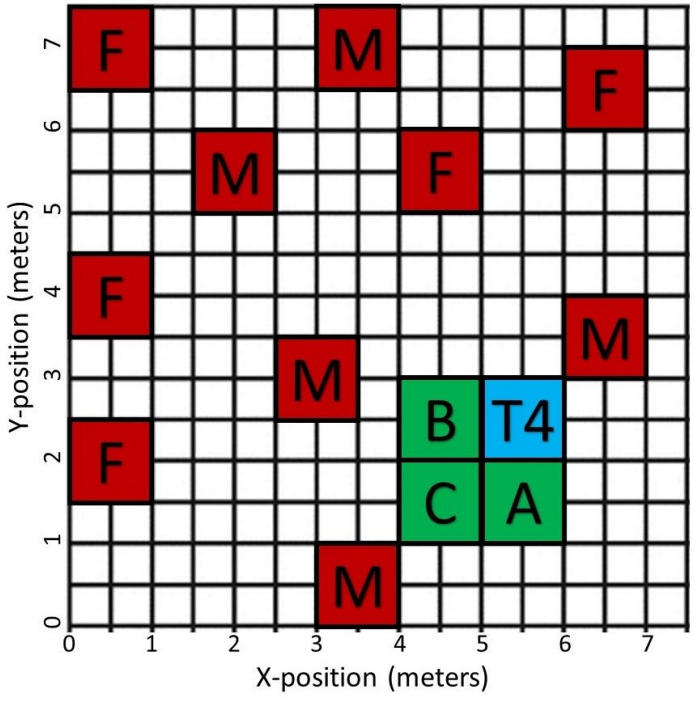
- Intensity based on distance to listener
- Binaural cues based on generic HRTF
- Anechoic simulation

[1]Cuevas-Rodriguez et al., 2019









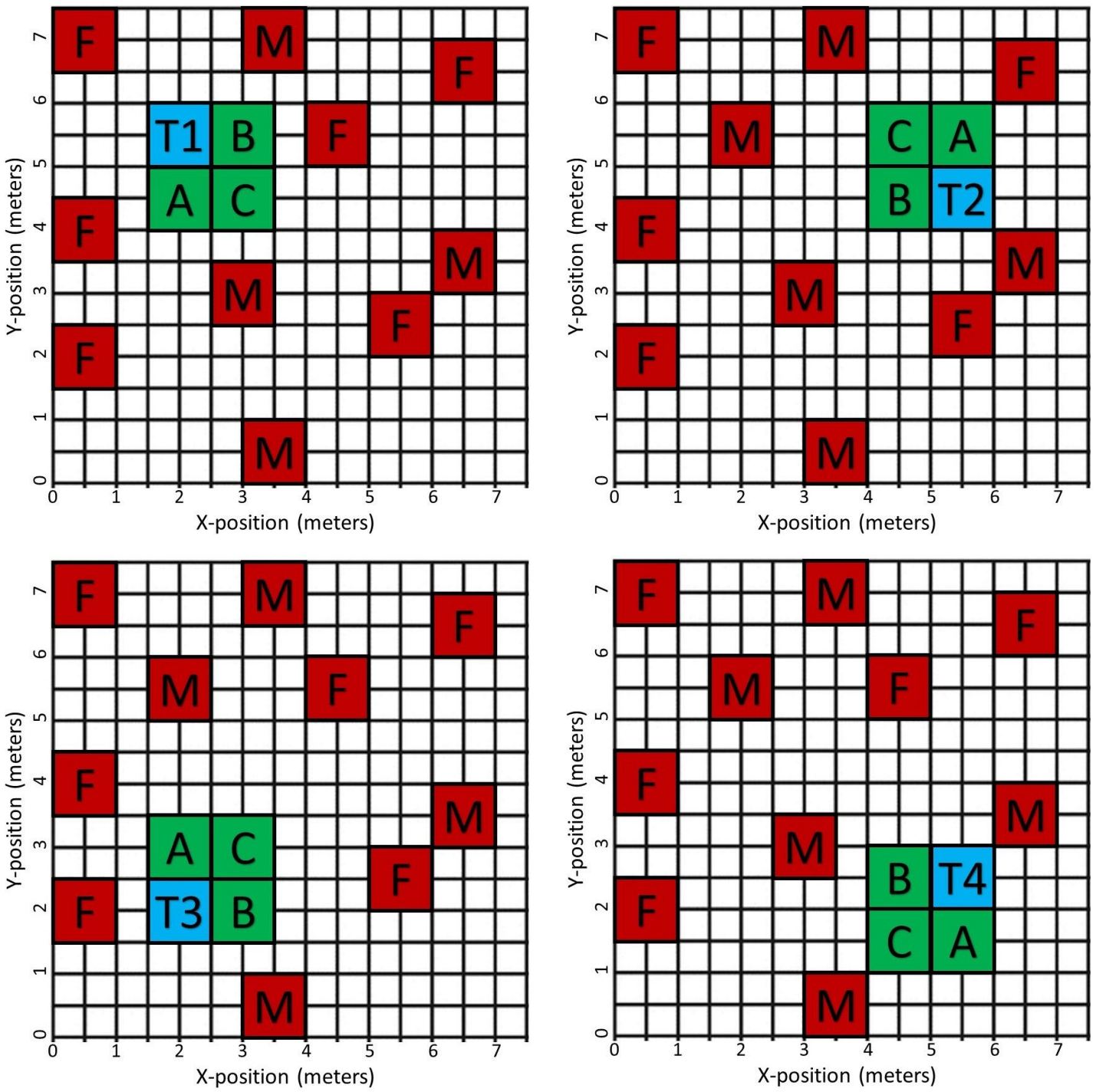
Simulated Restaurant

Female Target Talker (blue)

- Always 1m away at 0°
- BKB sentences (24 per condition)
- Intensity level adapts to estimate psychometric function and 50% correct threshold

Ten Maskers (red; male & female)

- Variable distance and angle, based on listener's position
- Narrative passages[1]
- Intensity set to 70 dB SPL at 1m away



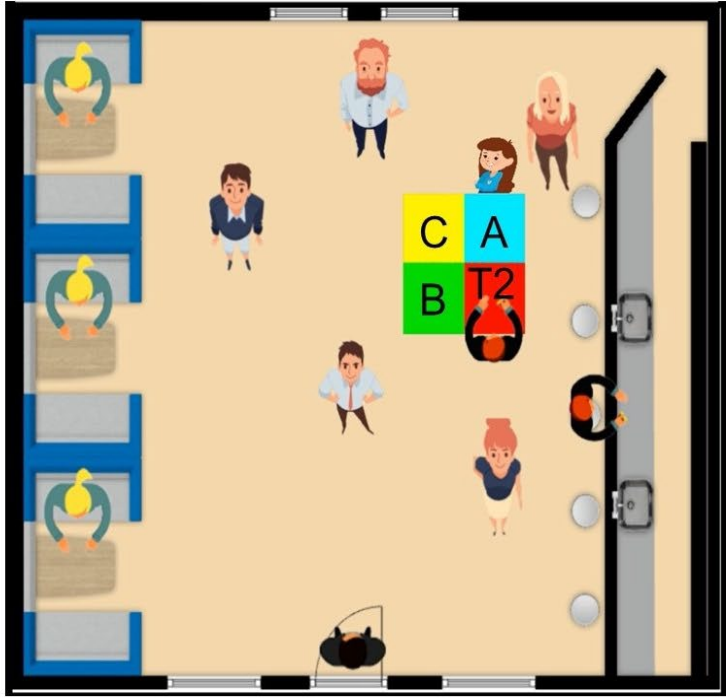
[1]Monson et al., 2013

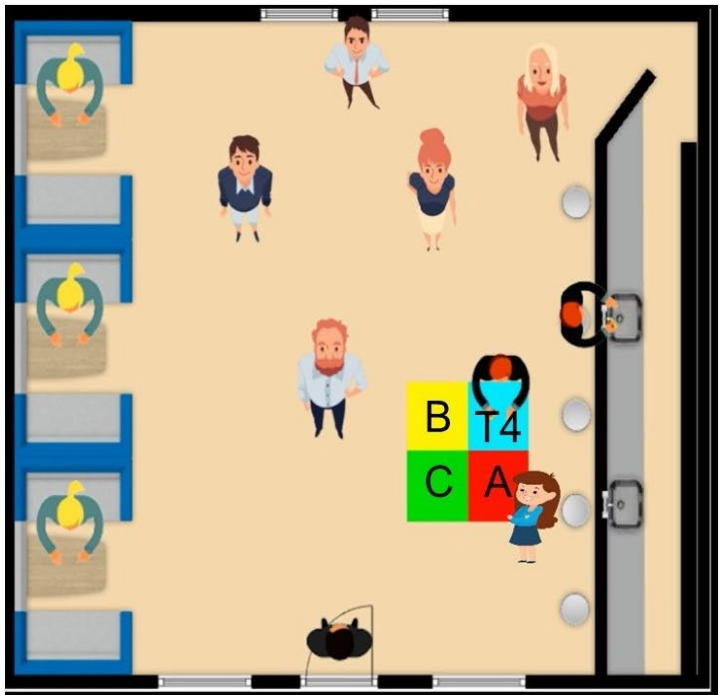
Graphical Interface

Participants knows which “seat” they are in during testing

Used to solicit “preferred seat” before and after testing

- Preferred seat at each table
- Preferred table overall





Tablet-based visual interface designed by Maria Sarier (undergrad)

Participants (n=66)

TOWSON UNIVERSITY

34 younger adults (19-39 years)

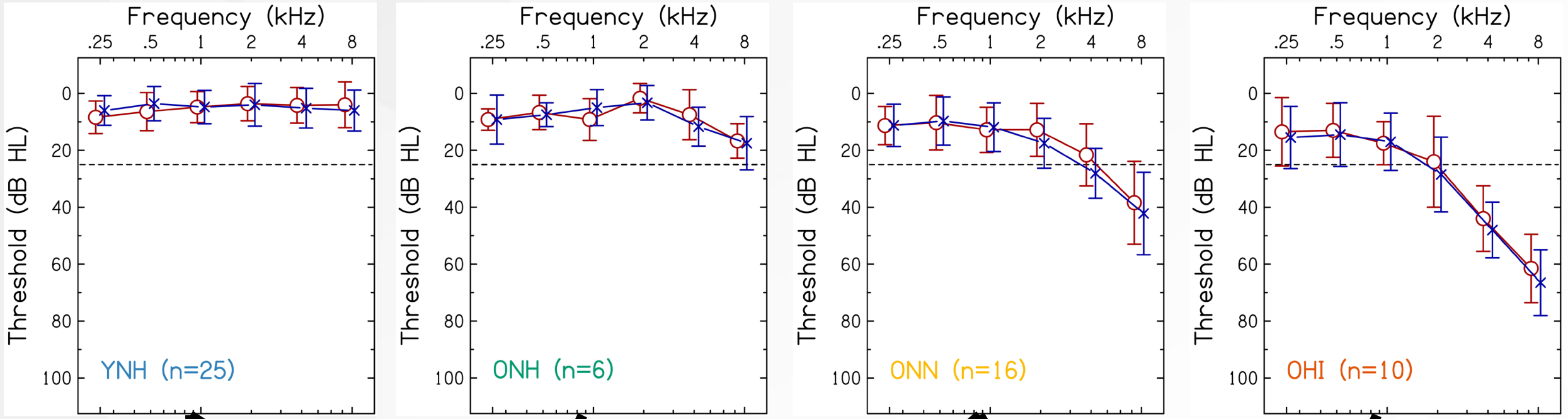
- 25 with normal hearing (**YNH**)
  - ≤ 25 dB HL for .25-8 kHz
- 1 with near-normal hearing
  - ≤ 35 dB HL for .25-4 kHz
- 3 with symmetrical hearing loss
  - Various etiologies
- 5 with unilateral or asymmetric hearing loss
  - Various etiologies

Karina Ball
AuD Thesis

32 older adults (51-83 years)

- 6 with normal hearing (**ONH**)
  - ≤ 25 dB HL for .25-8 kHz
- 16 with near-normal hearing (**ONN**)
  - ≤ 35 dB HL for .25-4 kHz
- 10 with symmetrical hearing loss (**OHI**)
  - Sensorineural hearing loss

Average Audiograms



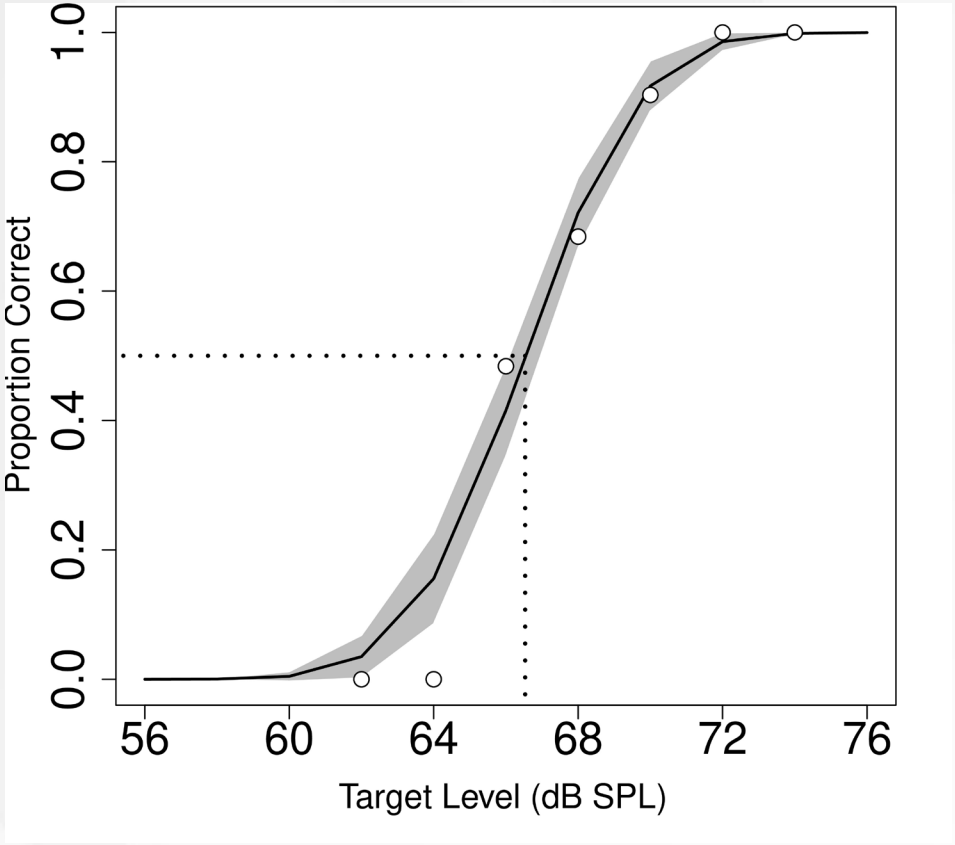
Effects of seat and table position

Effect of age (without HL)

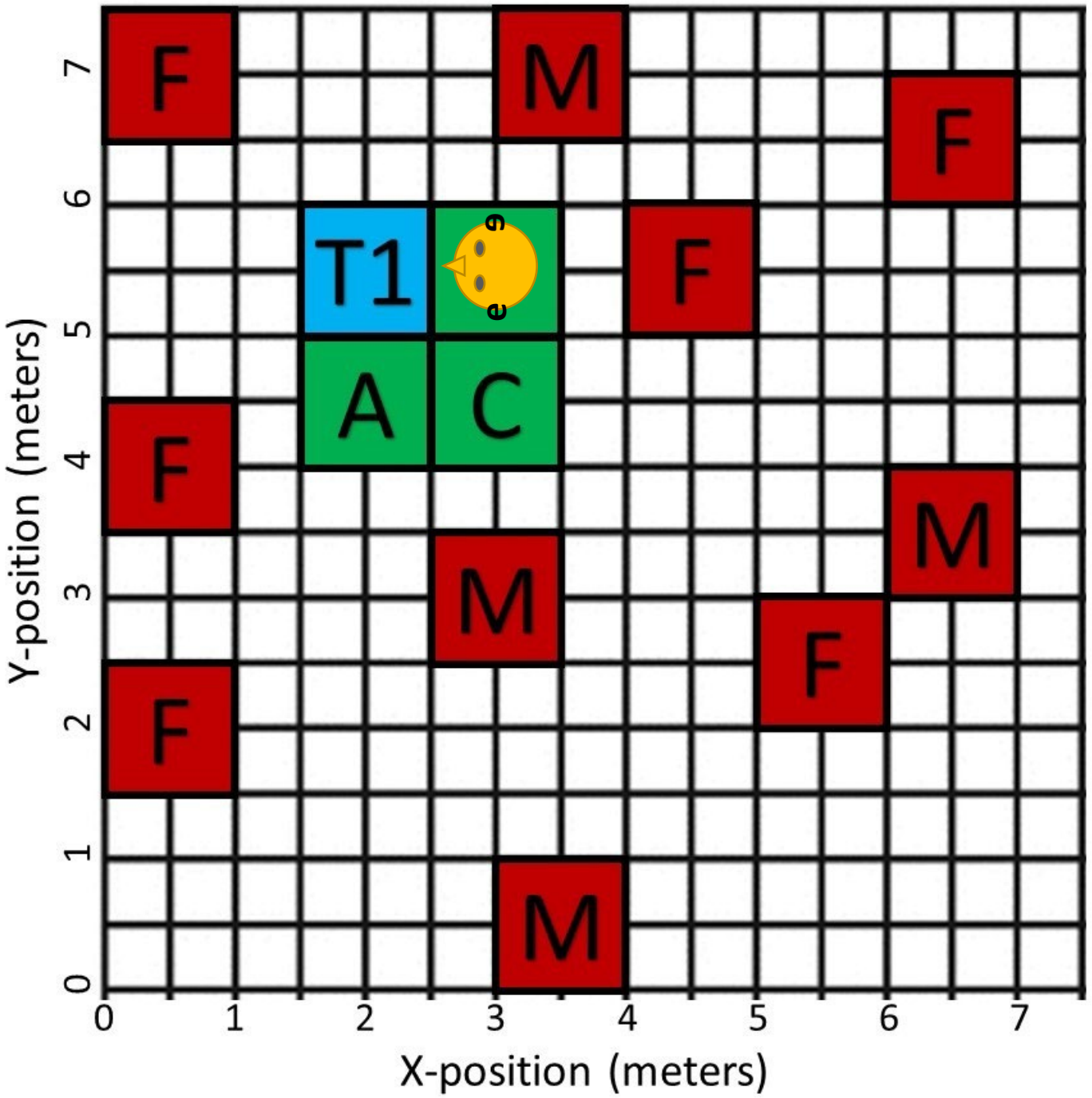
Effects of age + subtle high-frequency hearing loss

Effect of more substantial hearing loss

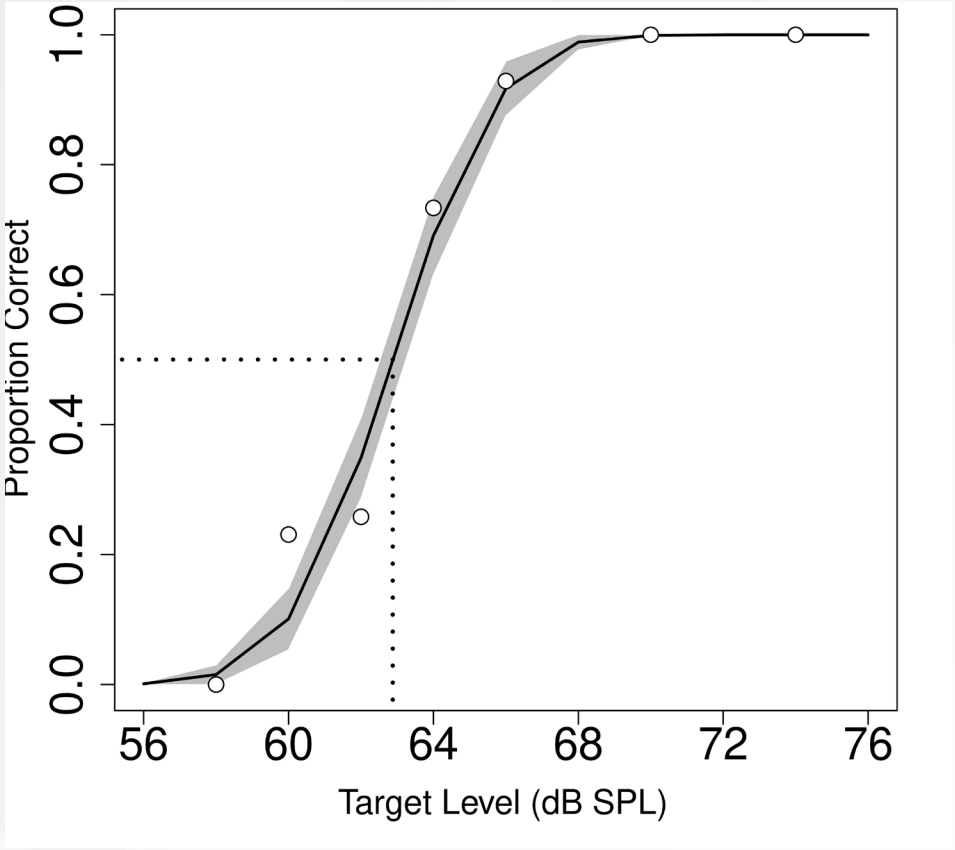
Data Analysis



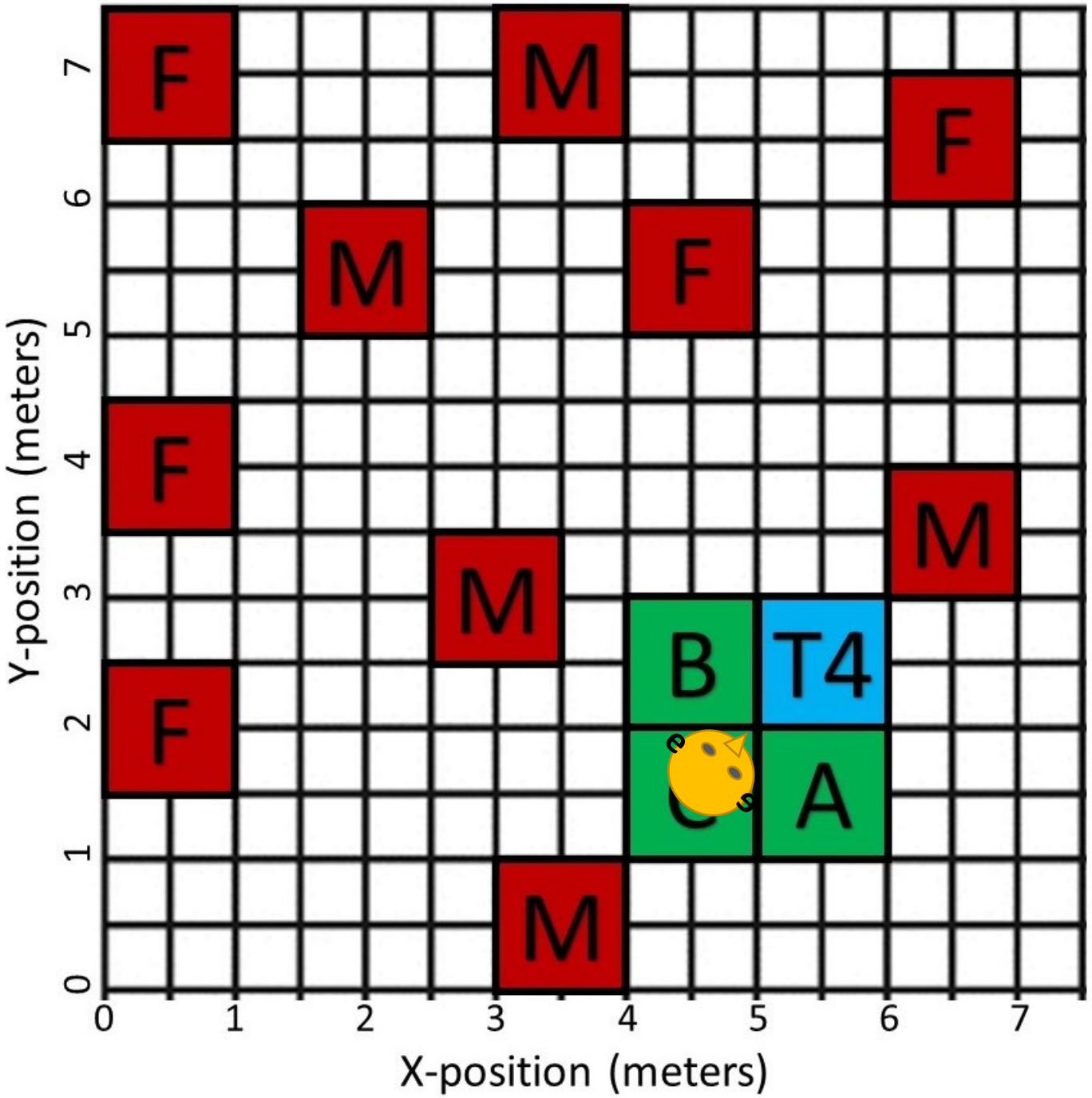
Threshold = 66.53 dB SPL



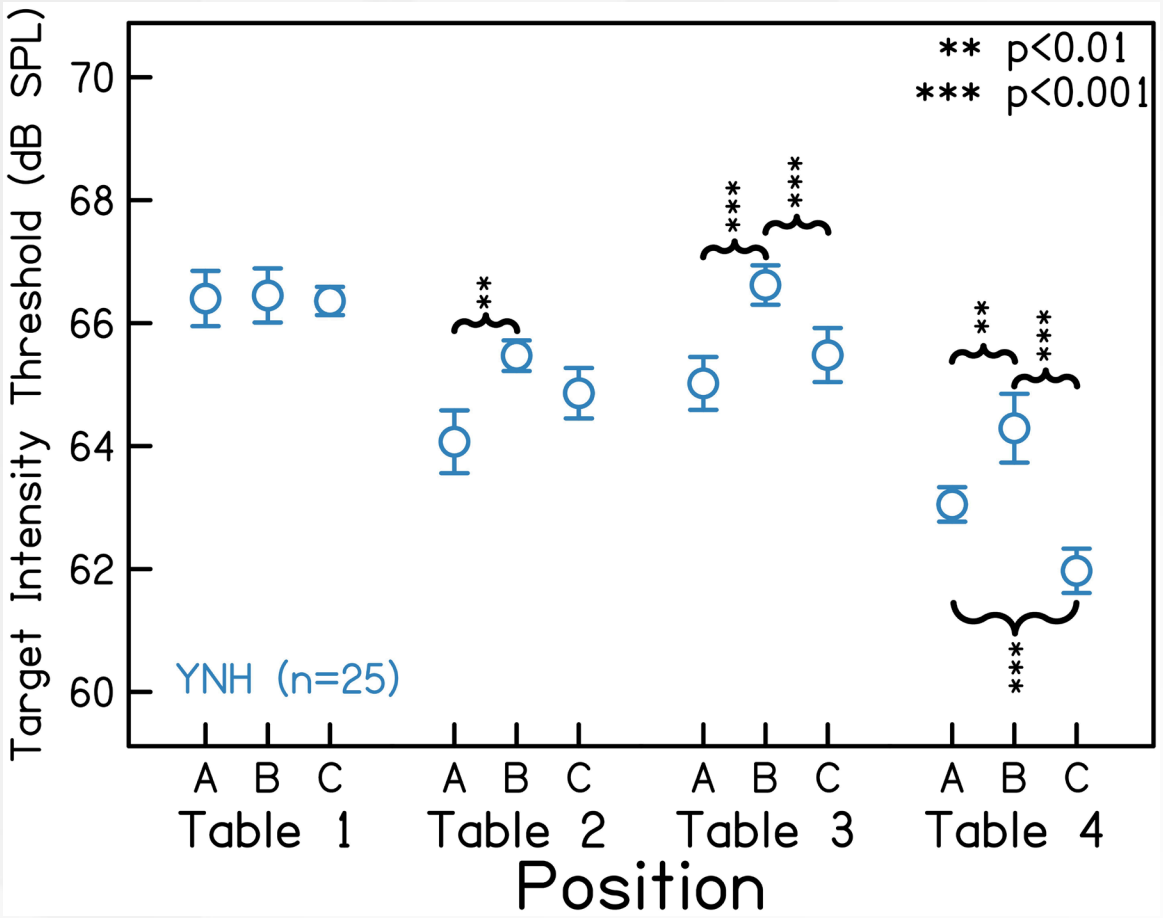
Data Analysis

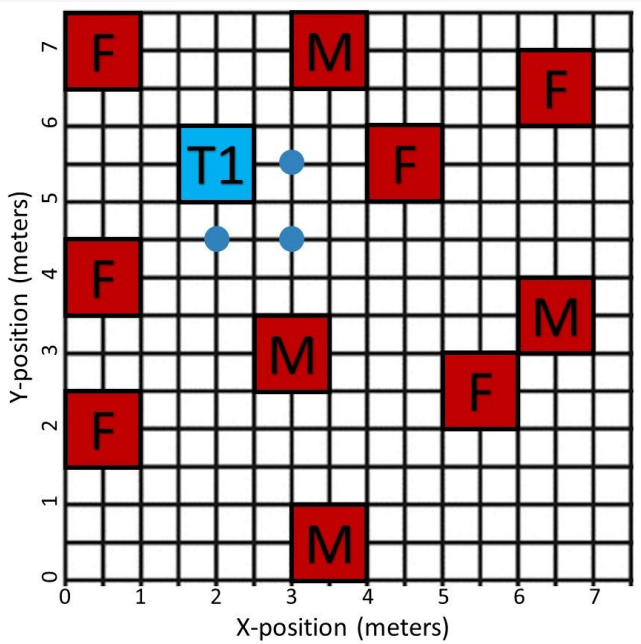


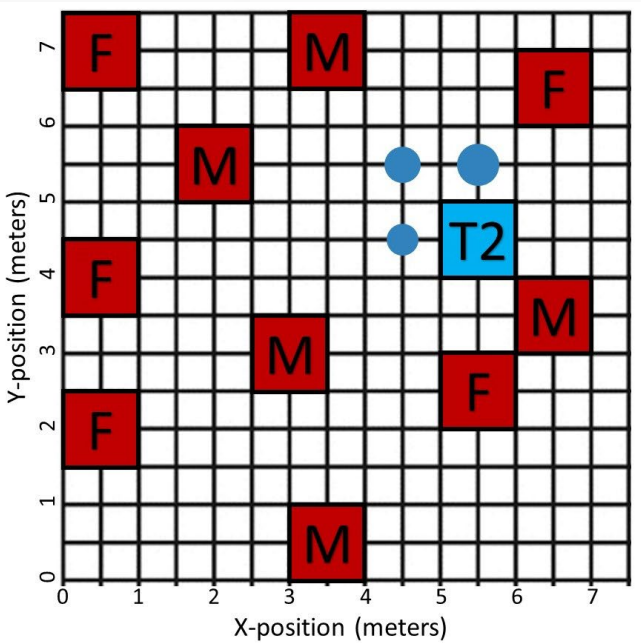
Threshold = 62.88 dB SPL

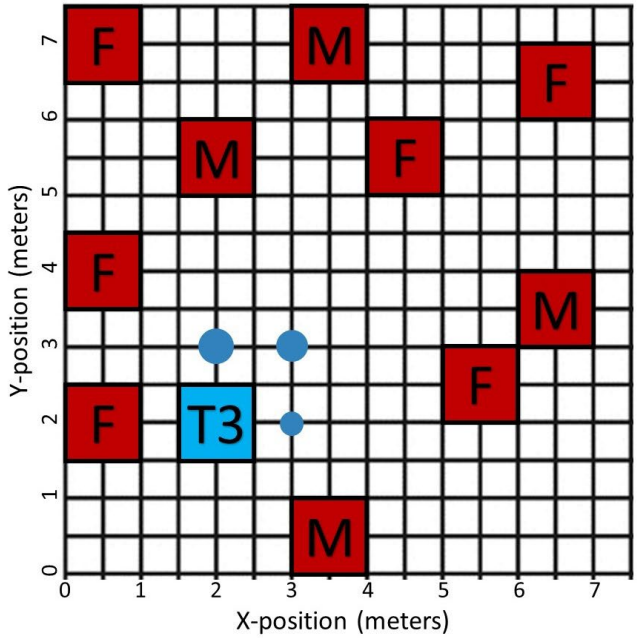


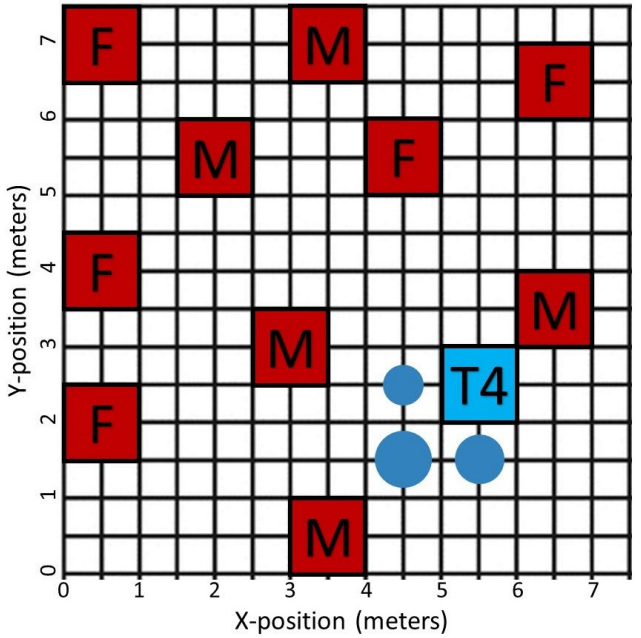
Effect of Position



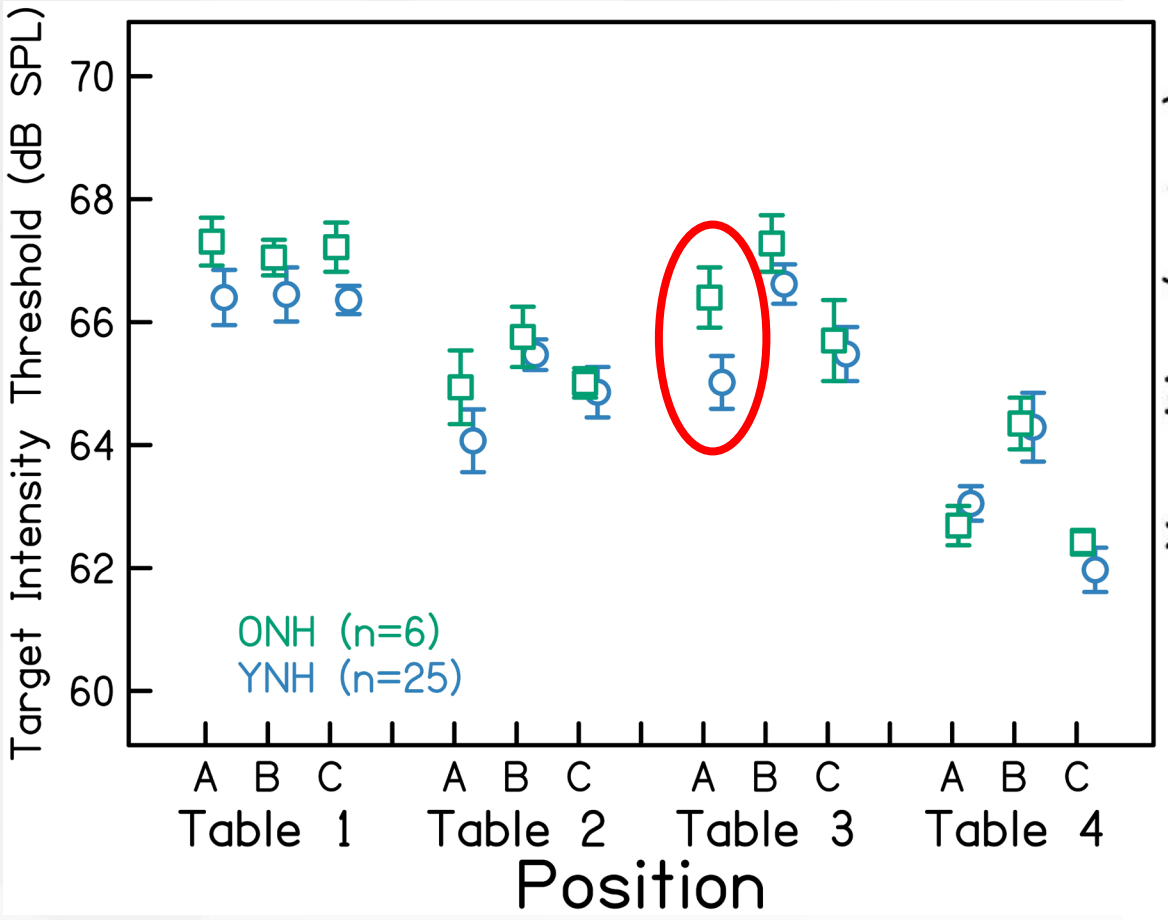


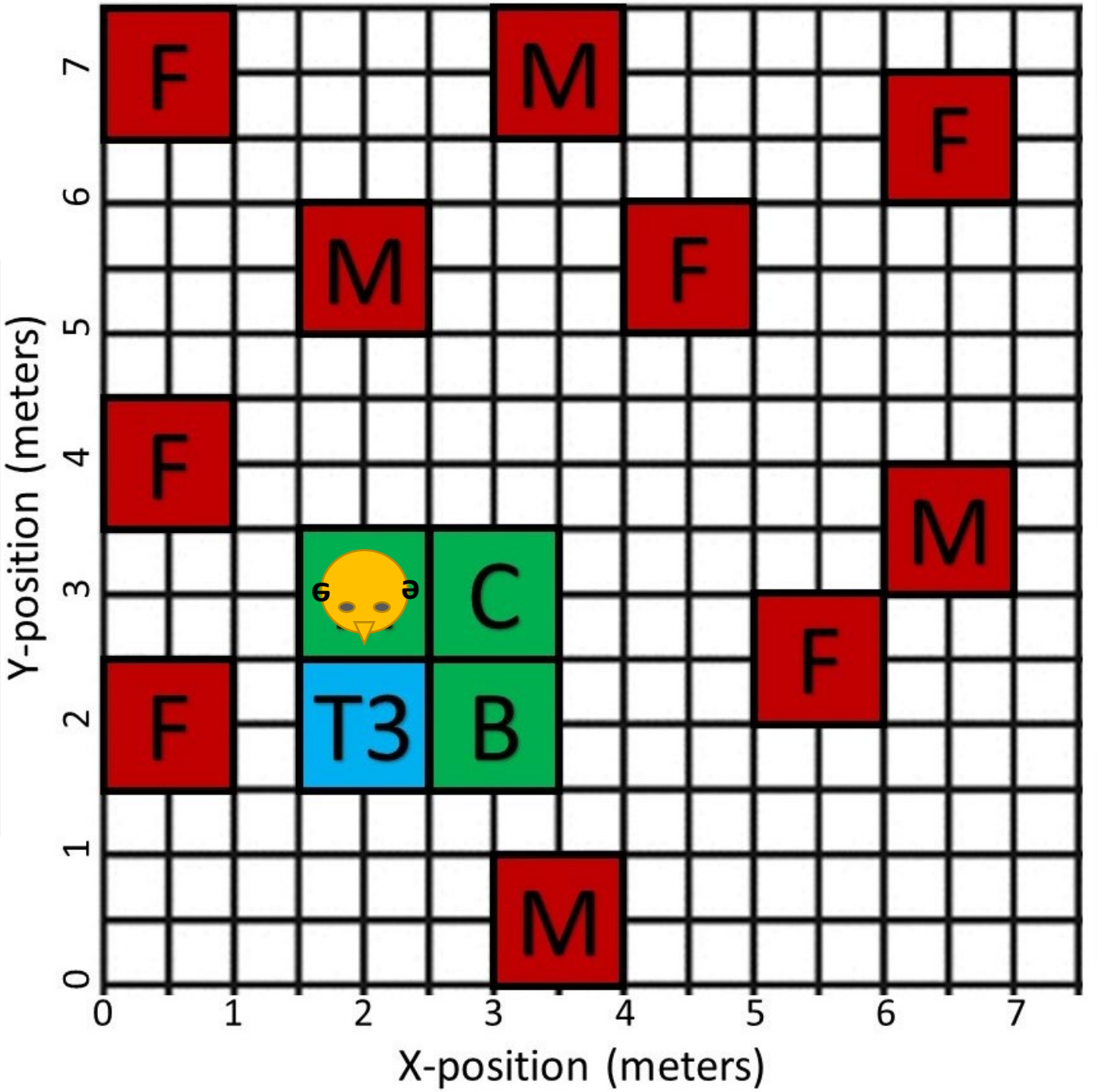




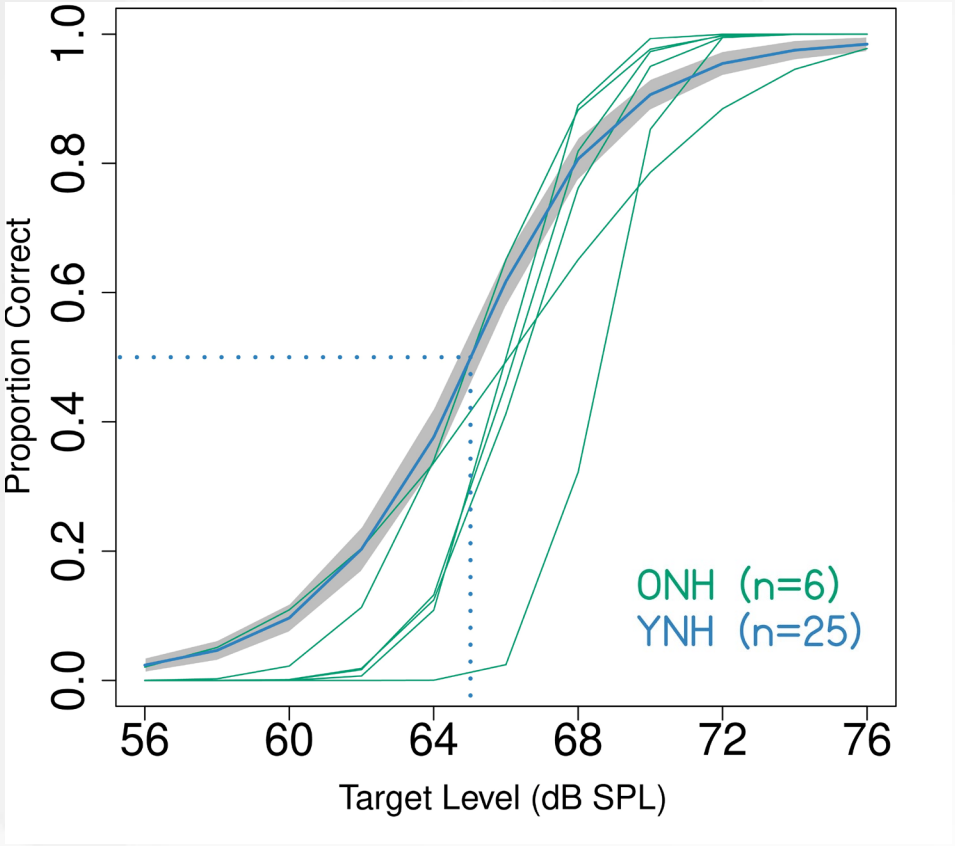


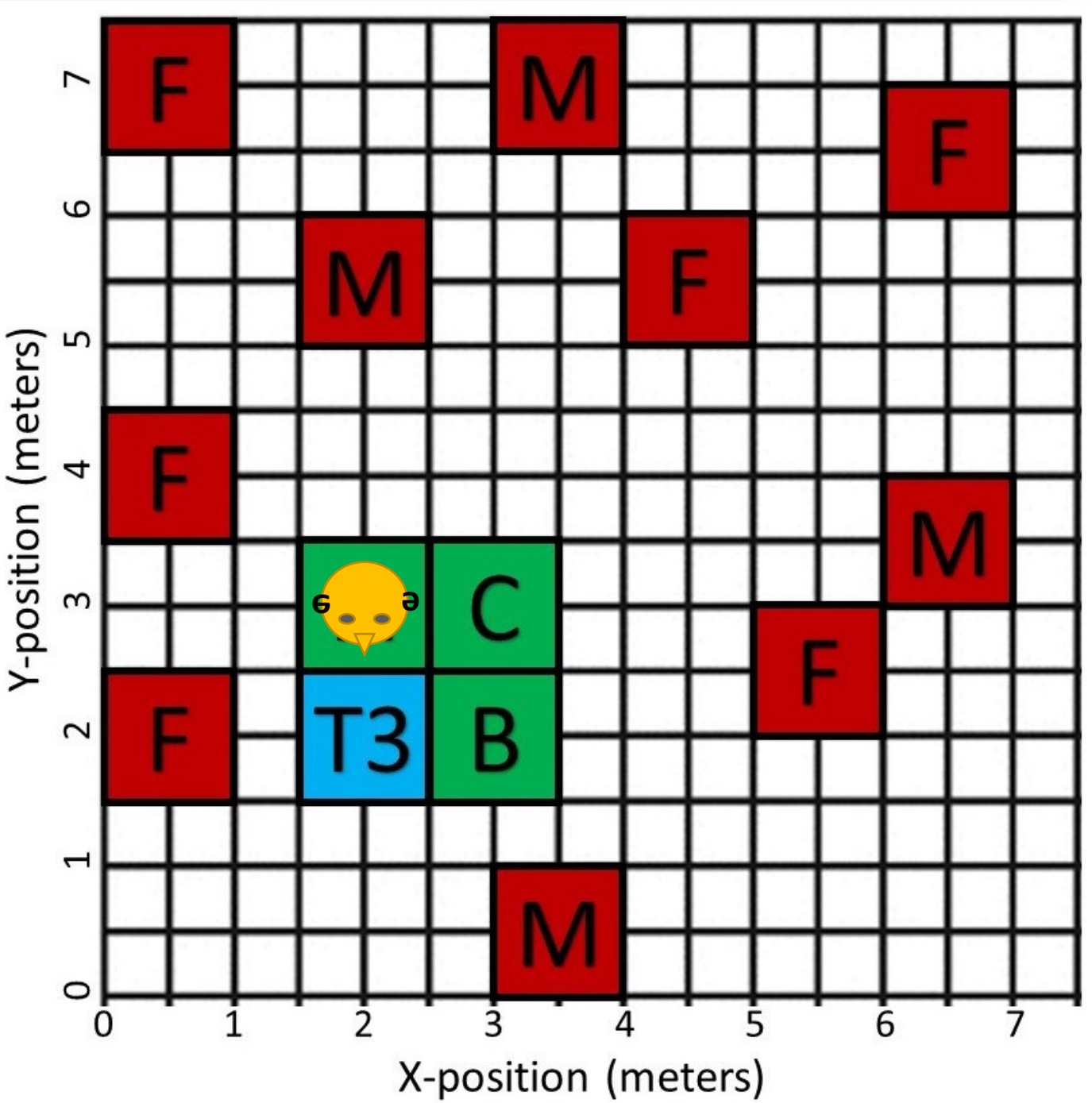
Effect of Age



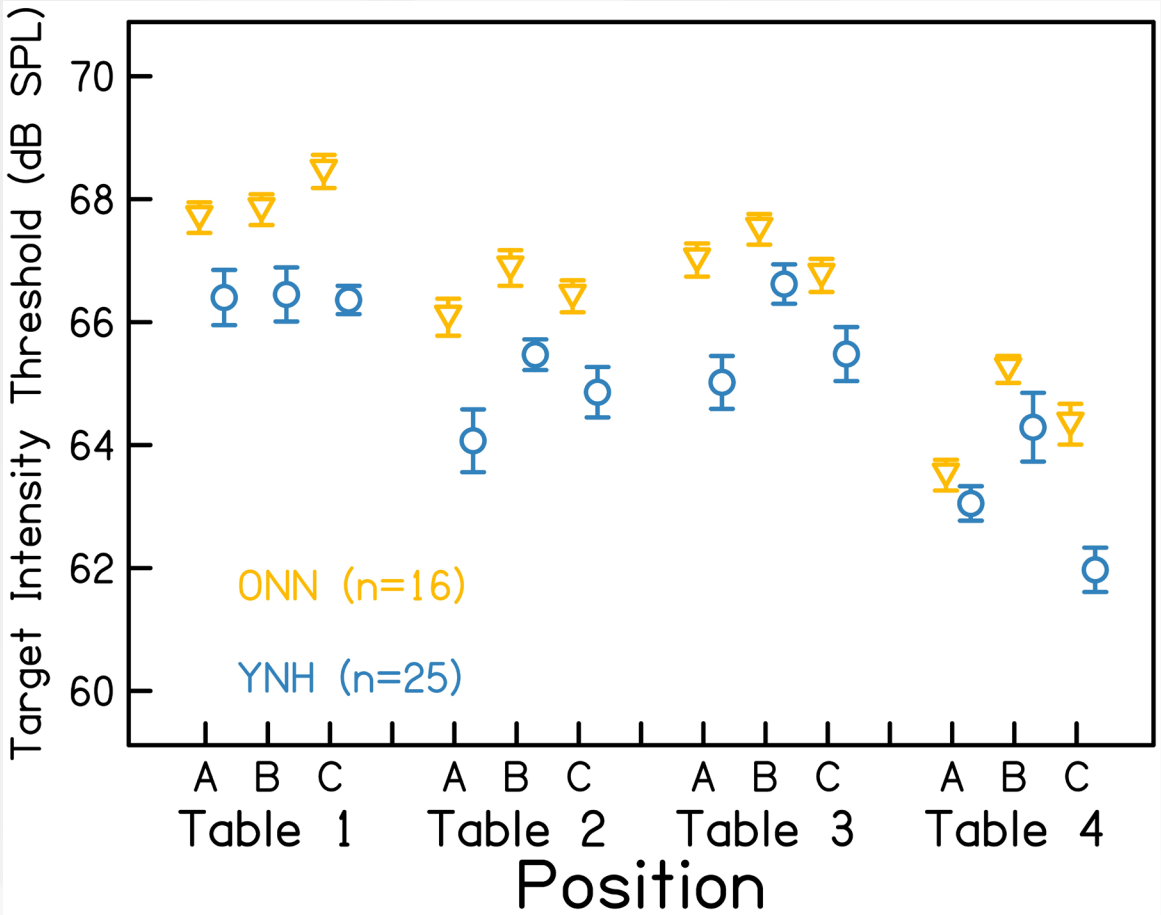


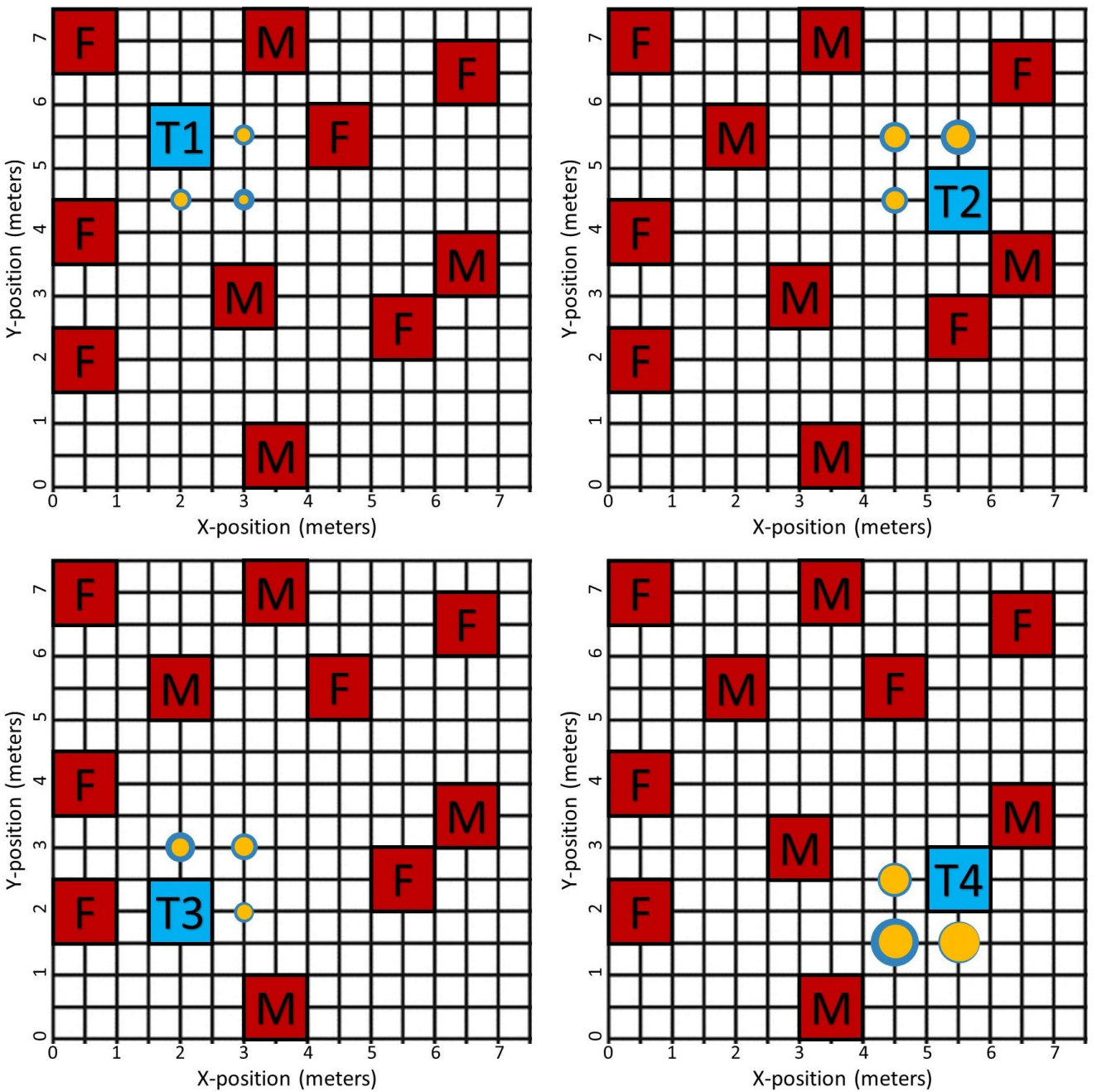
Effect of Age



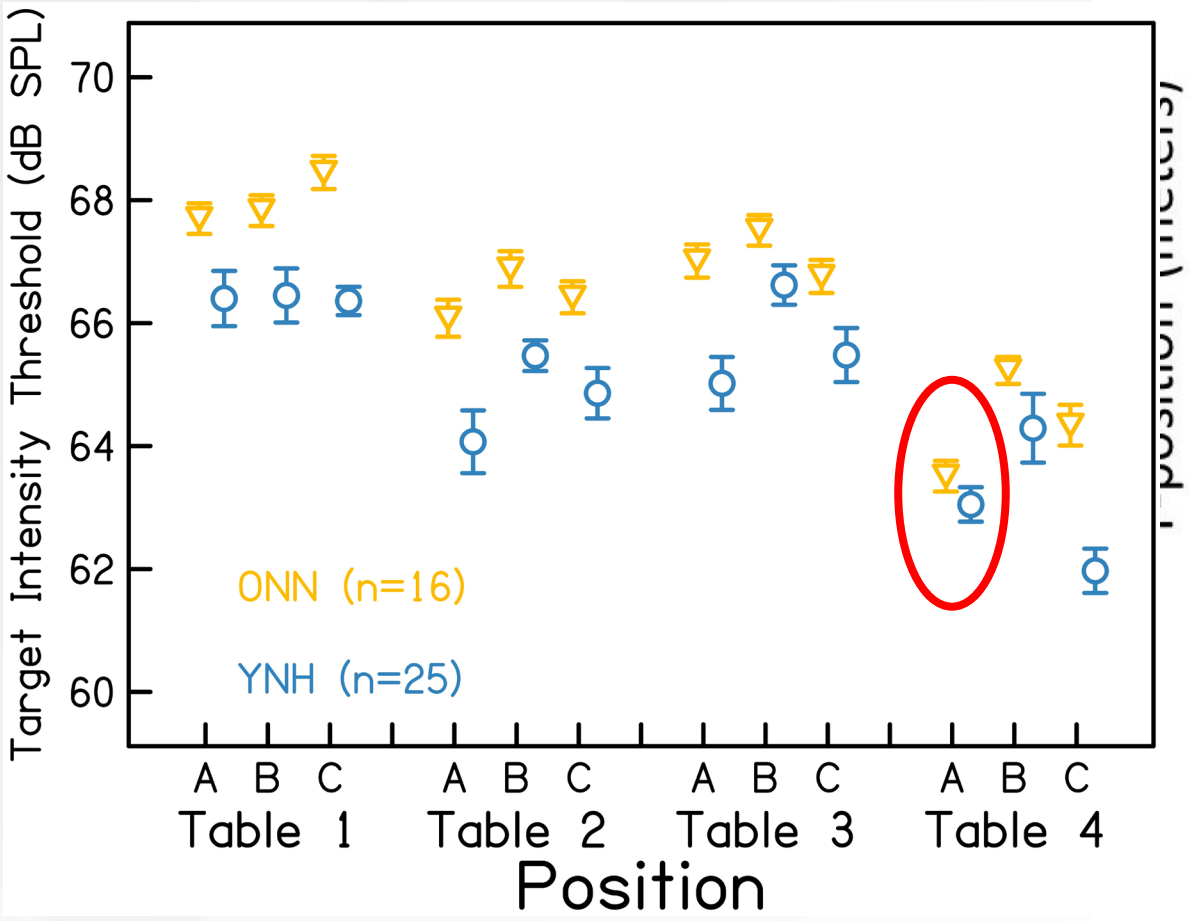


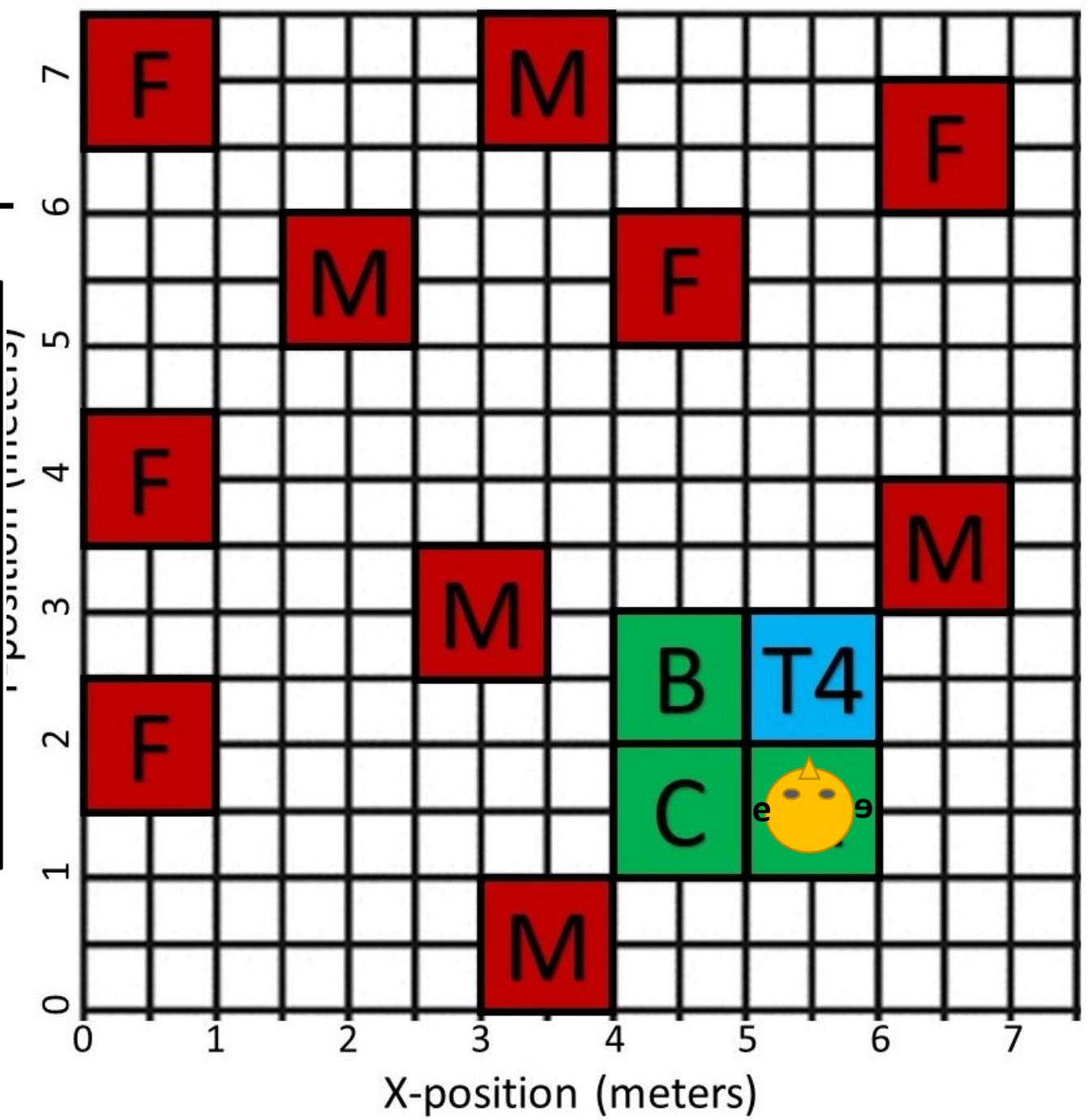
Effects Age + Subtle HL



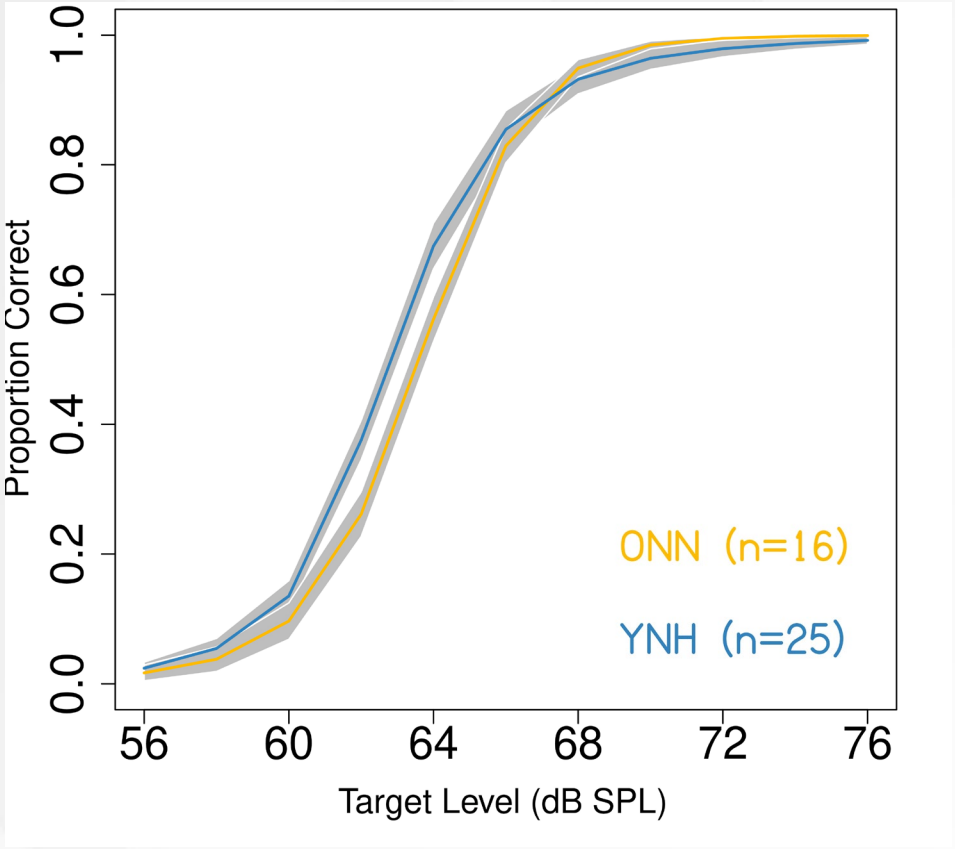


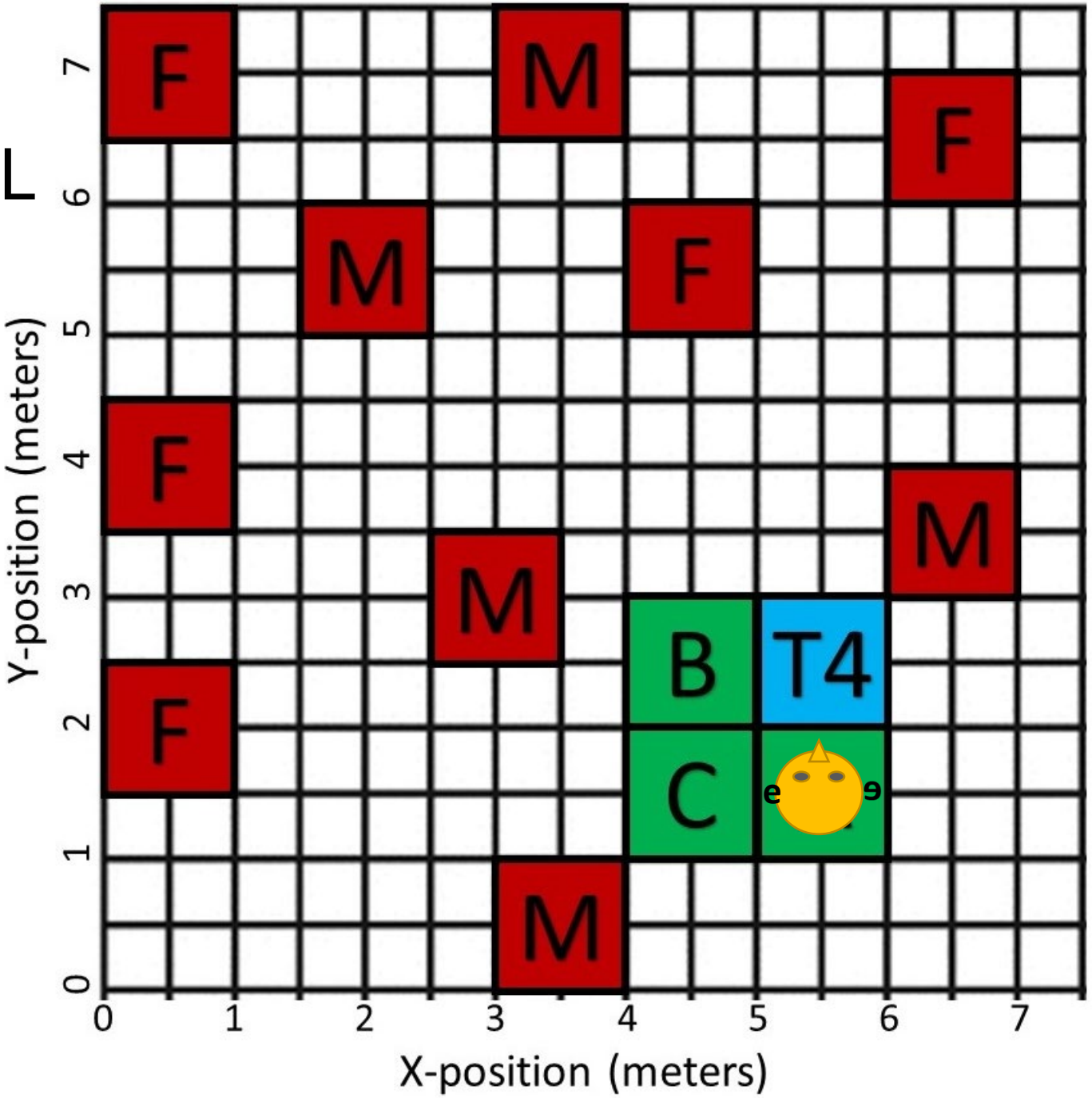
Effects Age + Subtle HL



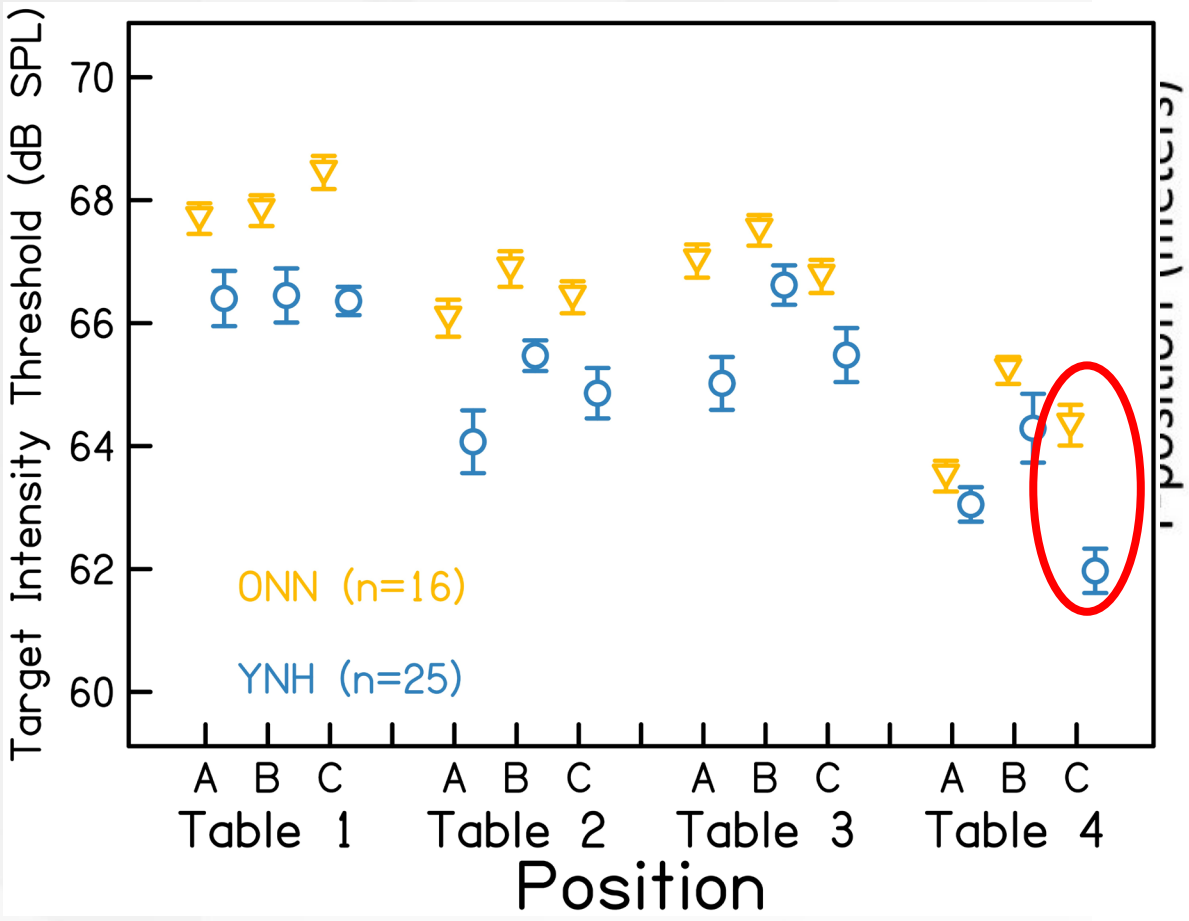


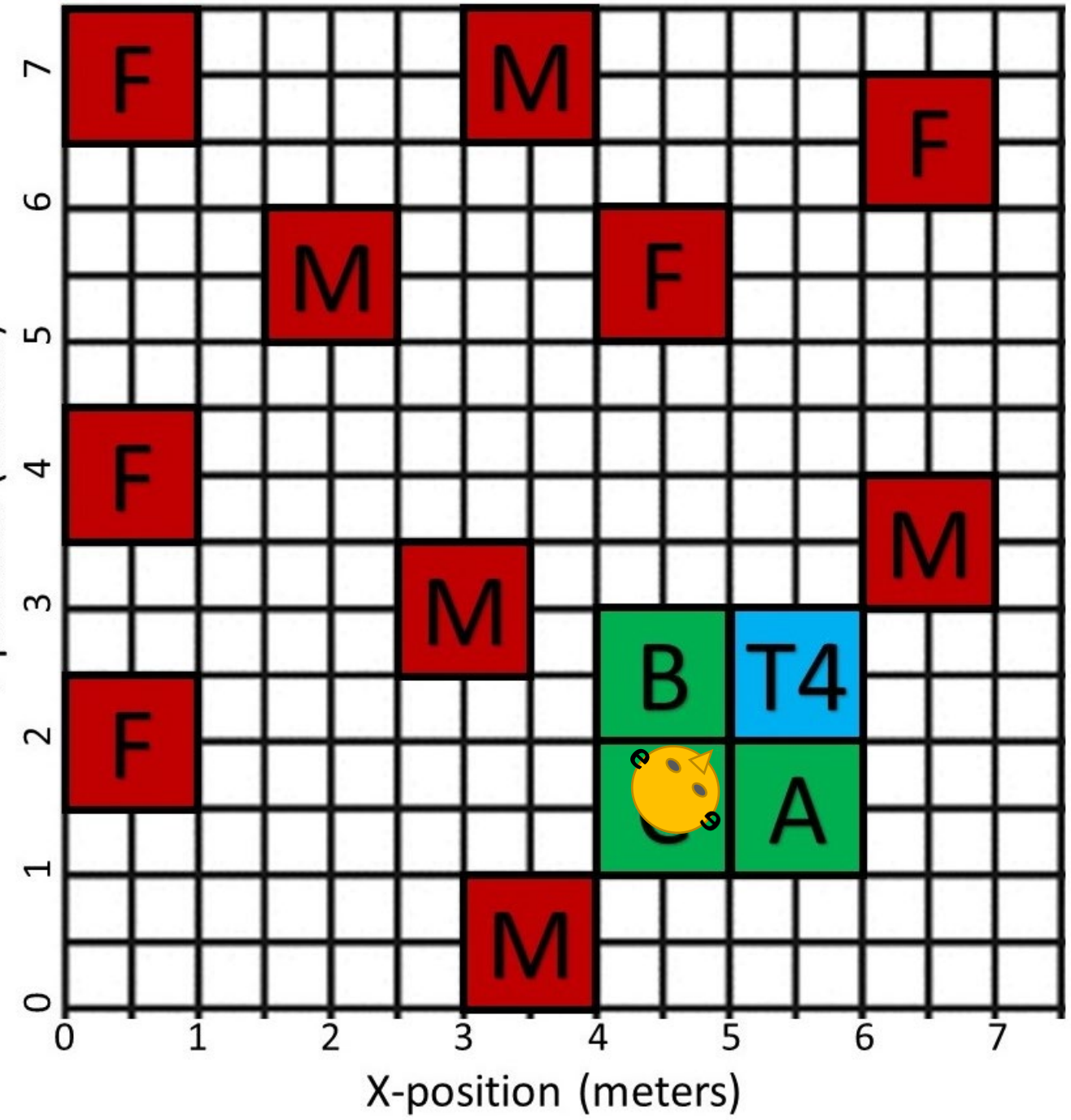
Effects Age + Subtle HL



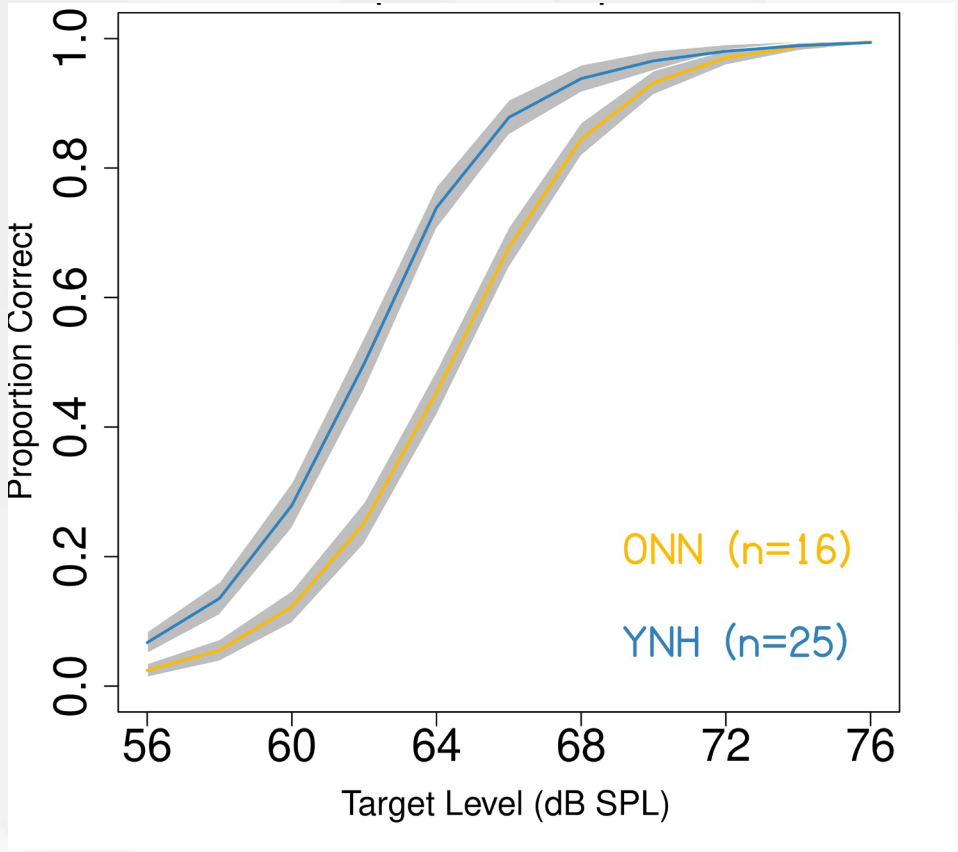


Effects Age + Subtle HL





Effects Age + Subtle HL



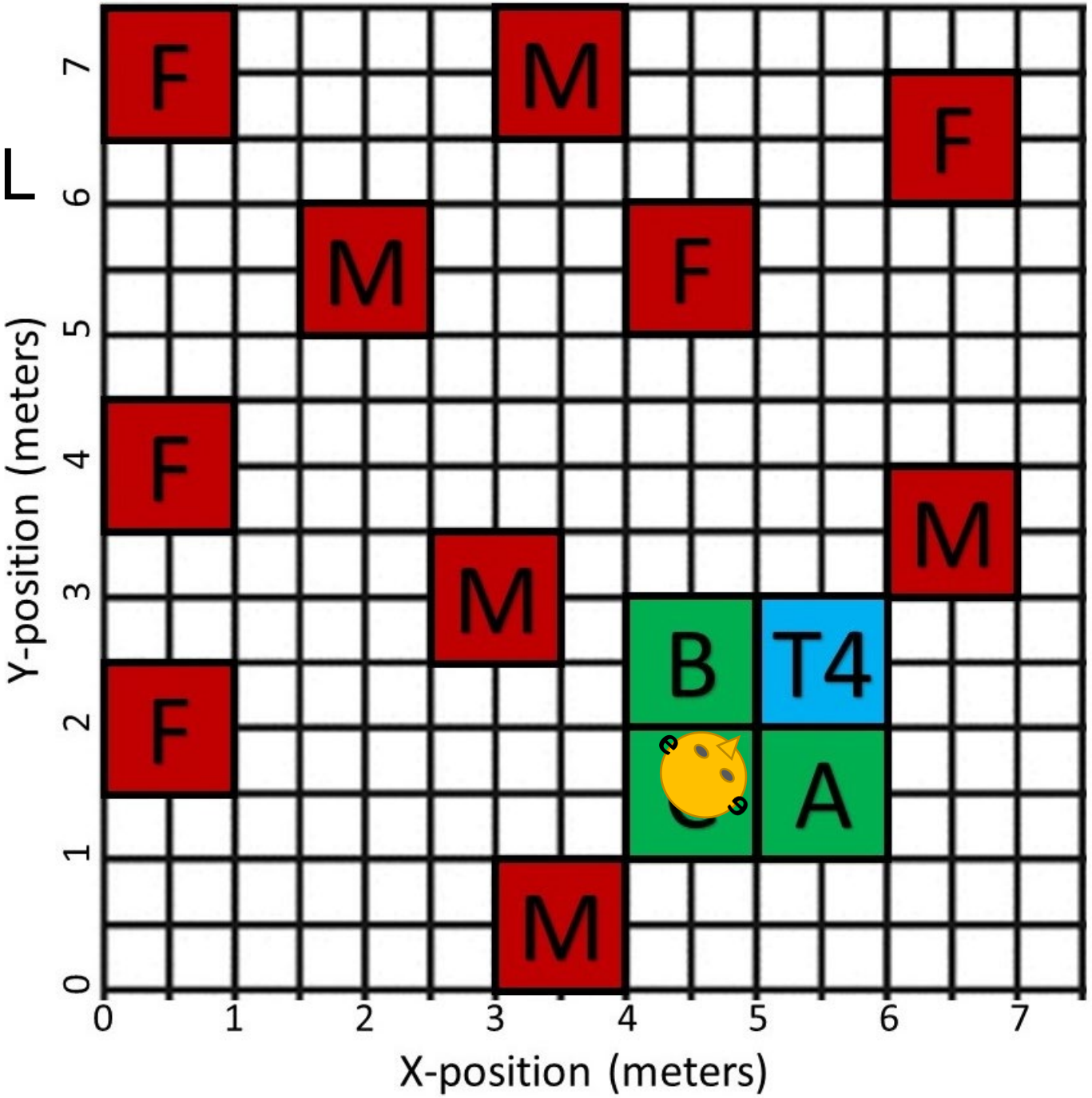
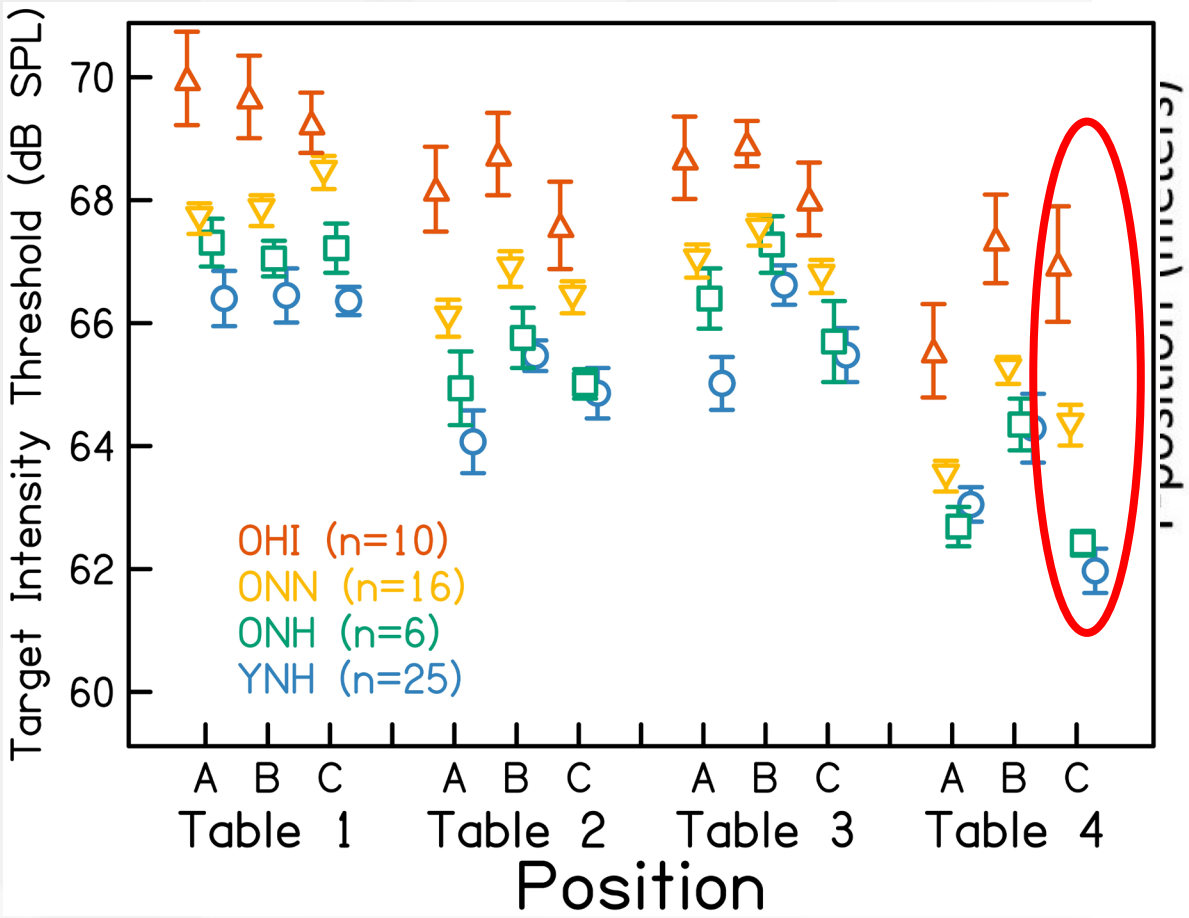
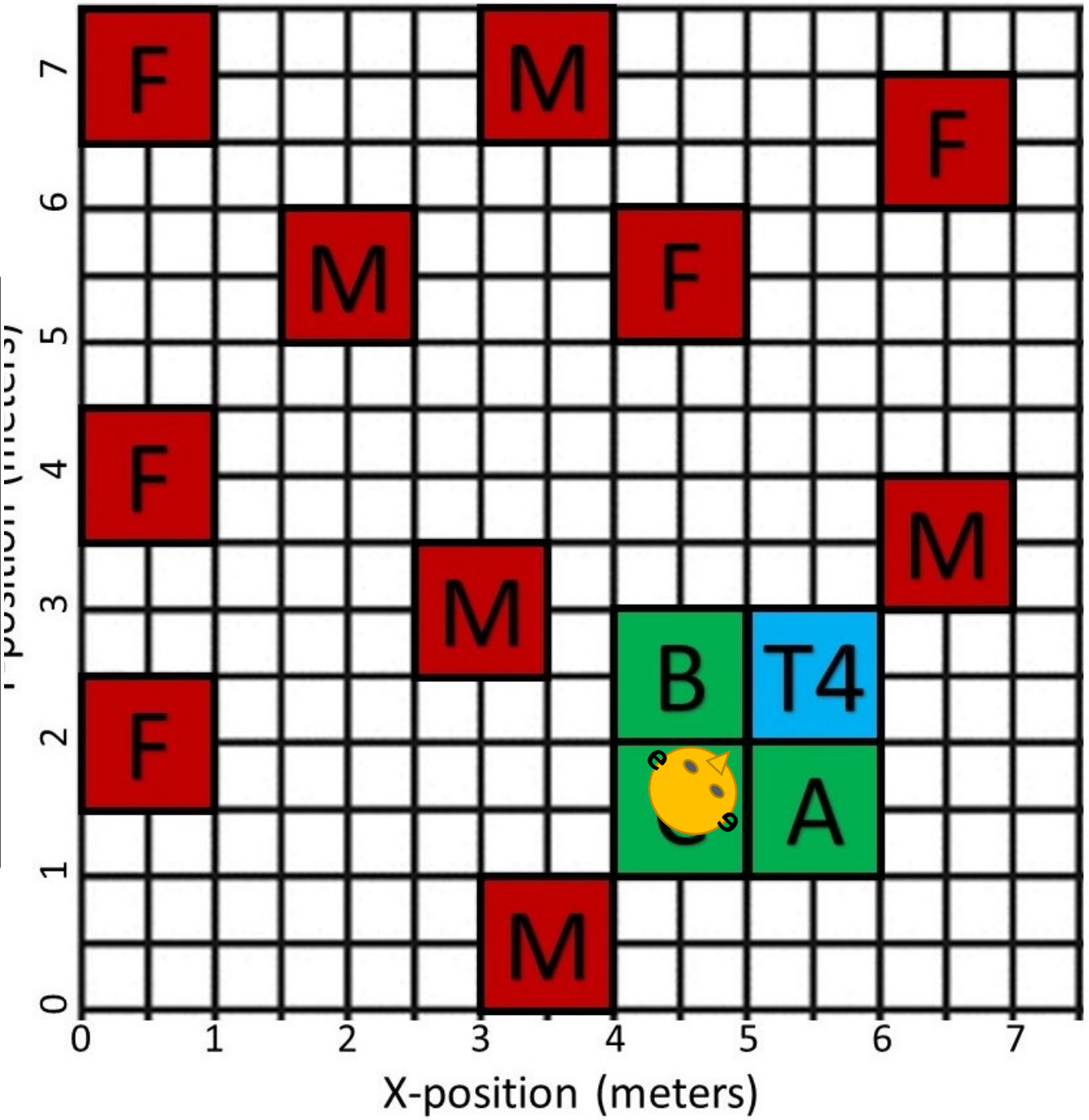
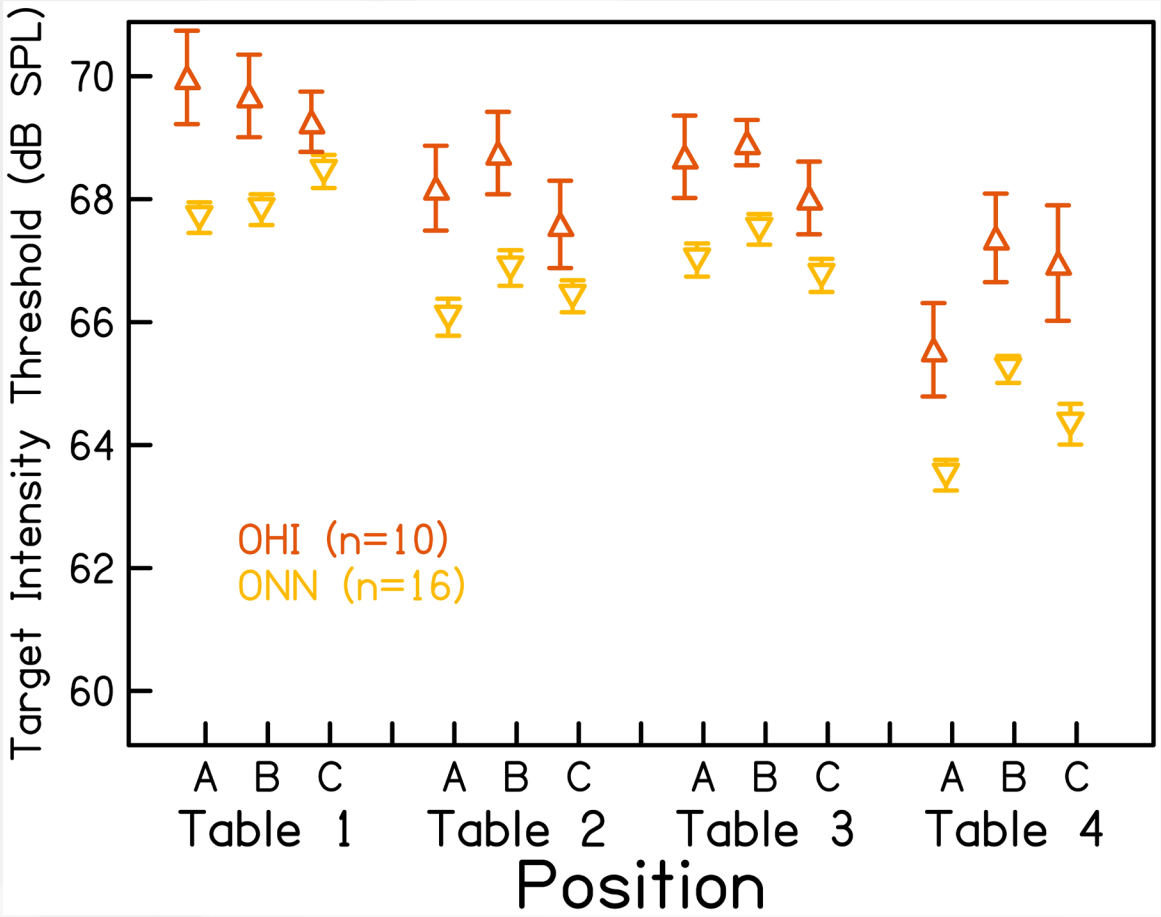


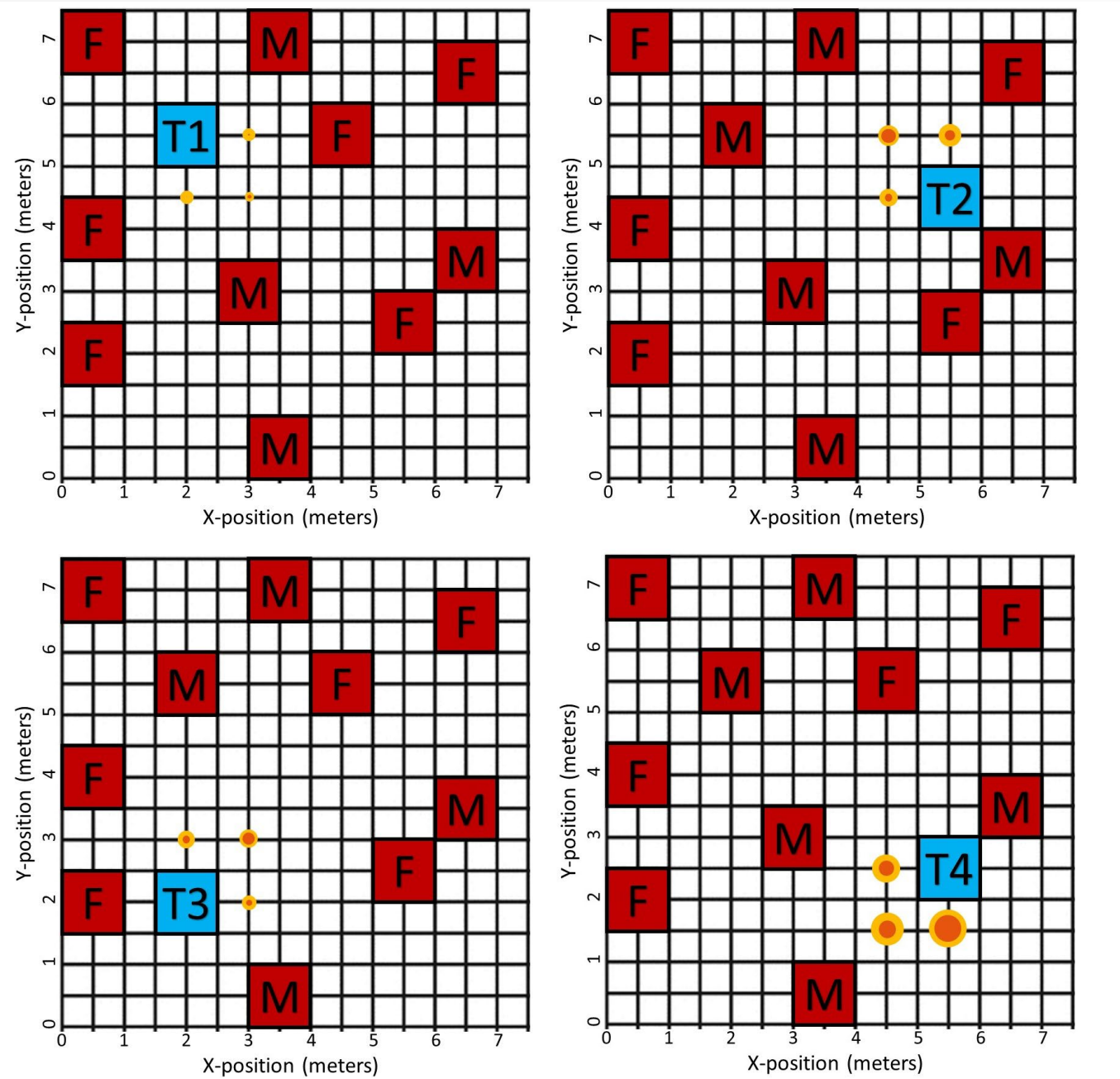
Table 4 Seat C



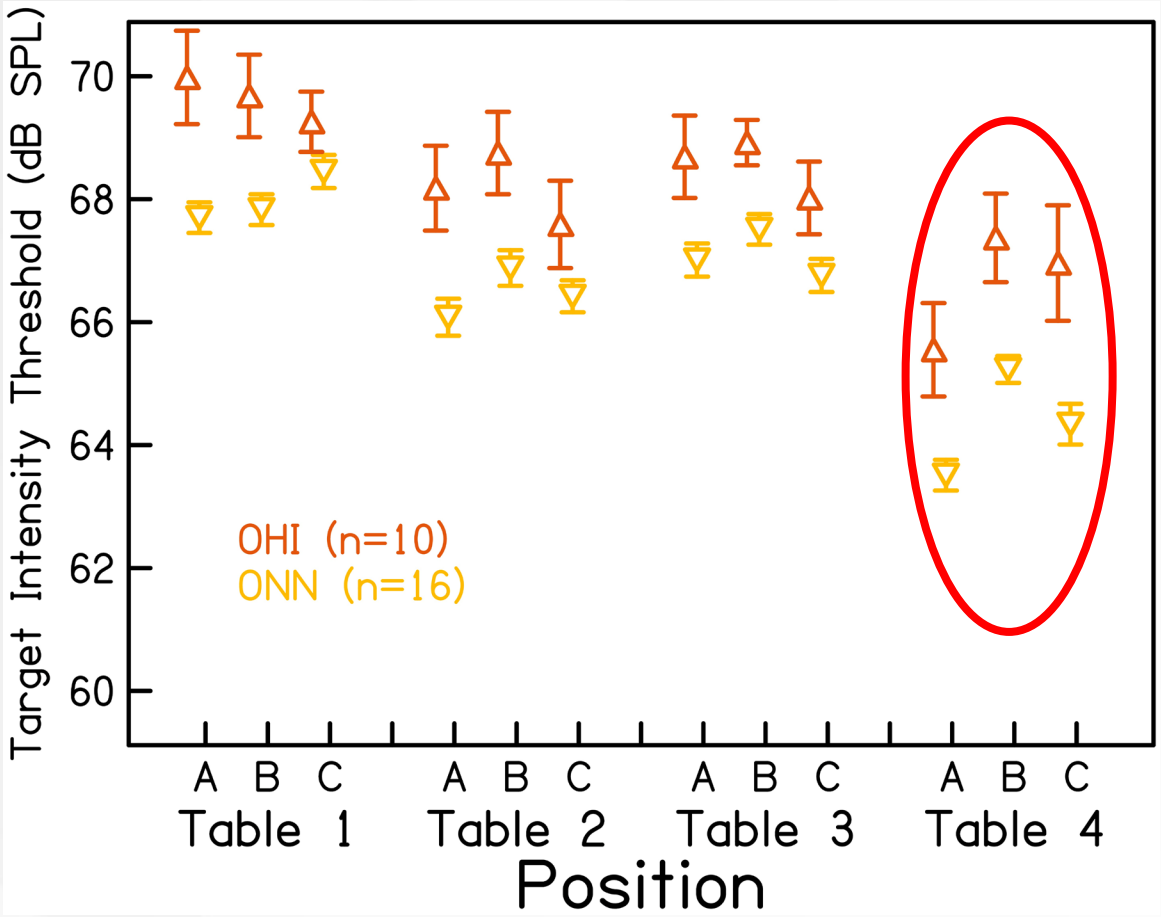


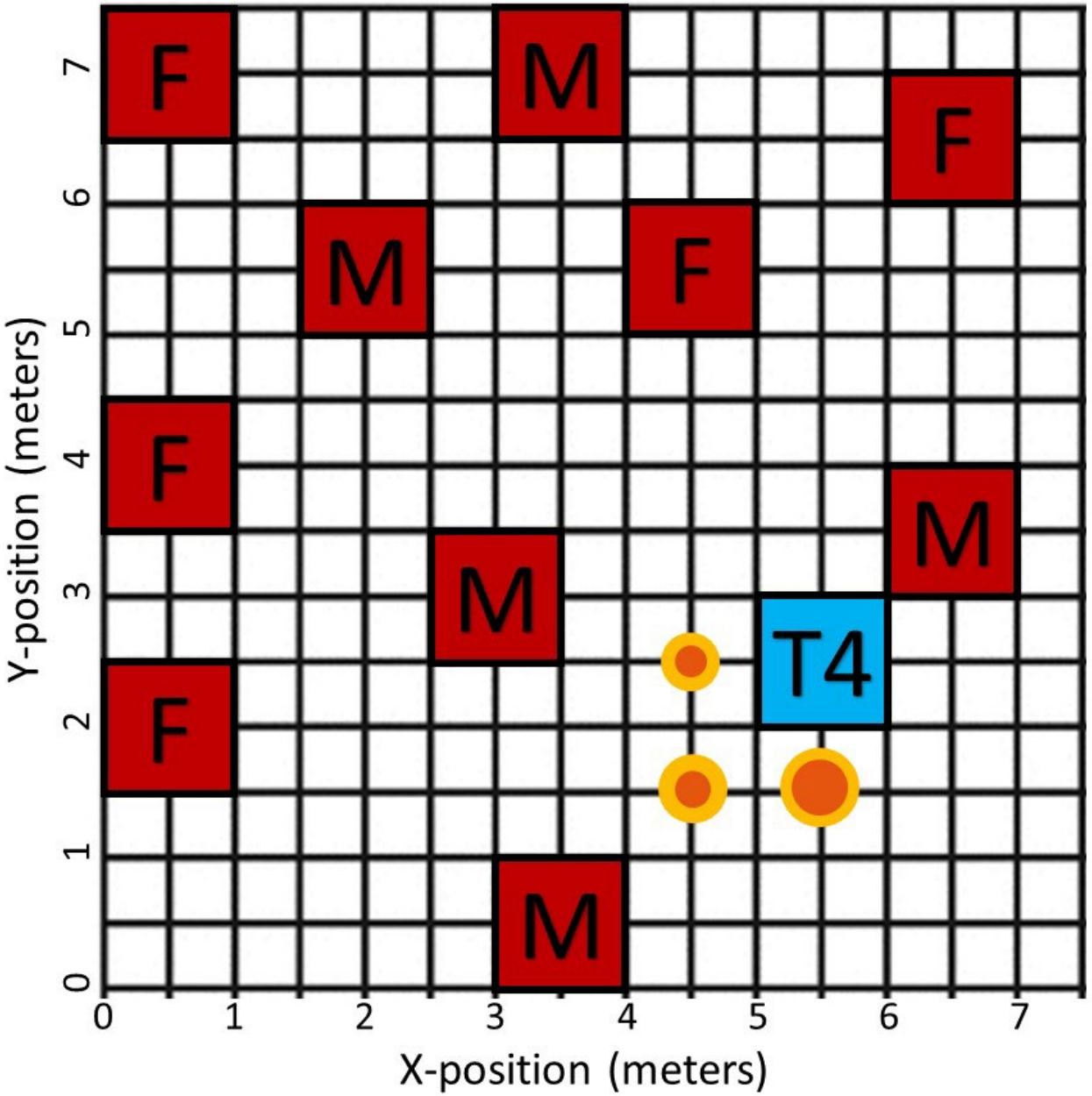
Effect of Hearing Loss



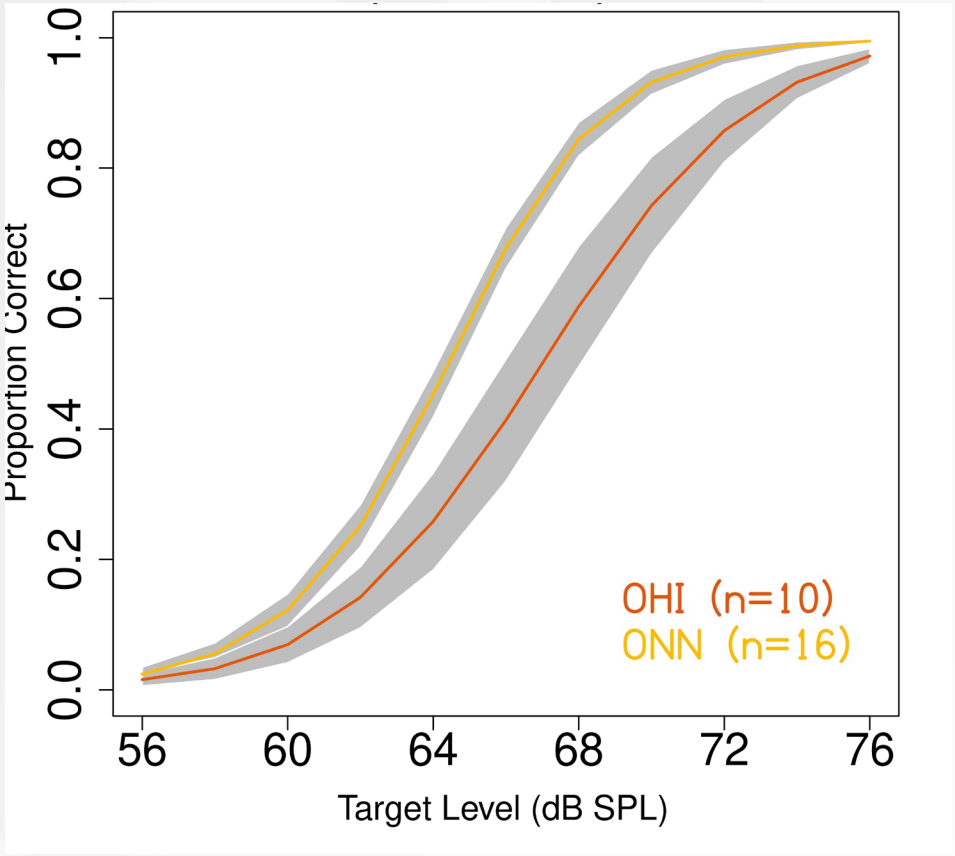


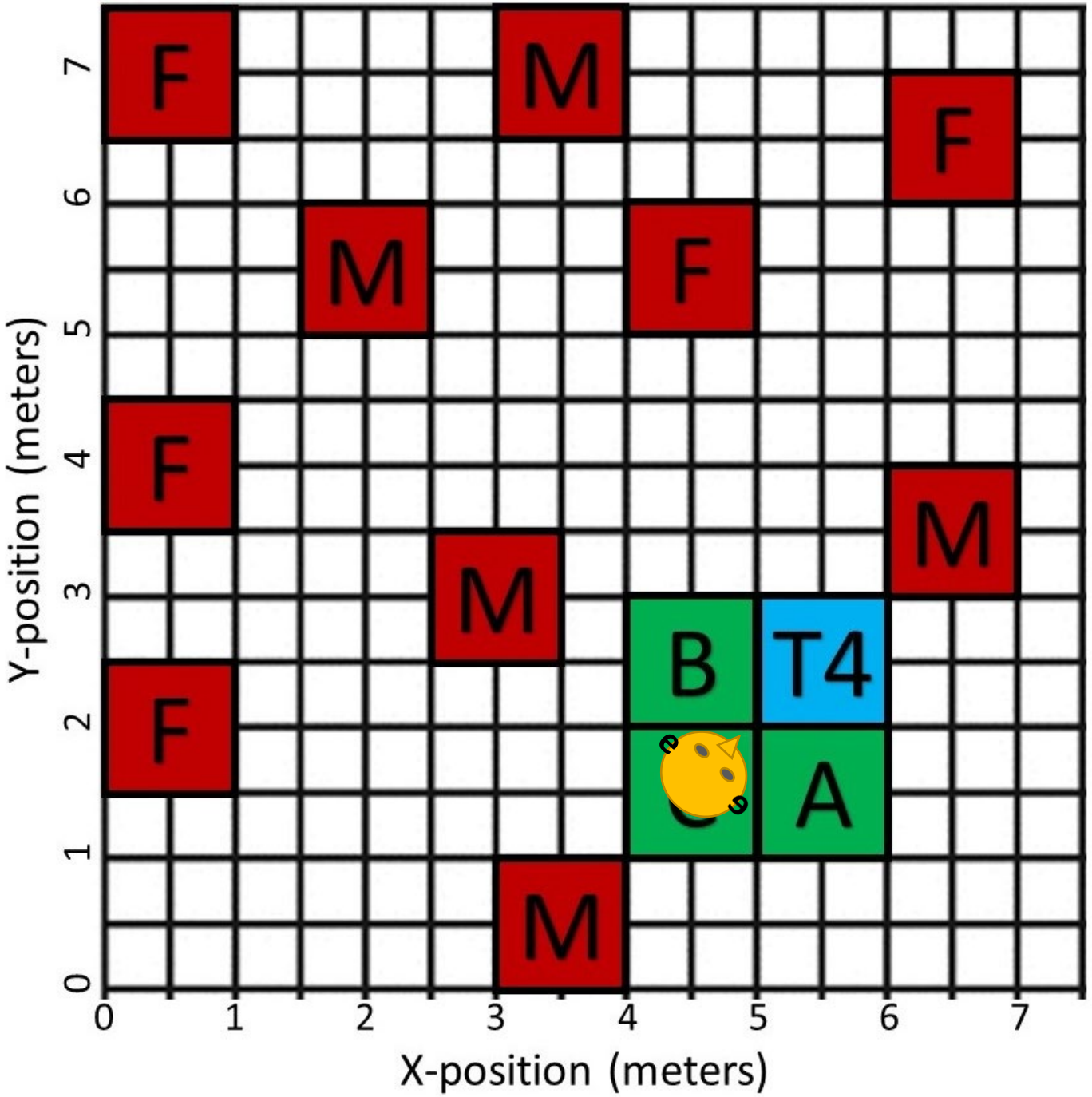
Effect of Hearing Loss



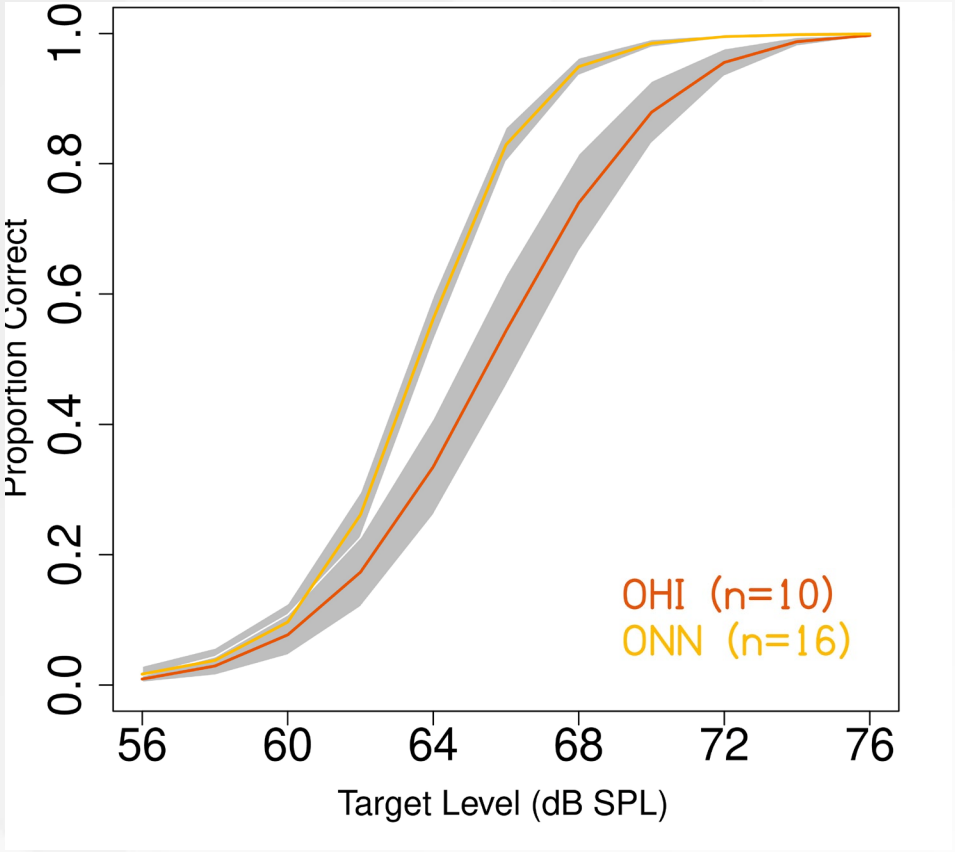


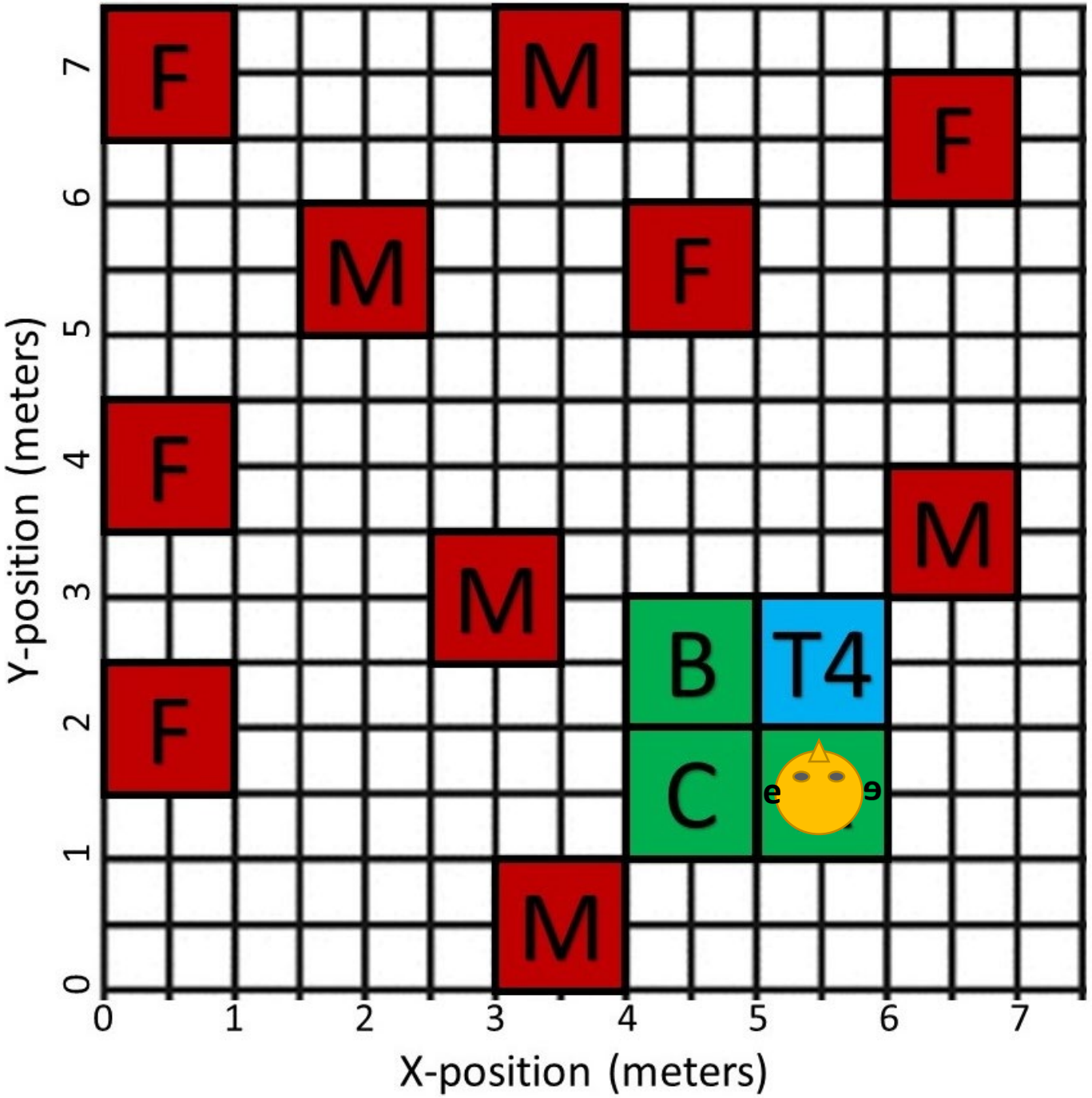
Effect of Hearing Loss



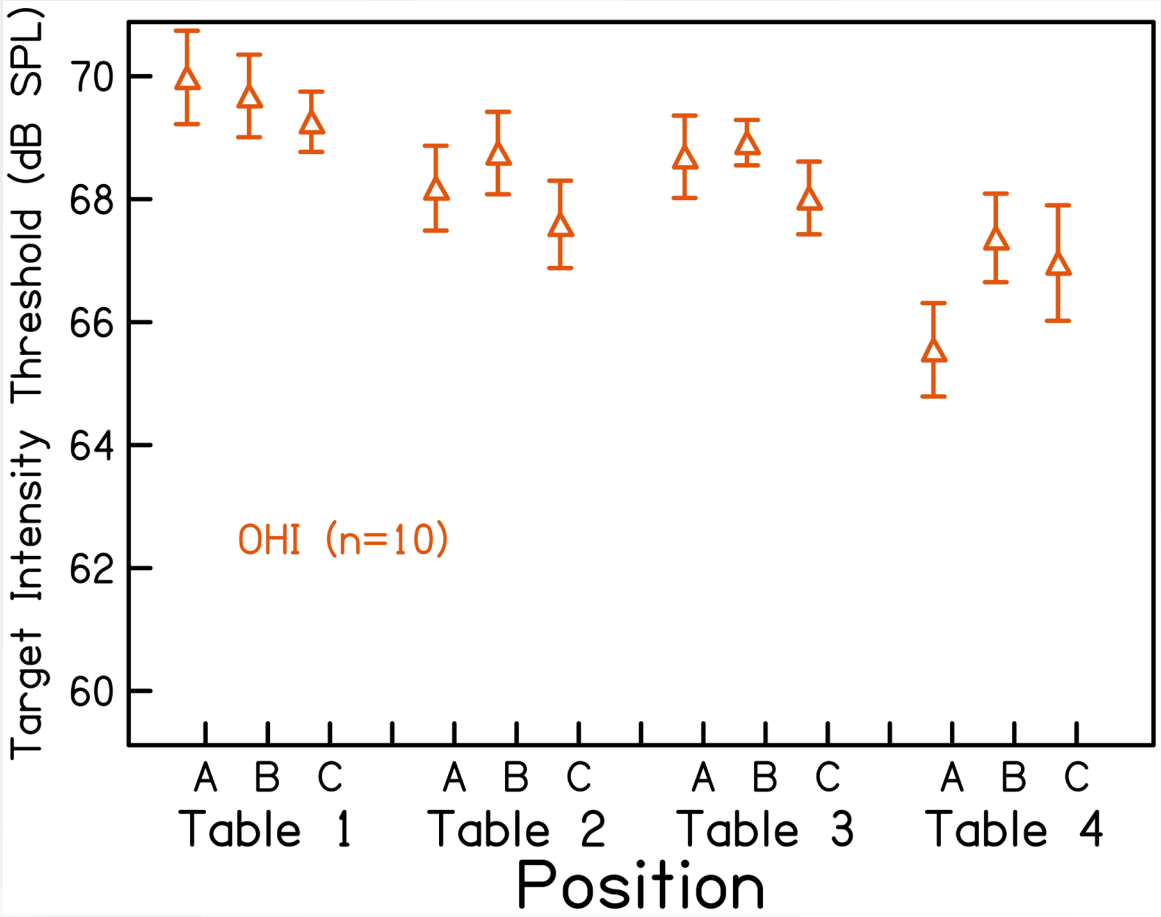


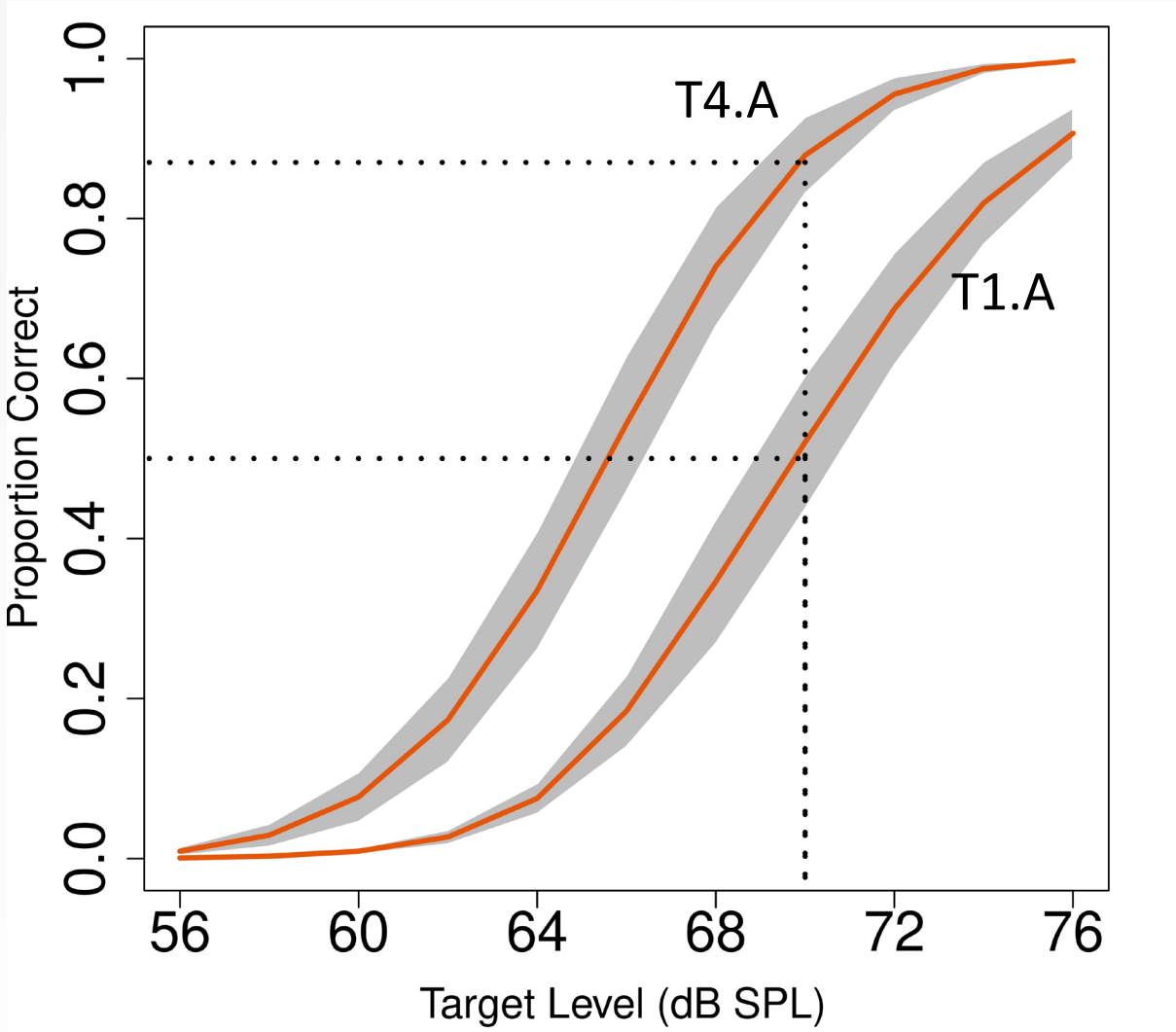
Effect of Hearing Loss





Effect of Hearing Loss





Conclusions – Effects of Table and Seat

Table and seat position each affect speech recognition

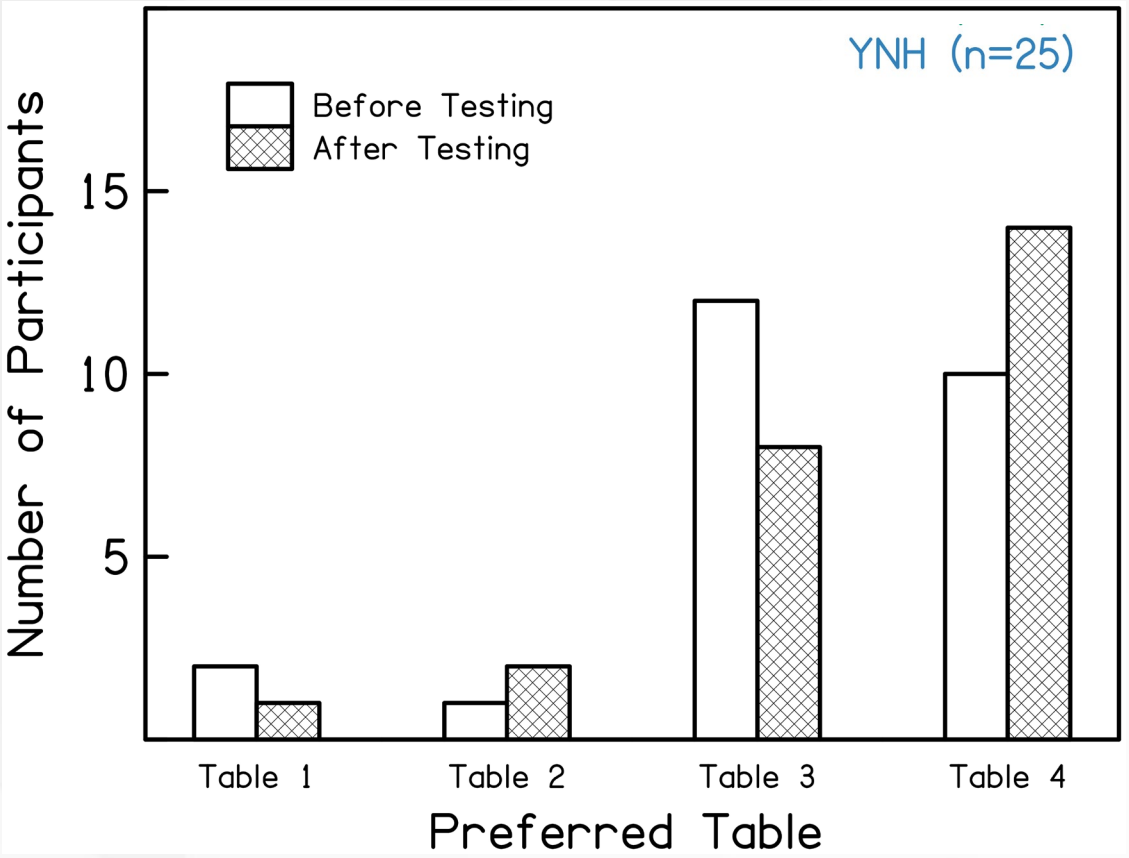
Similar trends in table effects between groups

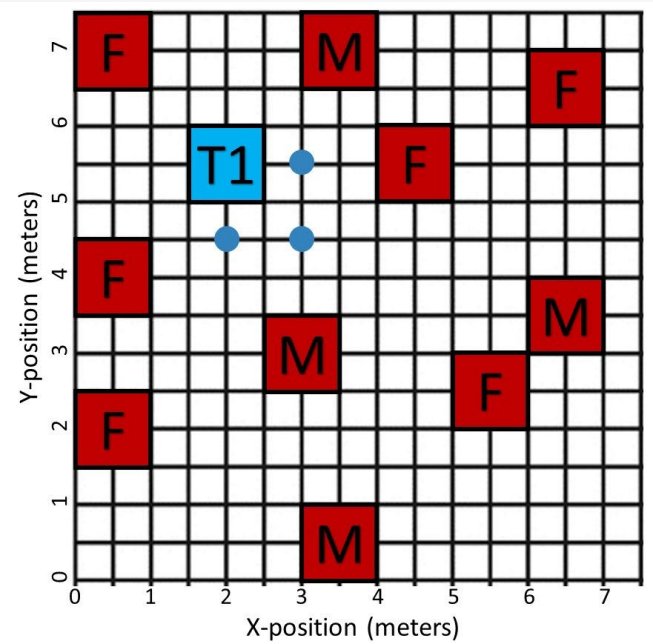
Effects of seat more sensitive to age/hearing status

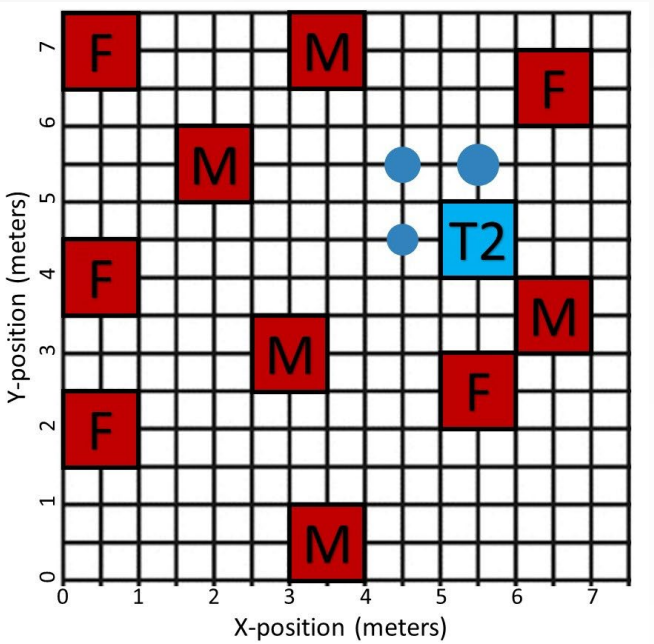
- Particularly true in the most advantageous table
- Some seat positions may offer a high-frequency acoustic cue

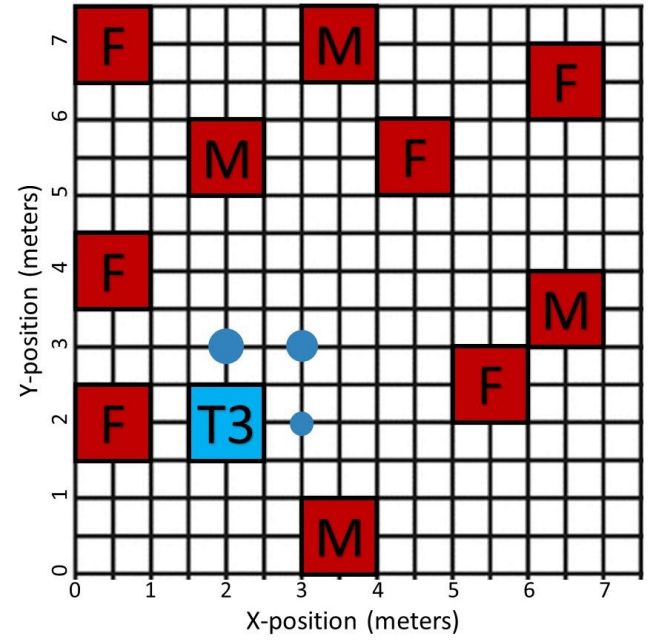
Good Positioning offered substantial benefits for all listeners

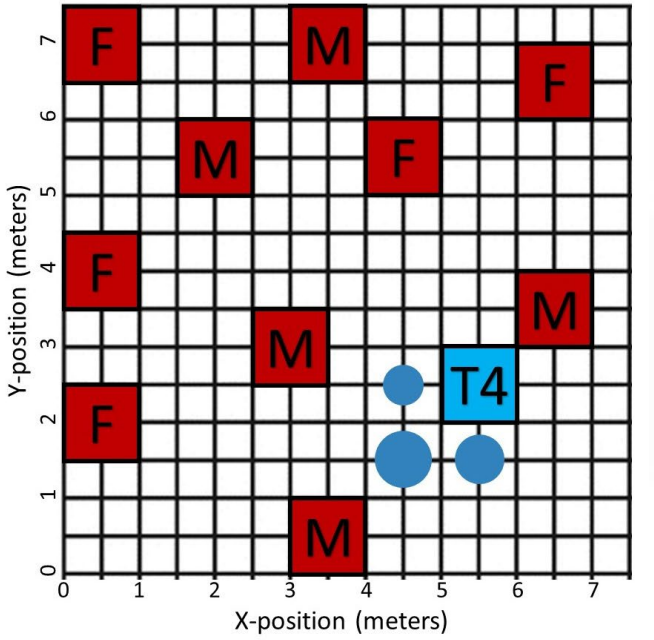
YNH Table Preferences



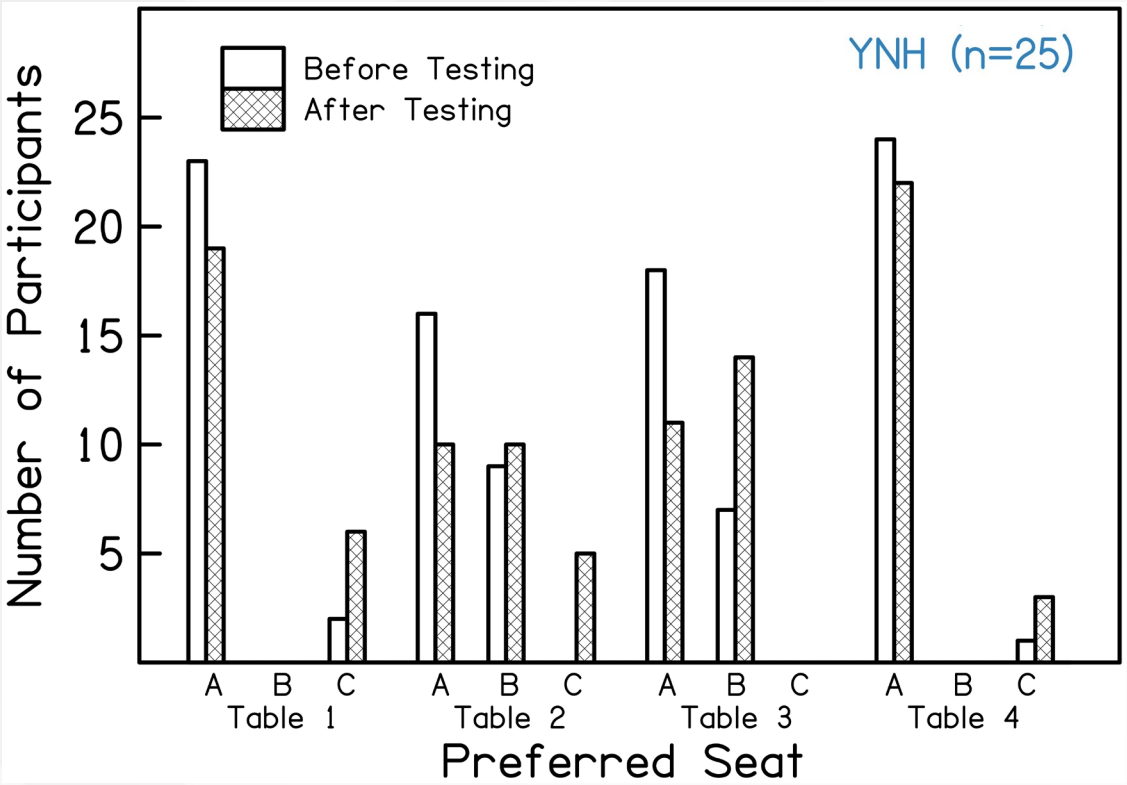


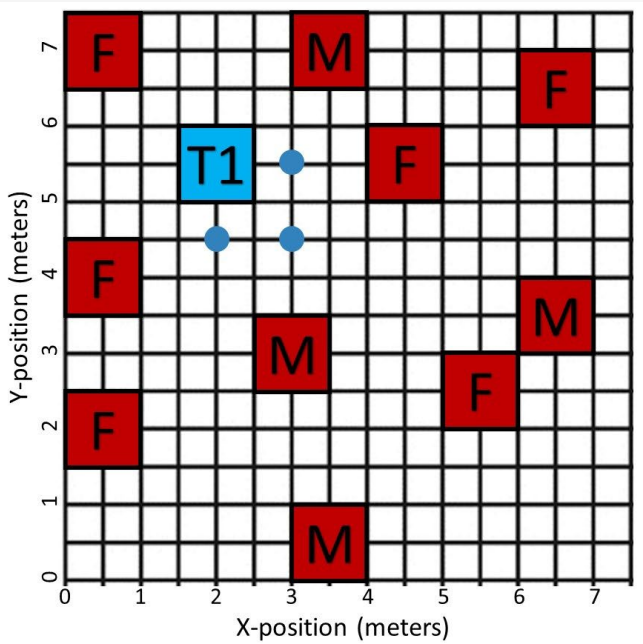


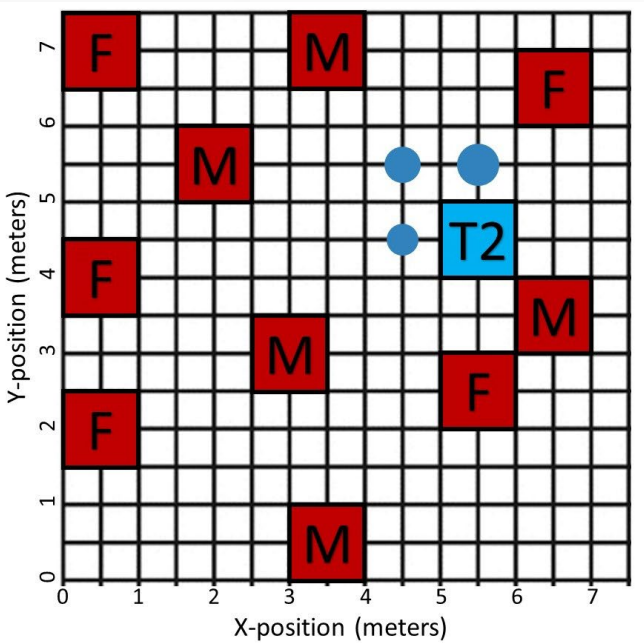


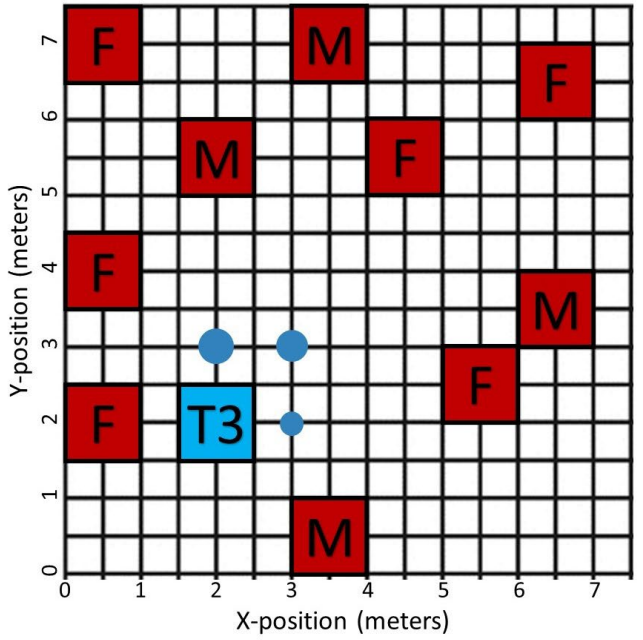


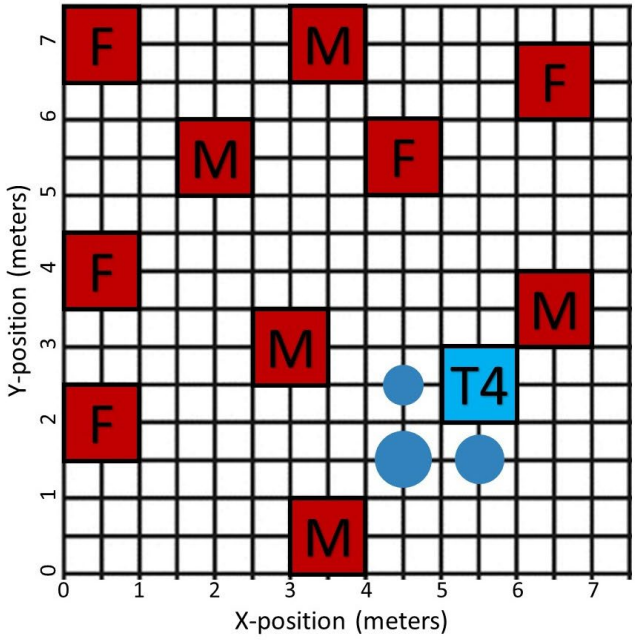
YNH Seat Preferences



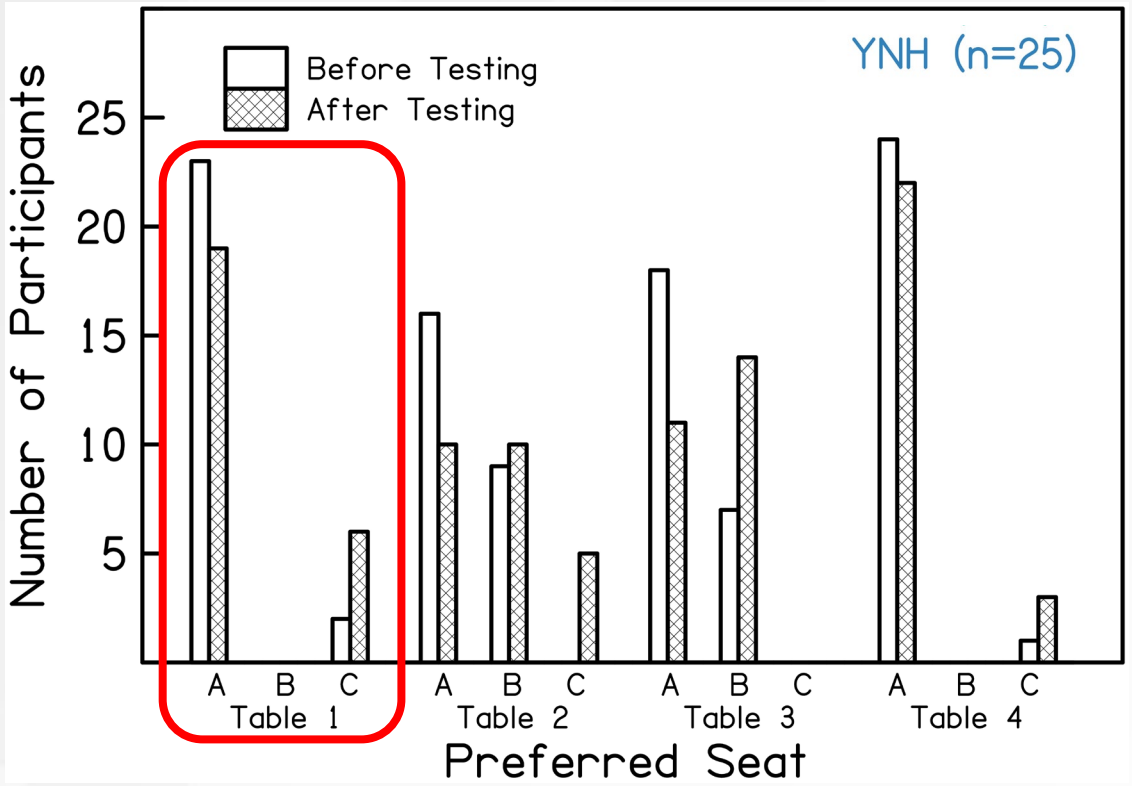


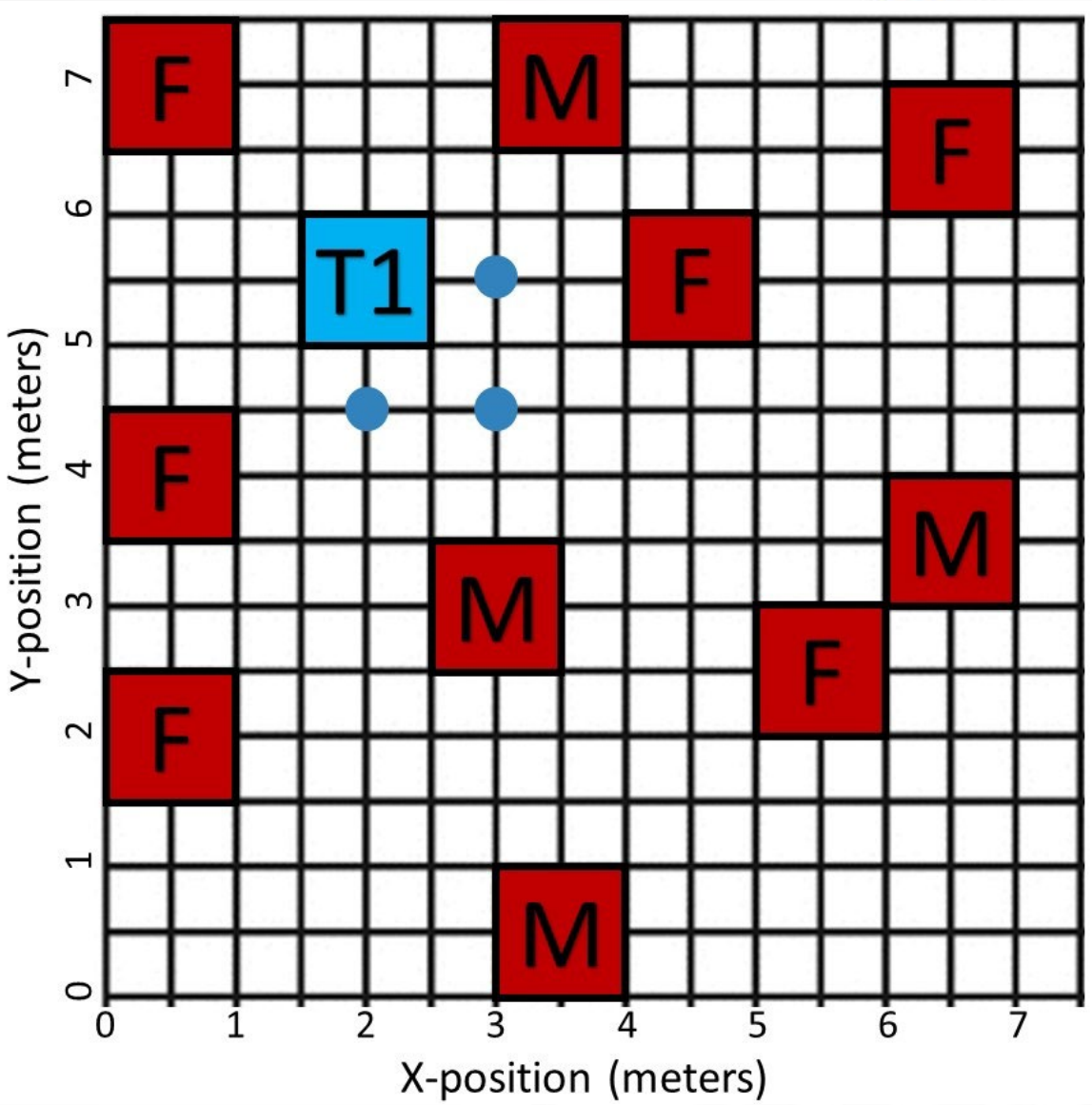




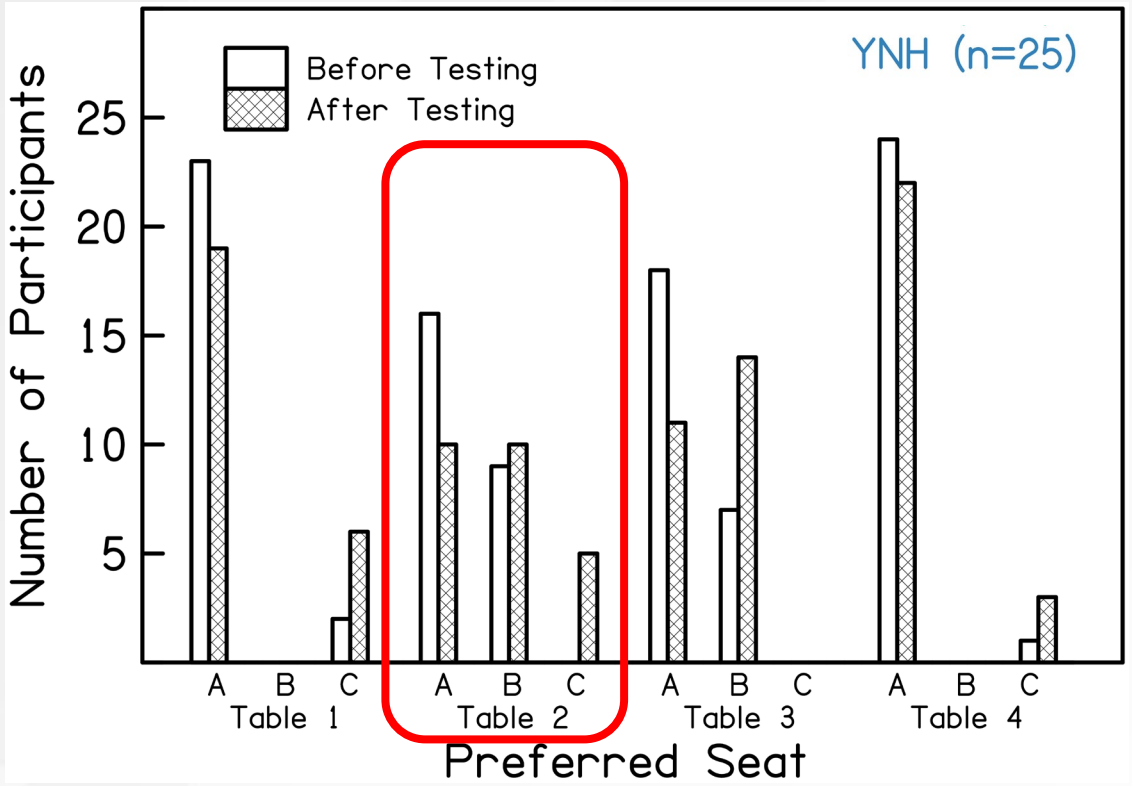


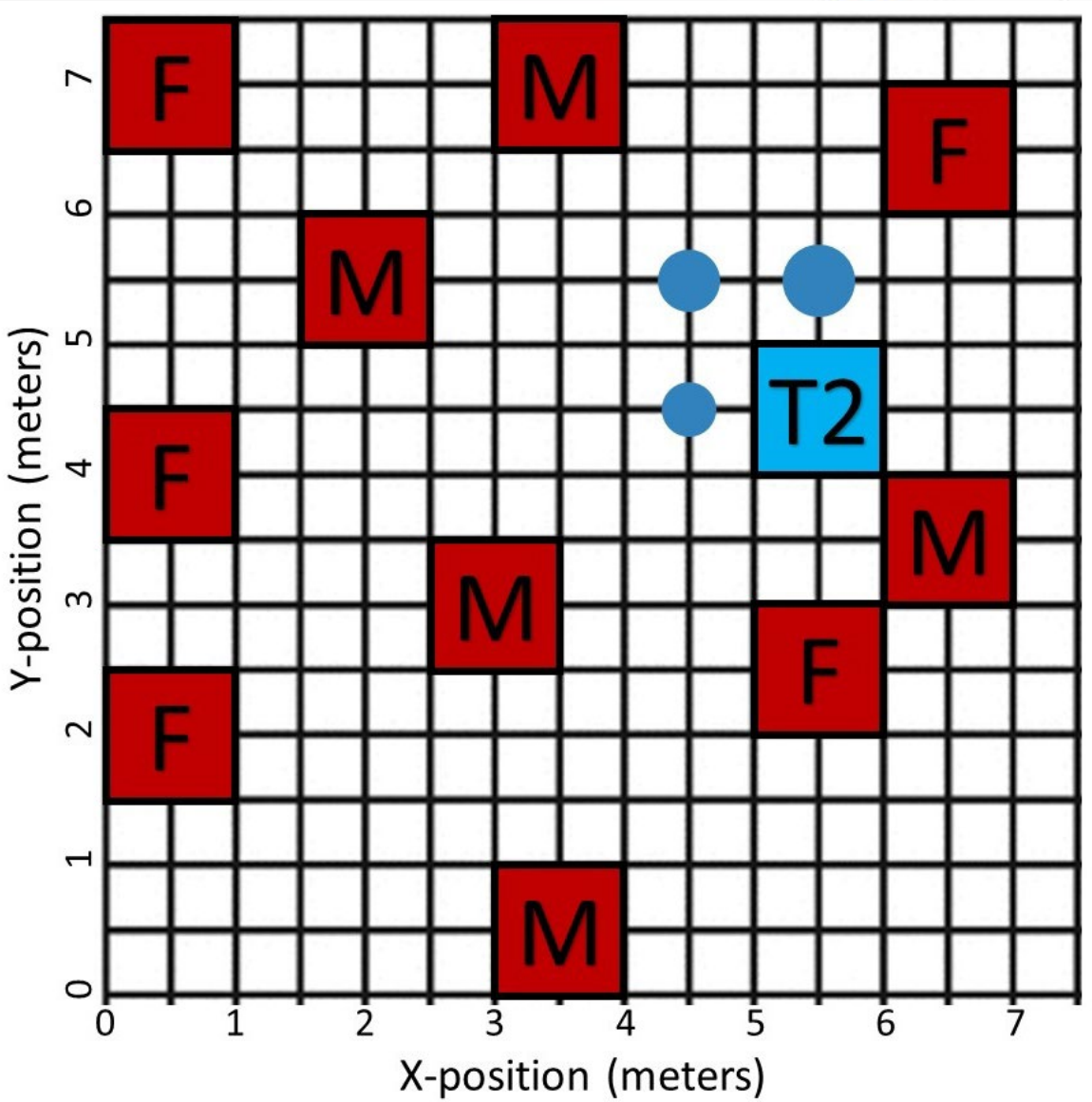
YNH Seat Preferences



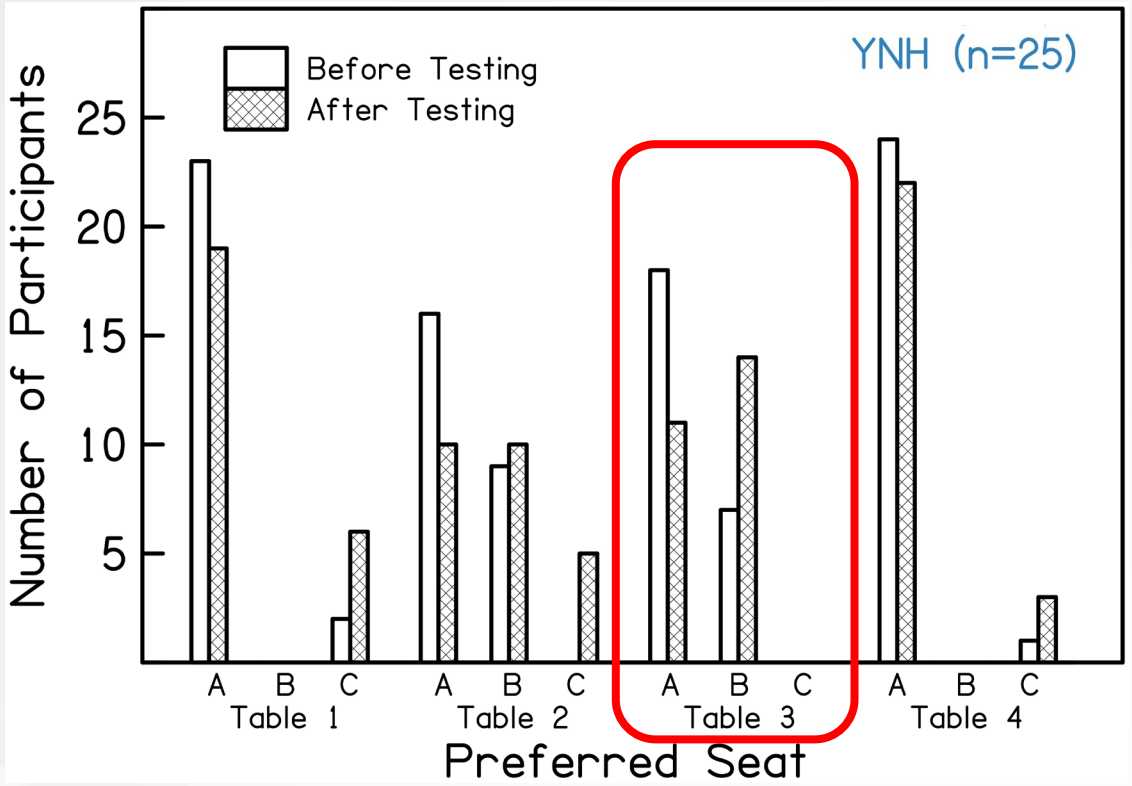


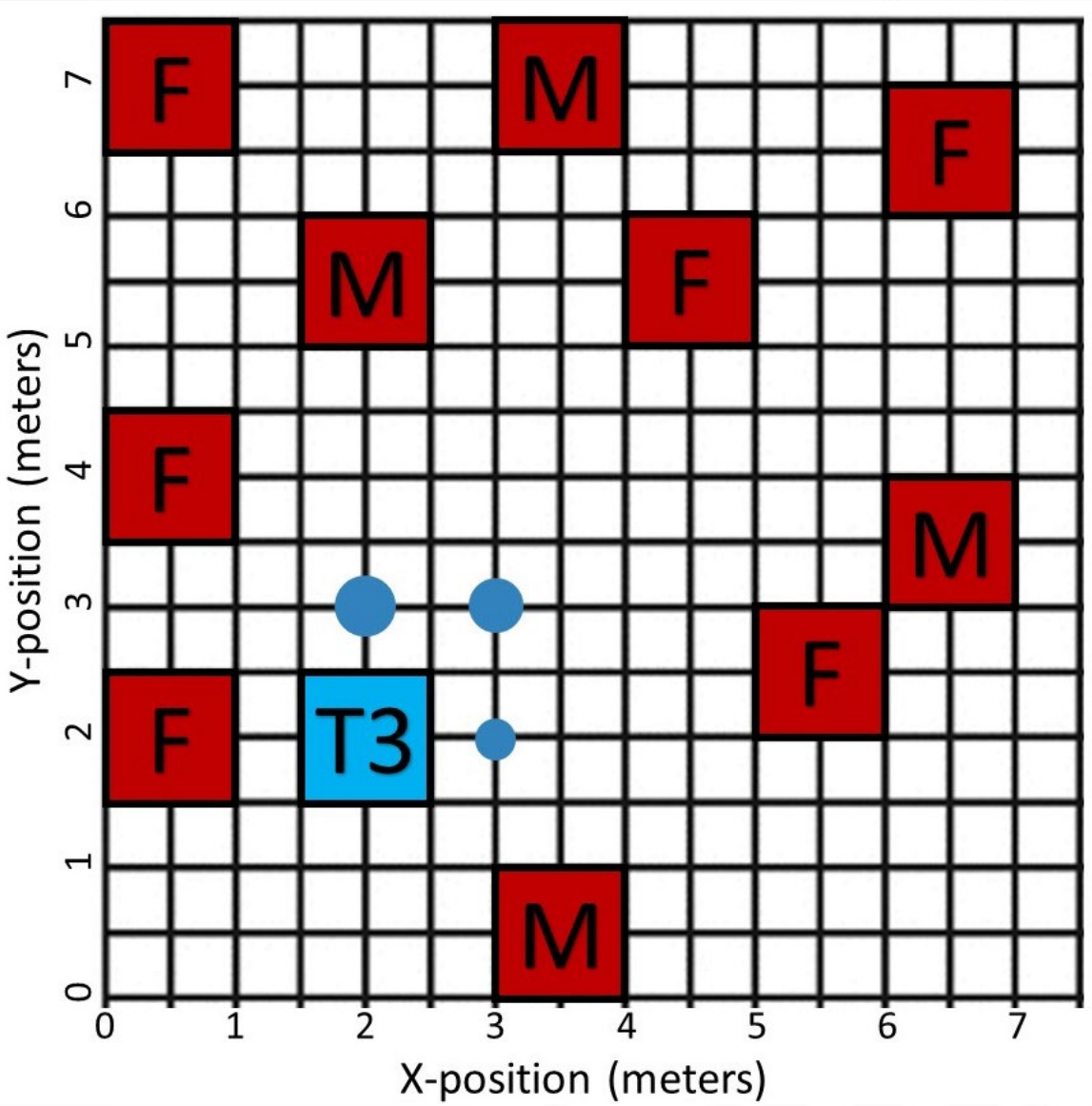
YNH Seat Preferences



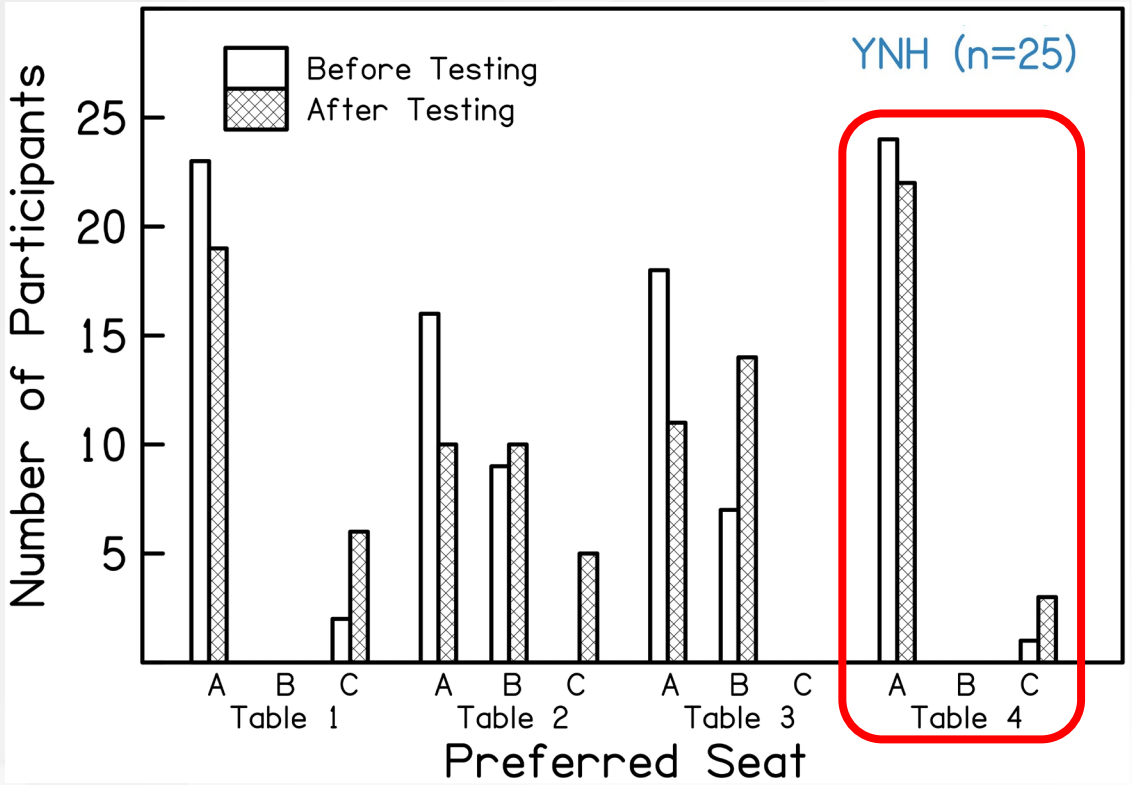


YNH Seat Preferences





YNH Seat Preferences



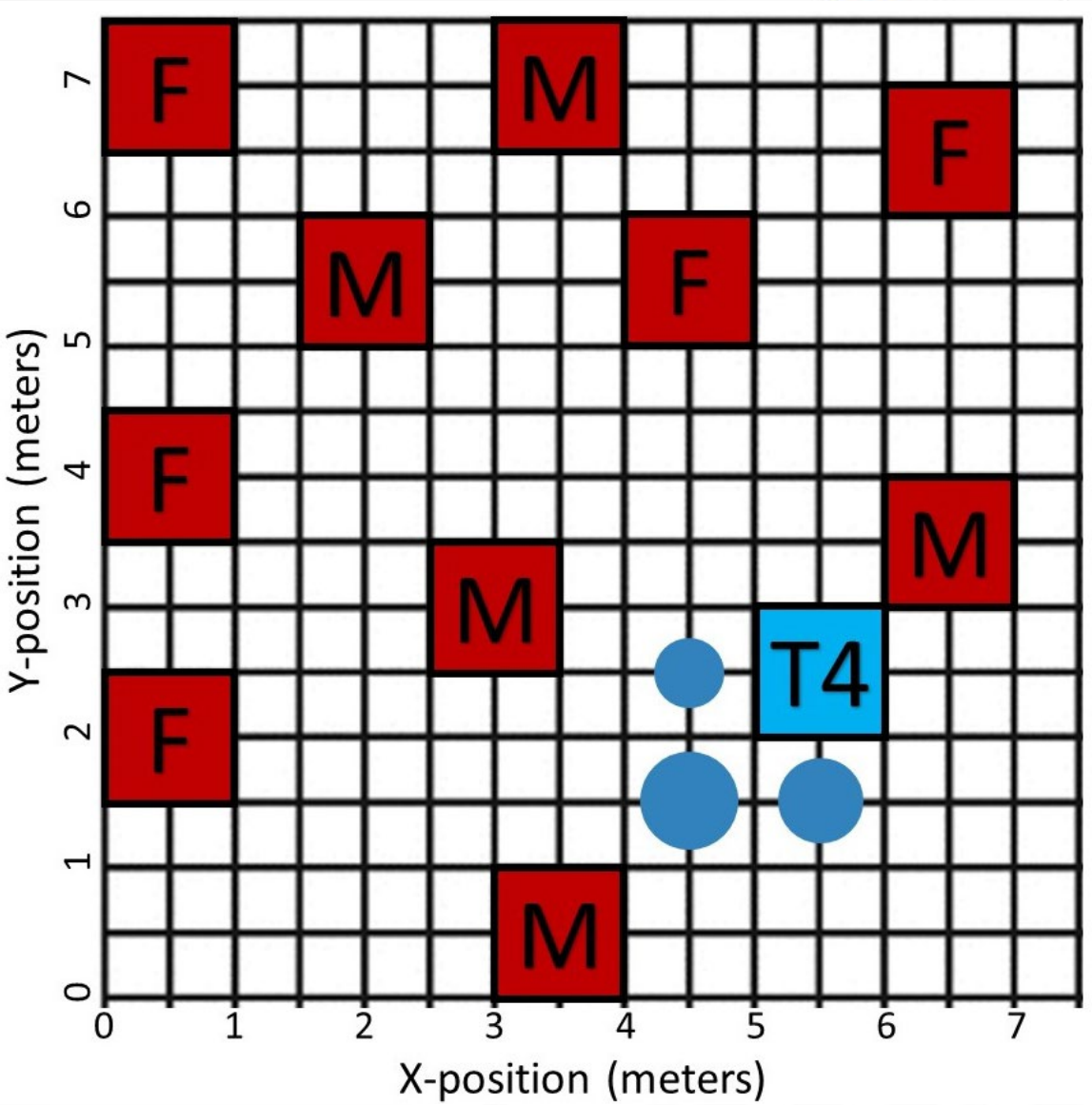
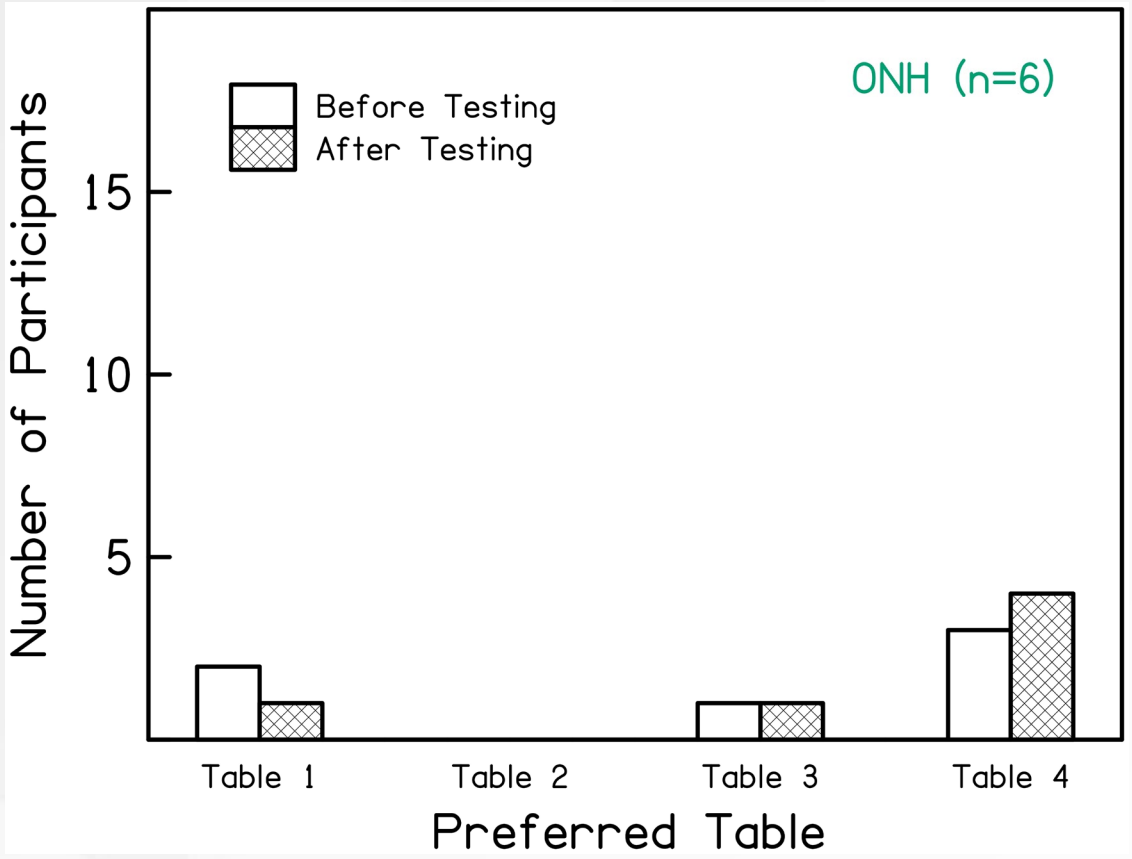


Table and Seat Preferences - ONH



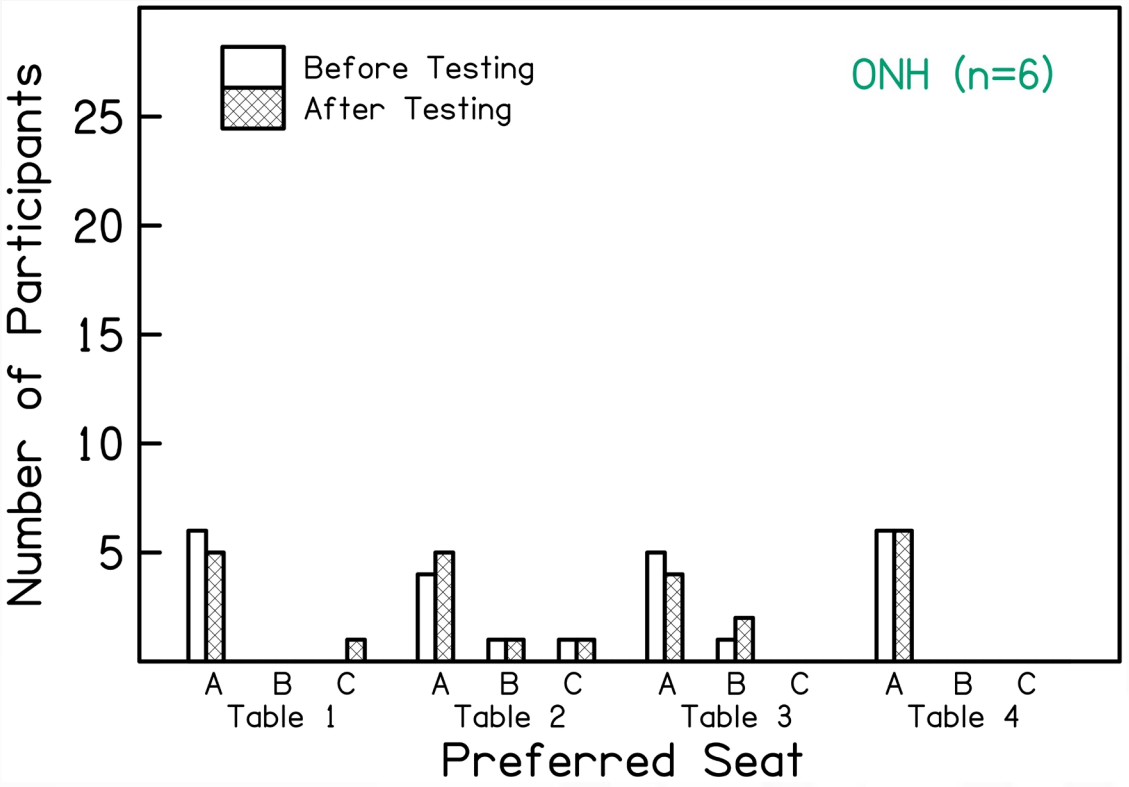
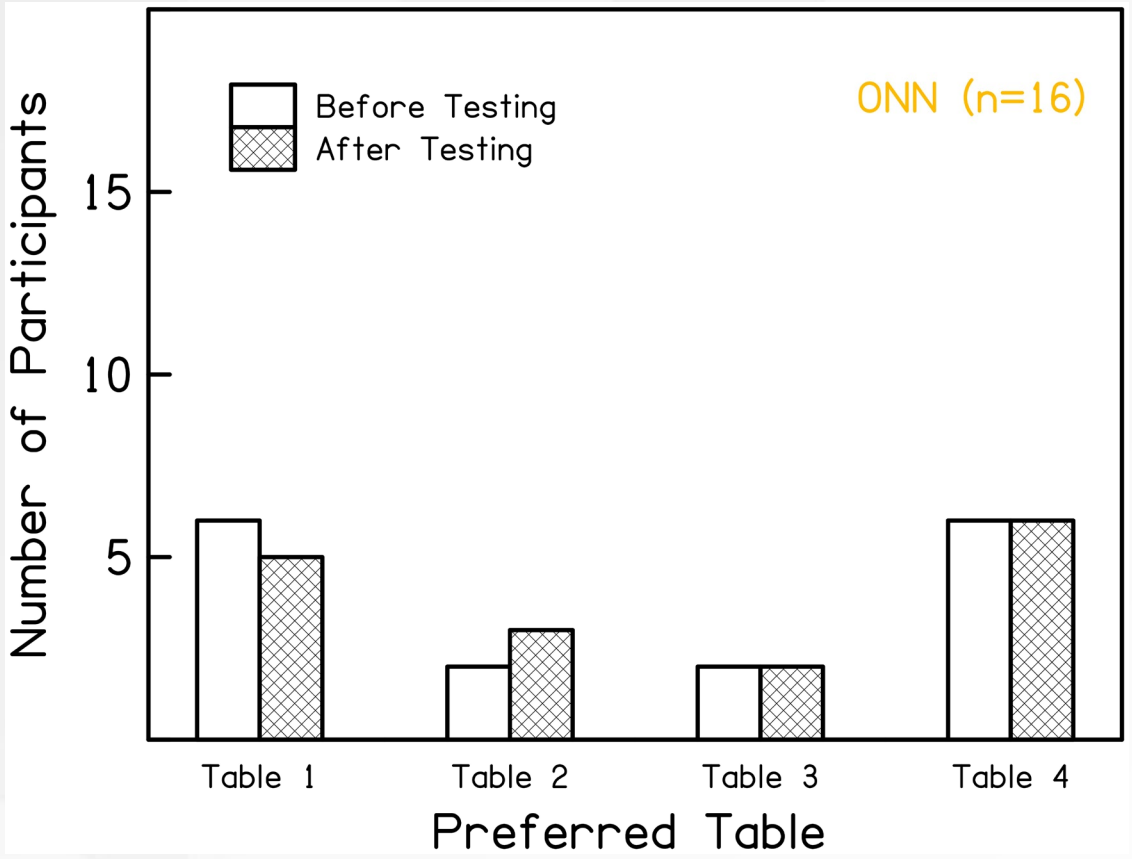


Table and Seat Preferences - ONN



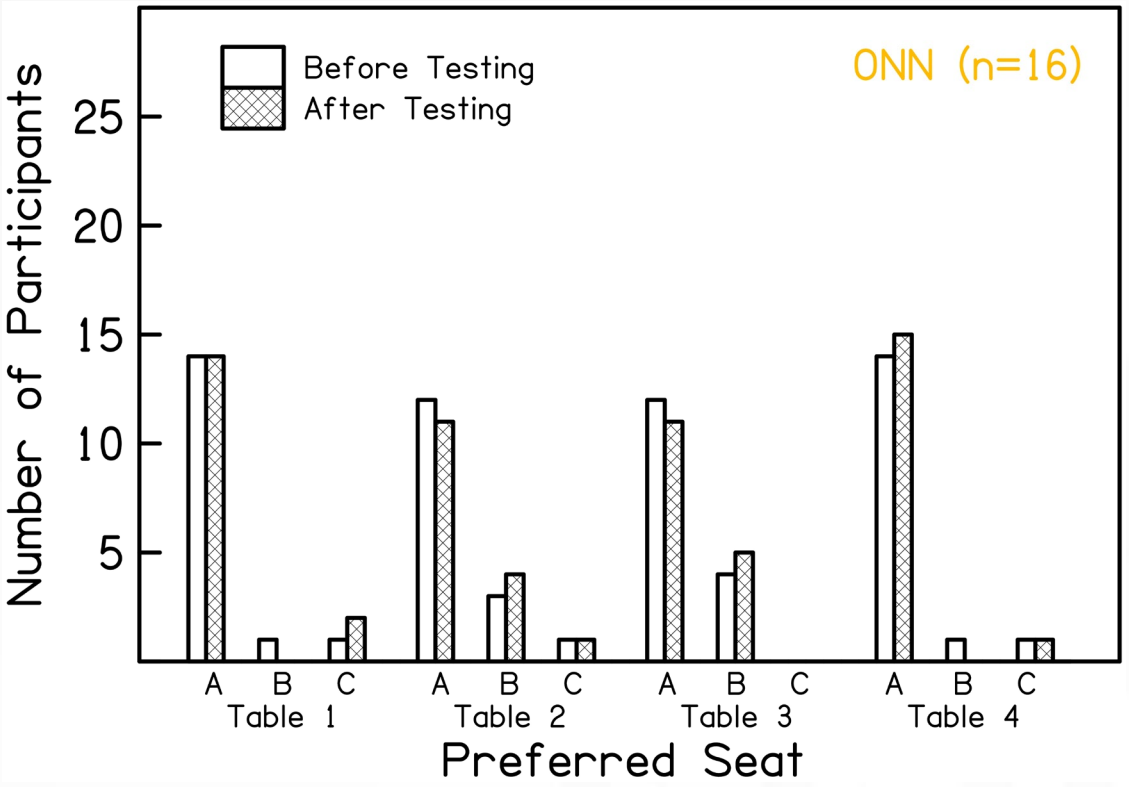
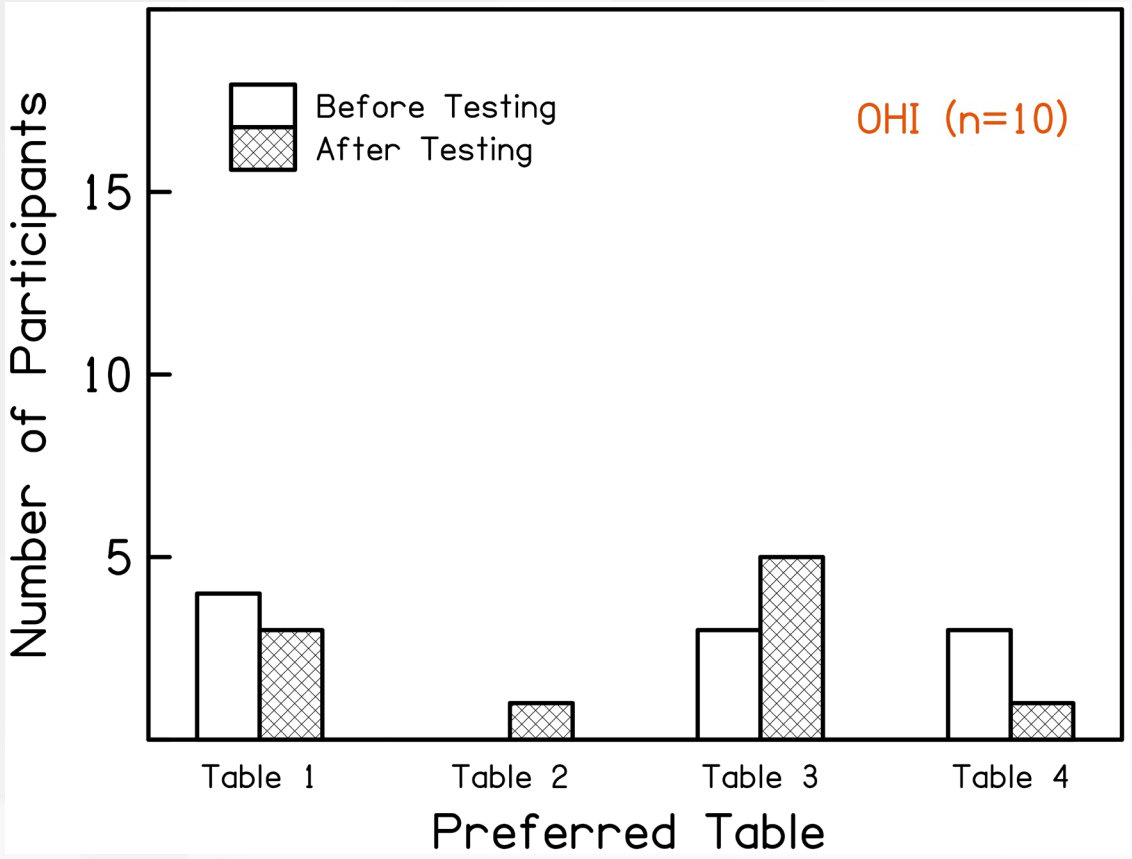
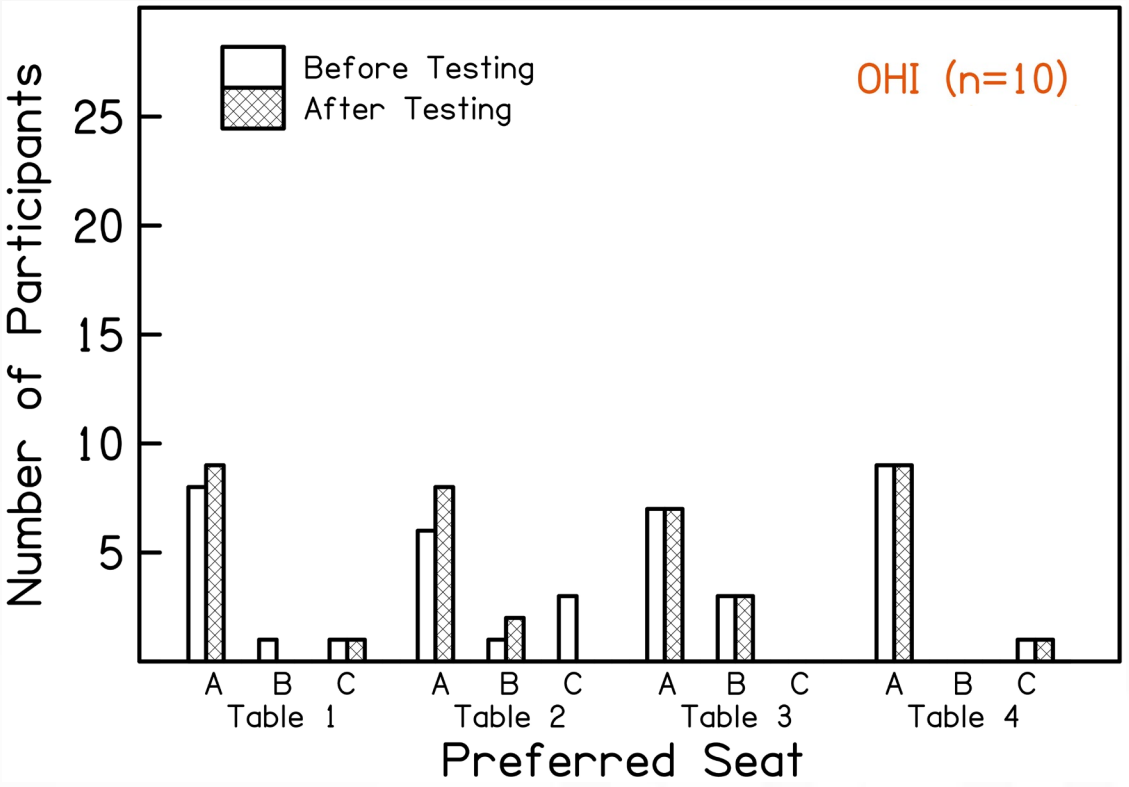


Table and Seat Preferences - OHI





Conclusions – Seating Preferences

Less than half of listeners chose the optimal table (before or after)

- Most listeners prefer to sit across from target

Older adults tend not to change their position after testing

- Less desire to change positions
- Stronger (nonauditory) preferences on where to sit
  - “I’m left-handed, so I don’t sit with someone on my left”
  - “Want to sit where I can see the door”
  - “I want to sit [close or far] from the kitchen”

Lagniappe /Lan–Yap/

Definition: “A little something extra,” or a small gift given to a customer by a merchant at the time of a purchase

- Example: The 13th donut when you buy a dozen

Bonus material that you may find interesting, but doesn’t fit neatly into the presentation

Lagniappe – Autism

All participants completed an Autism Spectrum Disorder screening questionnaire (RAADS-14)

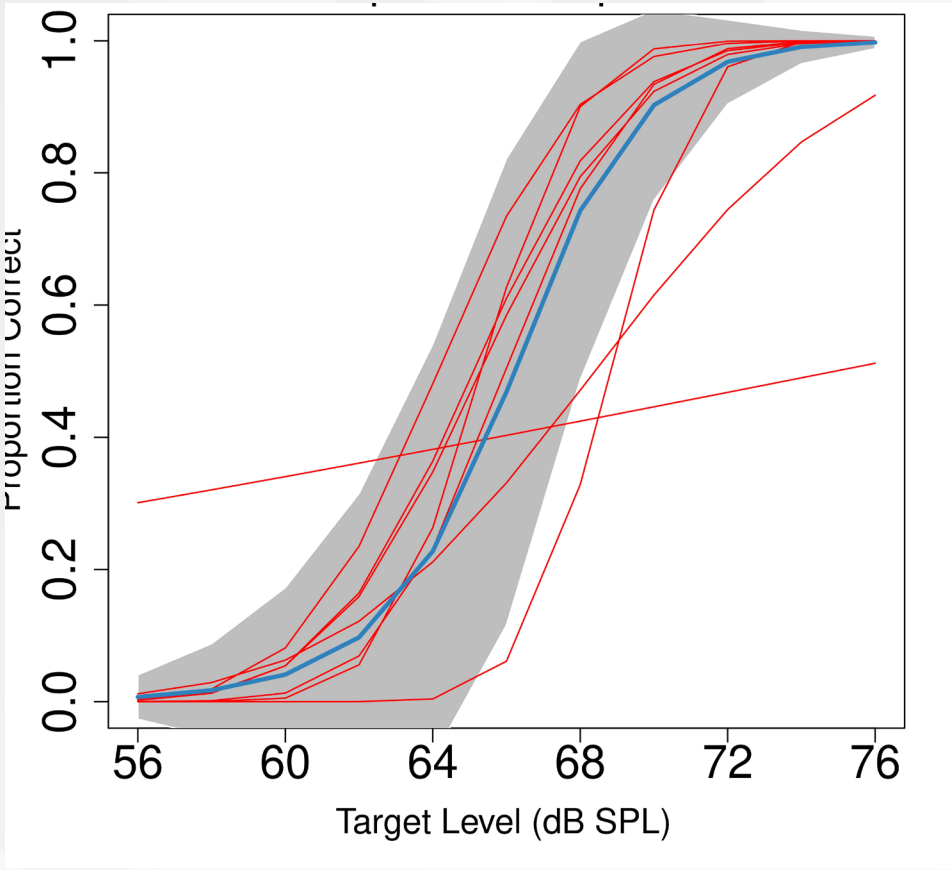
- 8 of the 25 YNH listeners scored above cutoff for ASD

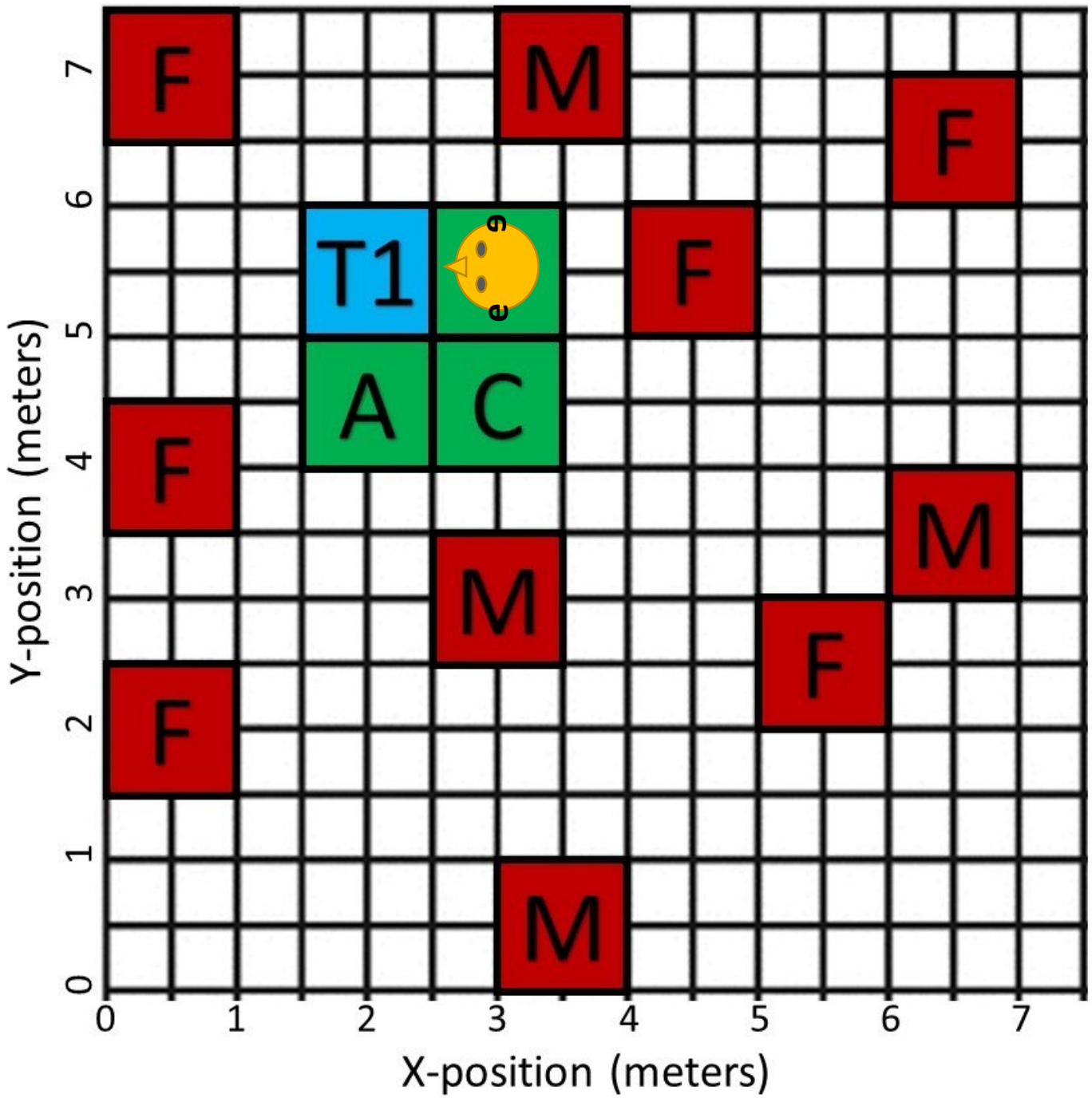
Research Question: Does speech recognition or positioning effects differ between neurotypical and autistic adults?

Dr. Kelly Coburn, Assistant Professor

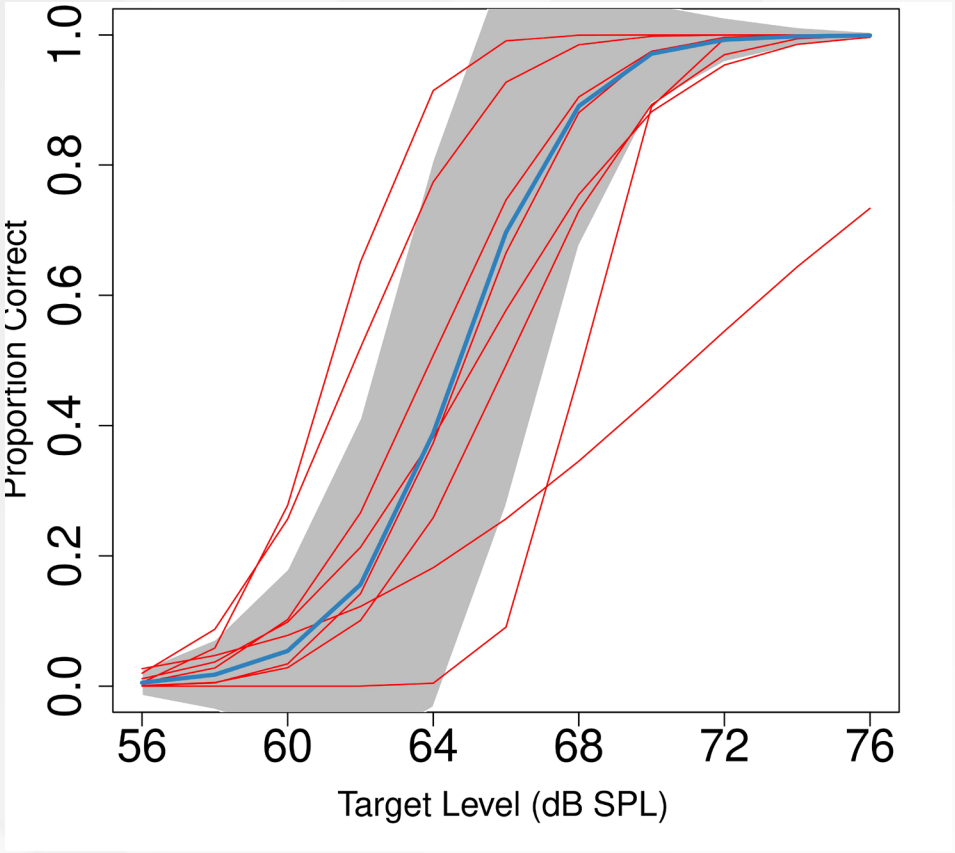
Alyssa Dolan, Undergraduate researcher

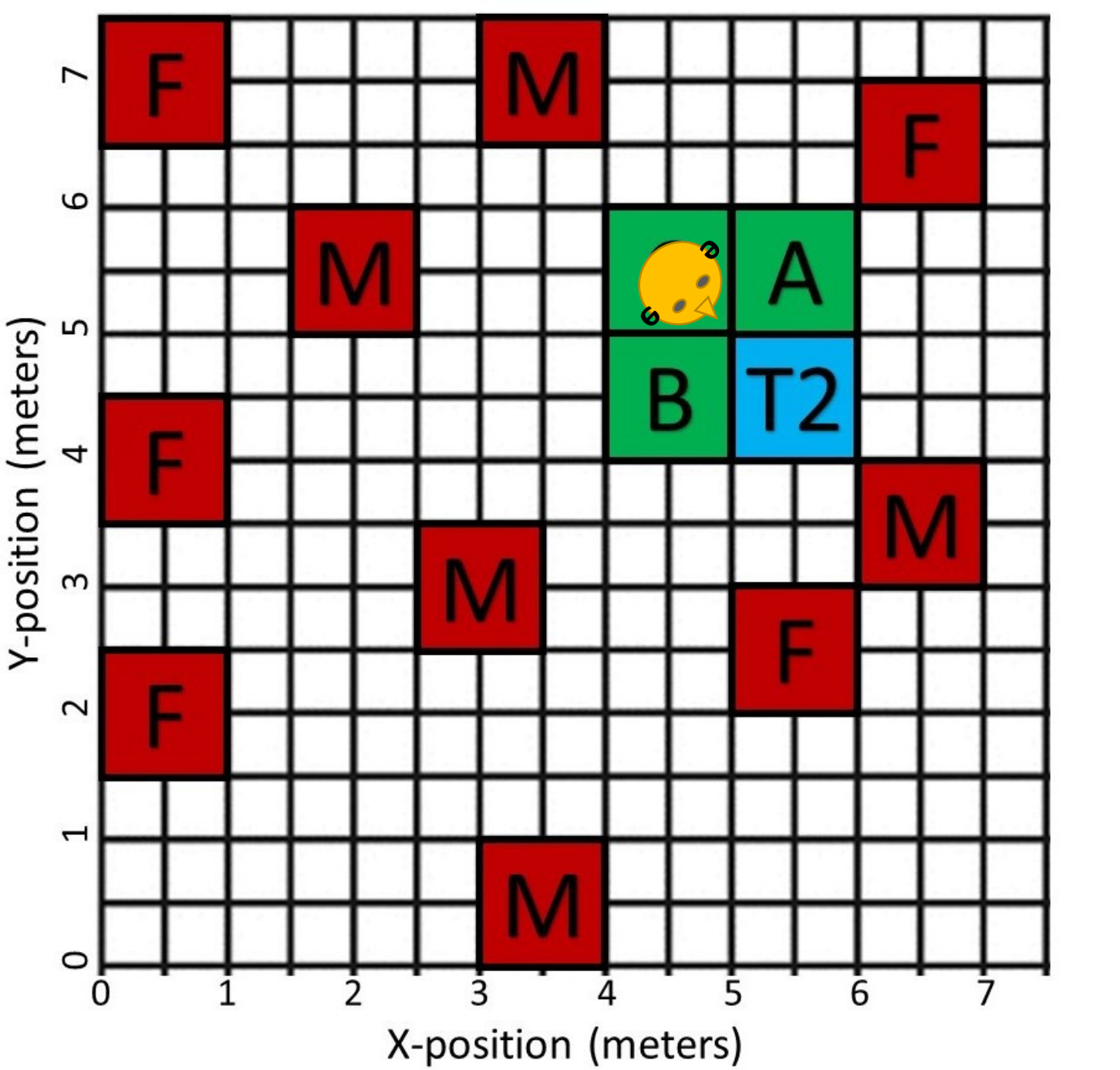
Effect of ASD



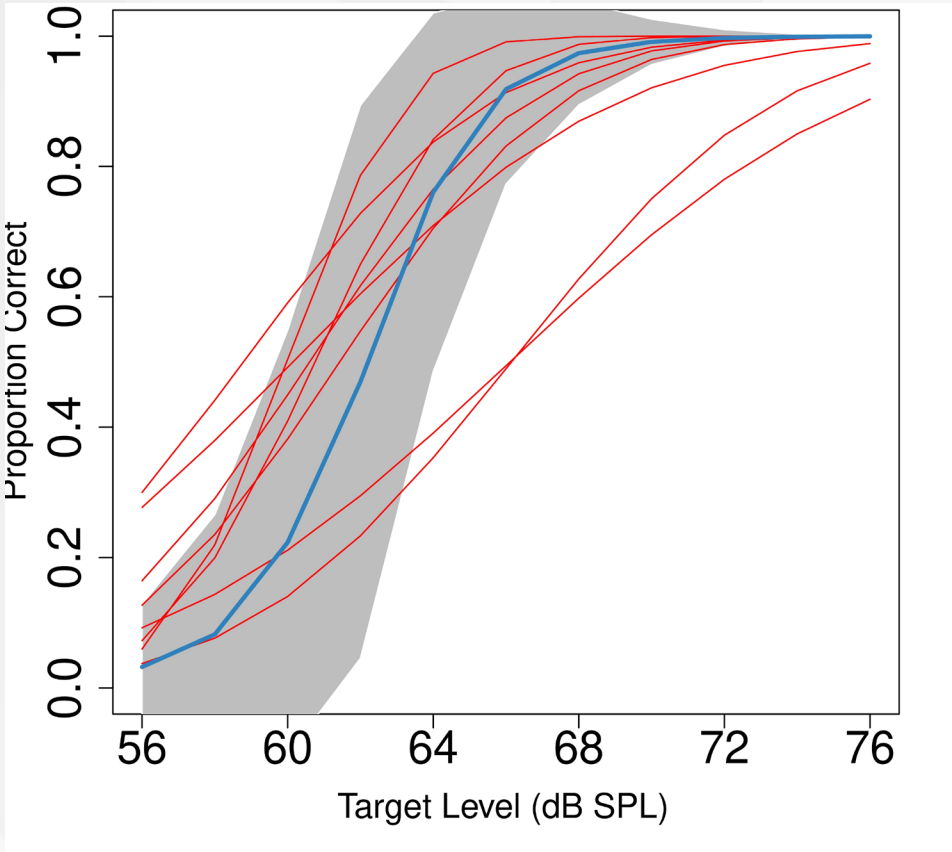


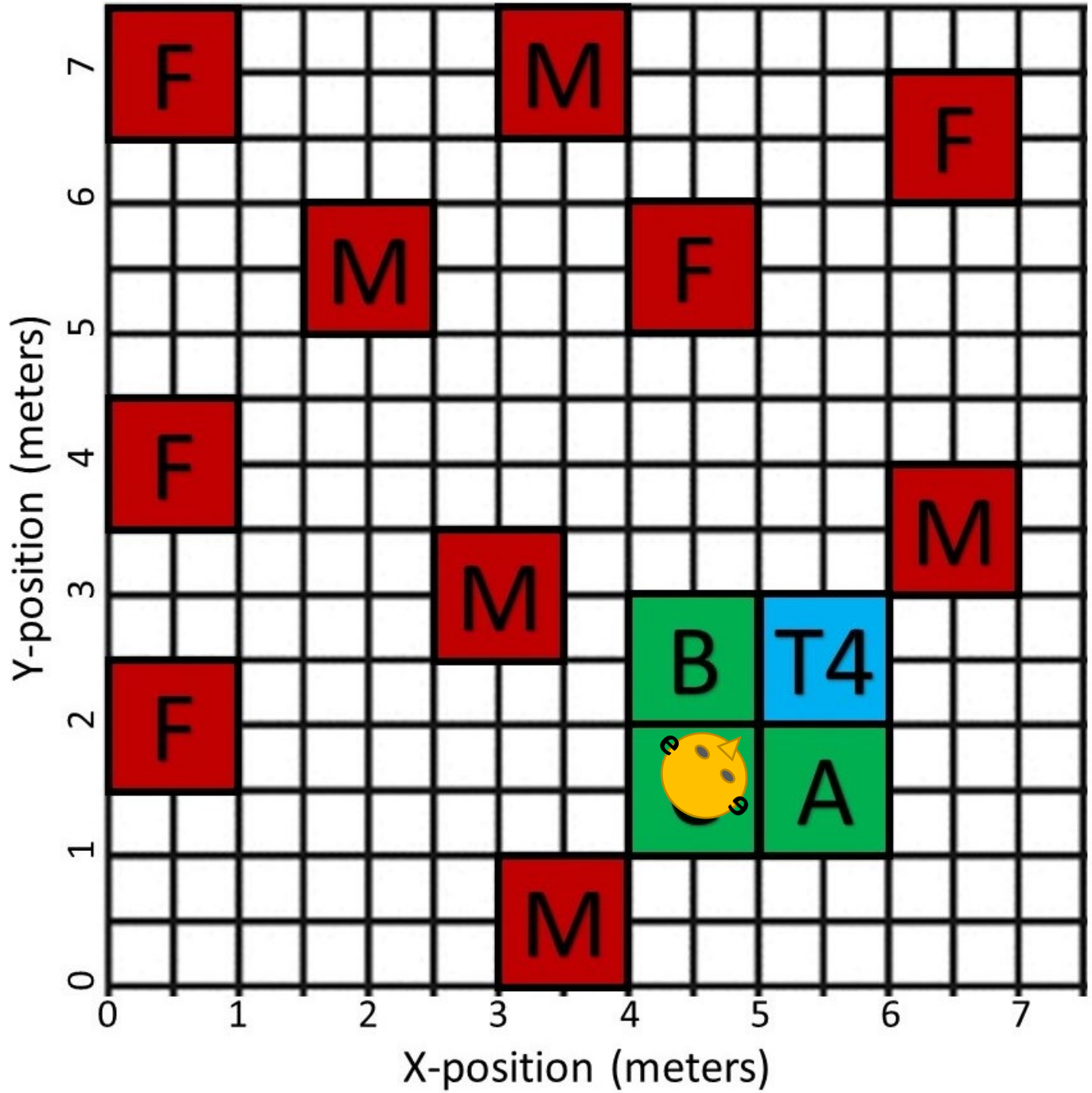
Effect of ASD





Effect of ASD





Initial Observations – Autism

Effects of position seem consistent between ASD and neurotypical adults

Many ASD participants are doing quite well on speech in noise

- Inconsistent with my expectations and limited published data
- Better performance may reflect a form of hyperfocus, typical of ASD

High variability in performance across ASD participants

- A few ASD participants really struggled with this task

Future Directions

TOWSON UNIVERSITY

Design more environments, based on real-world places

- Include simulated reverberation in a sound field

Evaluate changes in listening effort with position

Contributions of energetic and informational masking from “nearby” maskers

Virtual reality spaces with real-time movement effects

Acknowledgements

Student Researchers

- Kelly Avery
- Karina Ball
- Katie Buckheit
- Alyssa Dolan
- Katie Esser
- Tessa French
- Ciara Houlihan
- Courtney King
- Elizabeth Lund
- Maria Sarier
- Elaine Shaw

Collaborators

- Kelly Coburn
- Erick Gallun
- Chris Stecker
- Aaron Sietz

Research Support

- Towson Faculty Development & Research Committee Grant