COGNITIVE TECHNOLOGY RESEARCH LABORATORY

Developing Digital Assessments for Down-Syndrome Associated AD

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Clinical Trials

- Cognition Core Leader: DIAN-TU
- DSMB Member: Mission AD (Eisai)
- DSMB Chair: Caring Bridge (NIA: Rogalski, PI)
- DSMB Chair: Wall-E (NIA: Jacobs, PI)

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Overview

- Measurement burst designs for mobile monitoring of cognition.
- Developing a smartphone application for a global Phase 2/3 prevention trial for Down syndrome-associated Alzheimer's disease.
- Adapting existing tasks from the Ambulatory Research in Cognition (ARC) smartphone app
- Accessibility and User Experience: Design Considerations for Down syndrome participants
- If time: Advantages and perils of bring your own device (BYOD) study designs

LIMITATIONS OF TRADITIONAL COGNITIVE ASSESSMENTS

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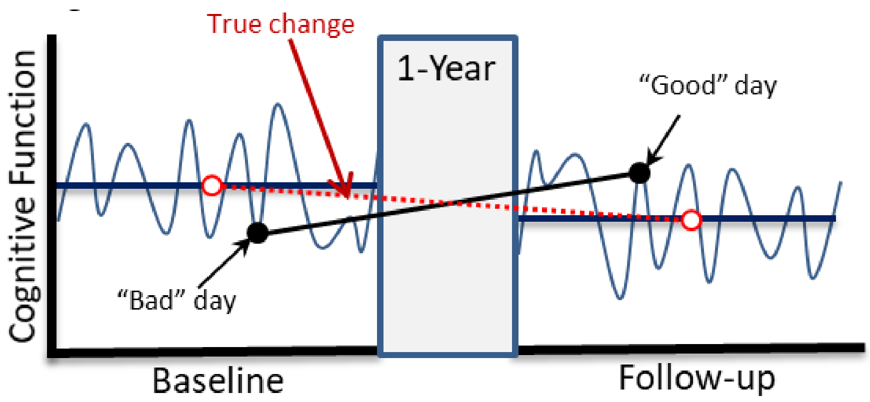
ARTIFICIAL

- Assessments very removed from reality.
- Feeling of being “tested” by other person.
- “White-coat” testing effects.
- Effects of daily stressors (fatigue, mood, illness, traveling to sites).

“ONE-SHOT”

- Testing typically completed in one extended session



High Variability = Drastic reductions in statistical power.

**Figure credit to M. Sliwinski

Ambulatory Research in Cognition (ARC)

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The ARC app administers very brief cognitive tests four times per day for one week. Each test session takes less than 3 minutes.

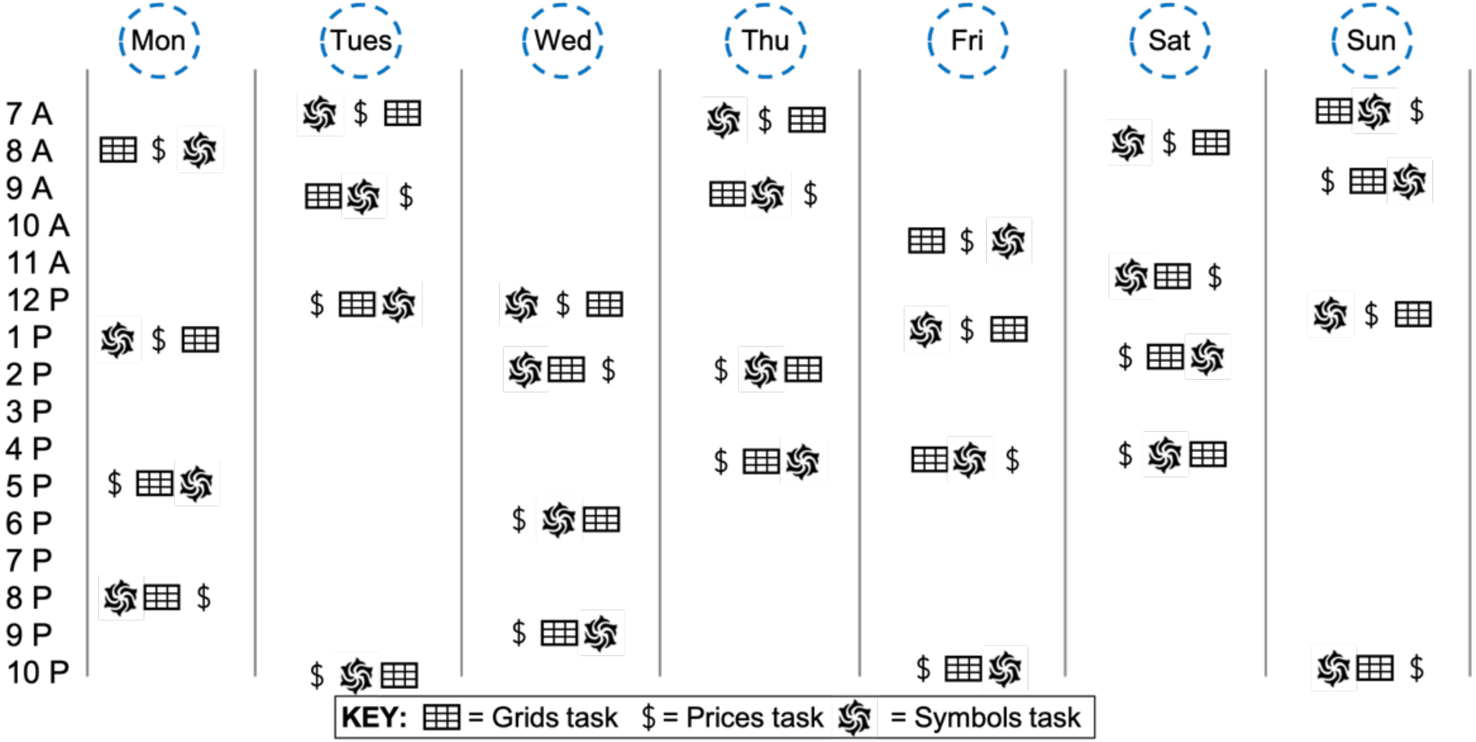
Participants use their personal smartphone, industry term is BYOD (Bring Your Own Device).

The idea behind ARC is simple:

1. **Test often and everywhere.**
2. **Keep it short.**
3. **Combine the results.**

With this simple formula we hope to significantly improve the precision of cognitive testing.

7-day "Burst" Design



ARC Publications

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- ARC sensitive to Dominantly Inherited Alzheimer Disease (DIAD). Good correlations between in-clinic cognitive assessments, AD biomarkers, and predicts disease onset. Hassenstab et al., 2020 *Alzheimer's & Dementia.*
- Bring your own device (BYOD): Device-specific response latencies (both tapping and display latencies) vary considerably depending upon programming and quality of devices. Nicosia et al., 2022 *Behavior Research Methods.*
- Smartphone-naïve older adults <u>can</u> enroll and successfully use smartphones, with very good adherence. Nicosia et al., 2022 *Frontiers in Digital Health.*
- In a sporadic AD population, good correlations with in-clinic tests, AD biomarkers, and excellent retest reliability at 6mos and 1-year (0.90 & 0.97). Nicosia et al., 2022 *Journal of the International Neuropsychological Society.*
- Also in sporadic AD, ARC was sensitive to time of day. Worse evening performance, and those with elevated AD biomarkers showed more decline in evening. Wilks et al., 2021 *Journal of Clinical and Experimental Neuropsychology.*

Can we adapt our tool for global Down syndrome studies?

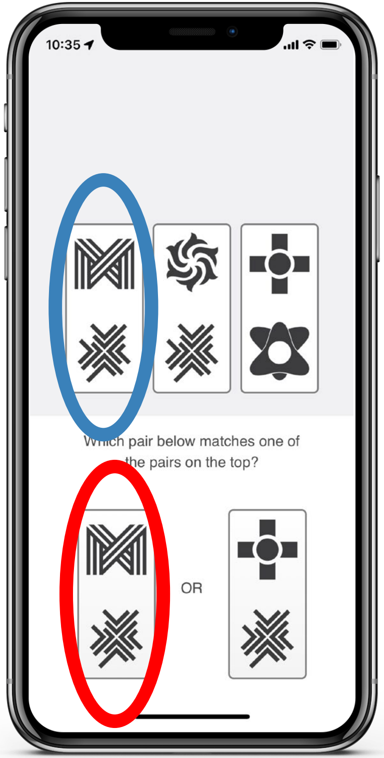
Considerations

- Intellectual disability (ID): Extremely wide range of intellectual abilities in DS Fortea et al, 2021 *Lancet Neurol*
- Many individuals with DS struggle with literacy.
- Physical considerations: Speech difficulties, low vision are common. Edgin et al., 2010 *Neurodev Disord*
- Do older adults with DS actually use smartphones?
- What role will study partners have?

Original Symbols Test (20-40 seconds) Processing Speed

SYMBOLS Test
Participants are asked Which pair below matches one of the pairs on top?

SYMBOLS Test
Participants complete 12 trials as quickly as possible. Primary outcome: Number correct and response time.



Nicosia et al. 2022 *JINS*

DS-ARC Shapes Test (60 seconds)
Processing Speed

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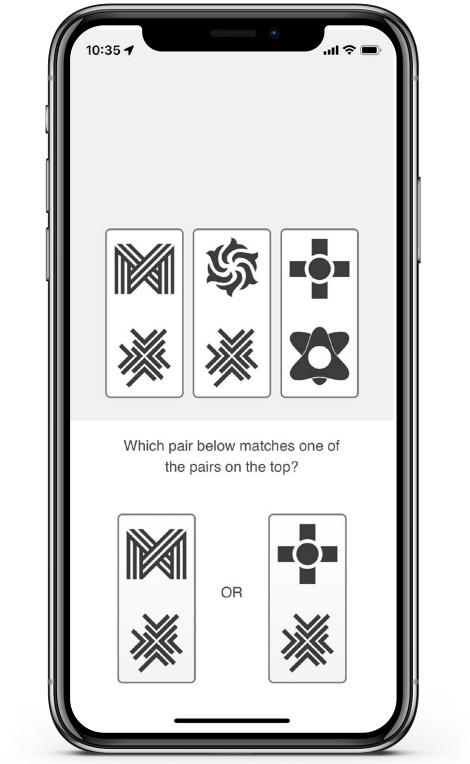
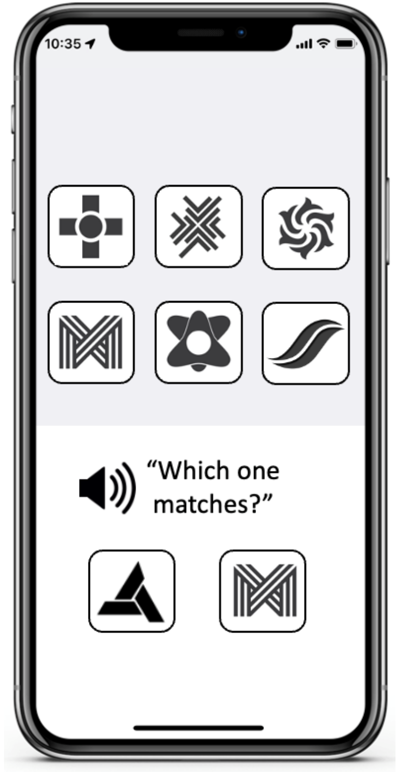
ARC SYMBOLS Test
- 12 trials
- Matching two abstract shapes
- Written instructions & tutorial



DS-ARC SHAPES Test
- 10 trials
- Matching one abstract shape
- Instructions & tutorial via audio



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Original ARC Prices Test (60 seconds)

ARC Prices Test

- 10 Price-item pairs per session
- At least $1.50 between item pairs
- 3s presentation
- Primary Outcome: Percent Errors

Study Phase

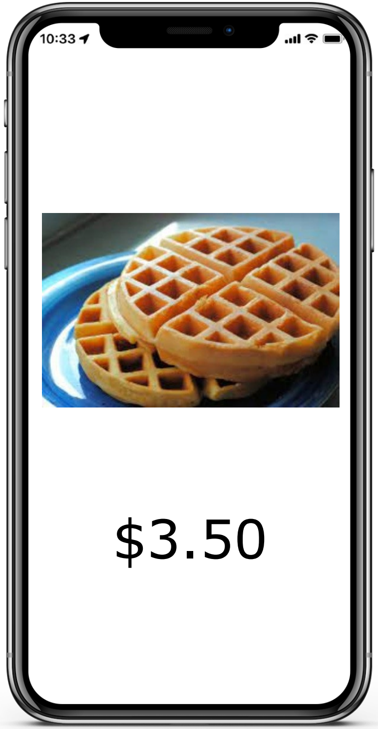
Recall Phase

Wilks et al, 2021 *JCEN;* Nicosia et. 2022 *JINS*

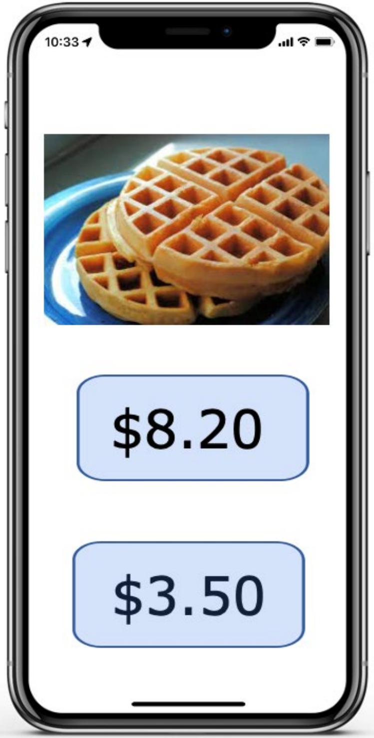
DS-ARC Prices Test (90 seconds)

DS-ARC Prices Test

- 6 Price-item pairs per session
- 2-digit prices
- At least $3 between item pairs
- 6s presentation
- Uses pictures of food items

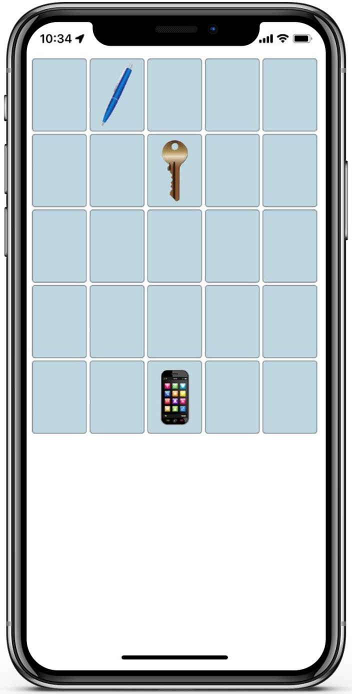


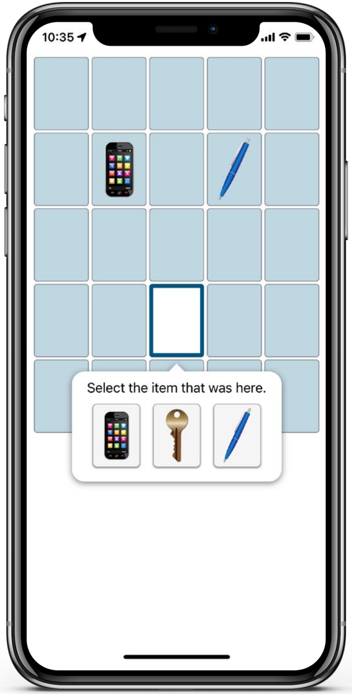
Learning



Recall

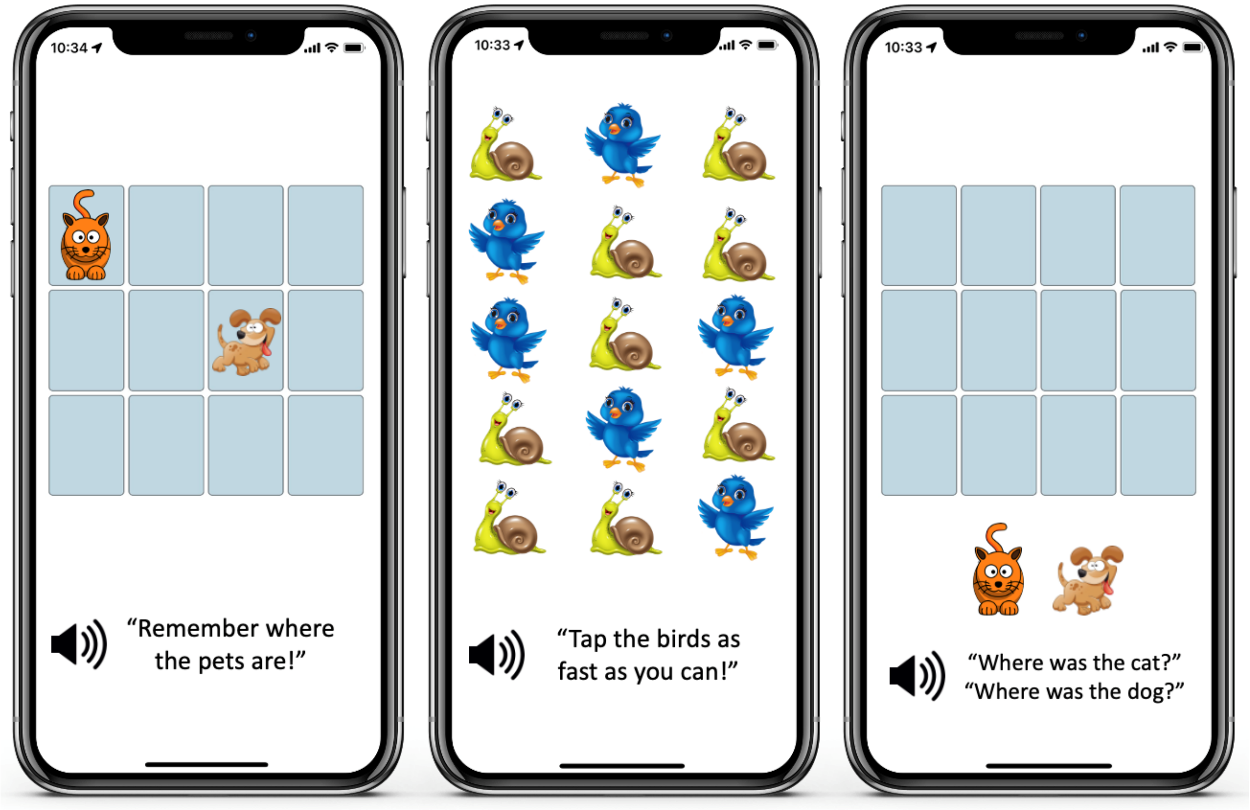
Original ARC GRIDS Test (30-40 seconds)
Spatial Working Memory





Wilks et al, 2021 *JCEN;* Nicosia et. 2022 *JINS*

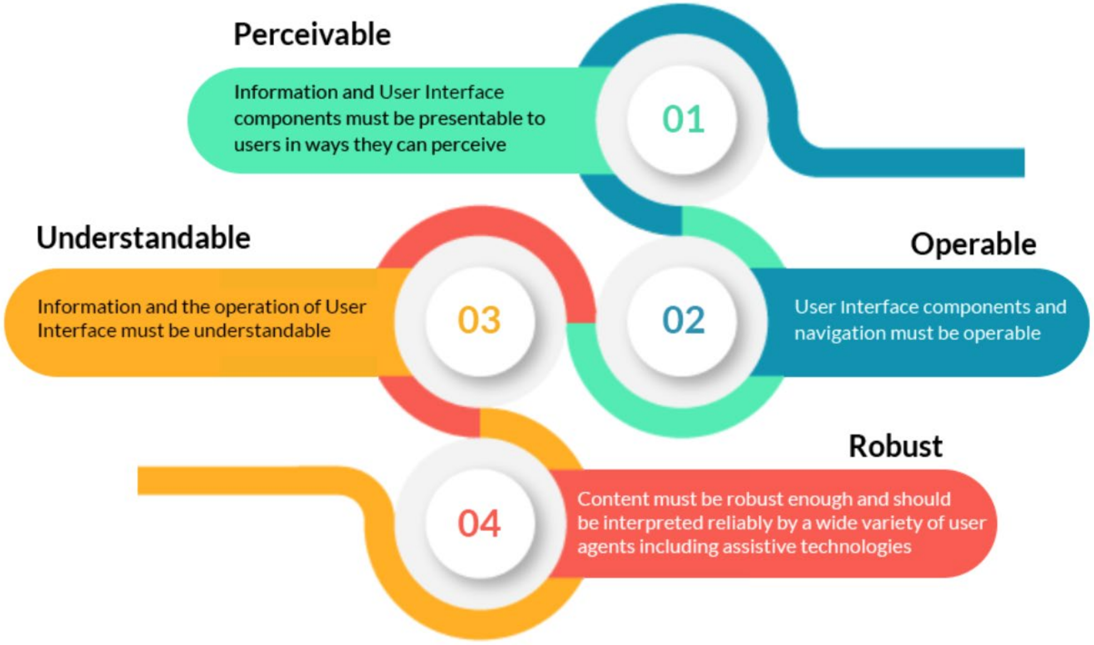
DS-ARC PETS Test (60 seconds)
Spatial Working Memory



Accessibility Resources for Tech Development

Web Content Accessibility Guidelines (WCAG; w3.org/WAI)

- Applies to any digital content, including smartphone apps, websites, gaming, productivity software, etc.



Web Accessibility Checklist

A checklist for creating accessible websites and web applications.

Share:

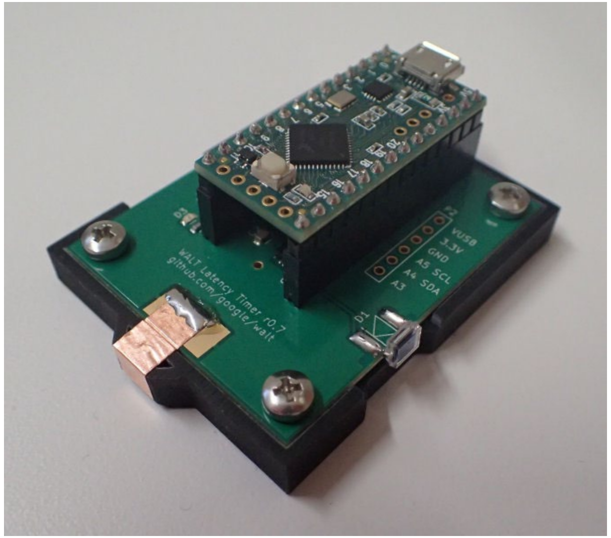
- [ ] Images should have meaningful alternative text +
- [ ] Links should be visually identifiable +
- [ ] Use descriptive section headings +
- [ ] Use correct semantic HTML element structure for your content +
- [ ] Forms have descriptive labels +
- [ ] Information should not depend on color, sound, shape, size, or visual location +

webaccessibilitychecklist.com

If BYOD, What about device latencies?

WALT Latency Timing Device

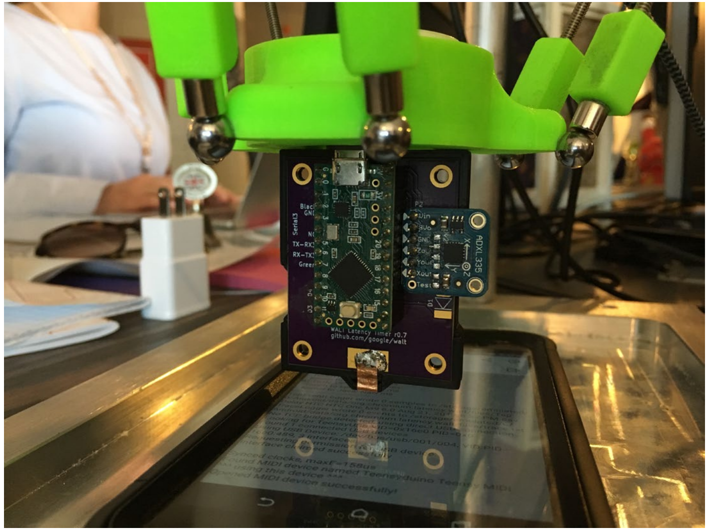
Developed by Google/Android engineers to assess smartphone and tablet performance.

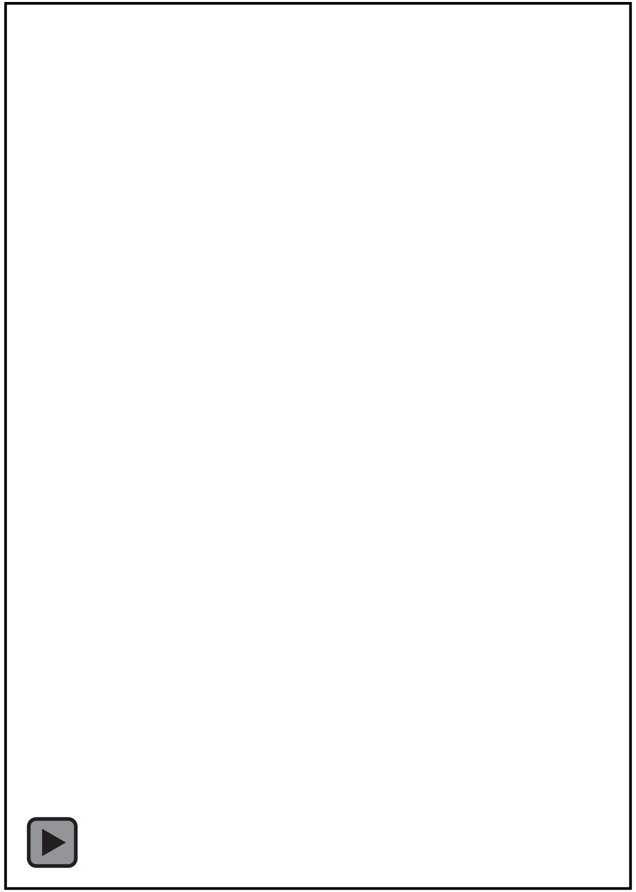


"Suggested" Tap Latency Protocol

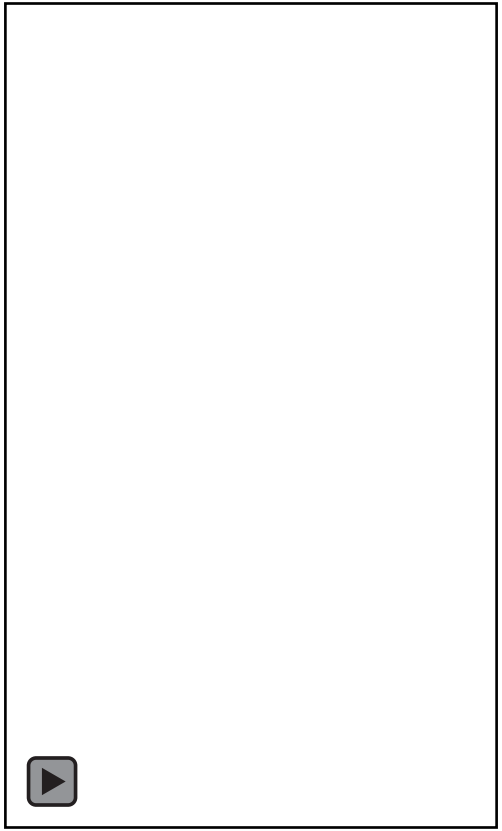
Enter the TapBOT, AKA Tappy

First Prototype

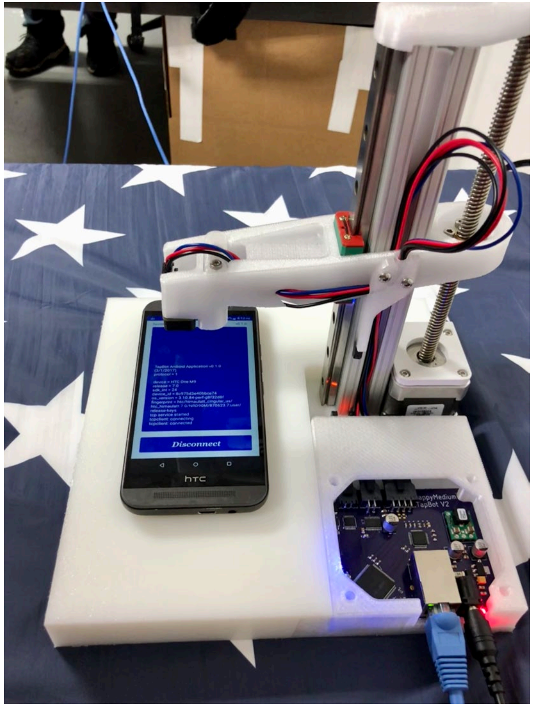




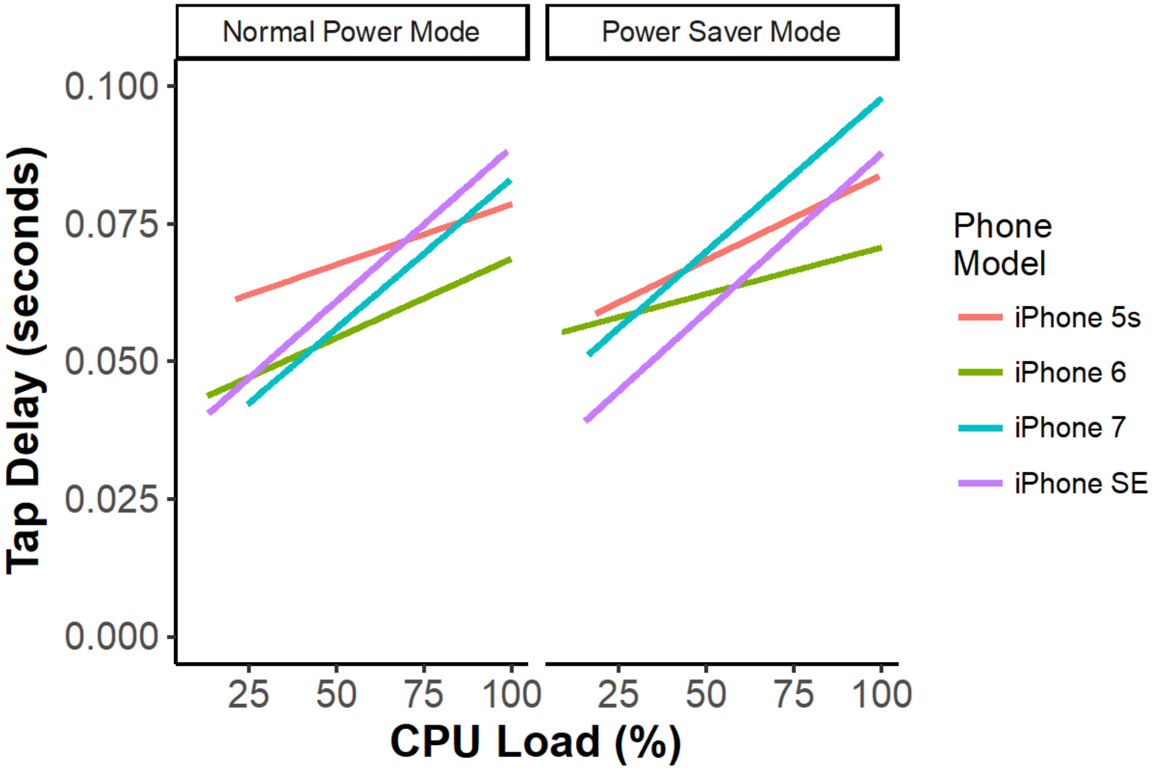
TAPBOT 2.0



TAPBOT 3.0 “Tappy”

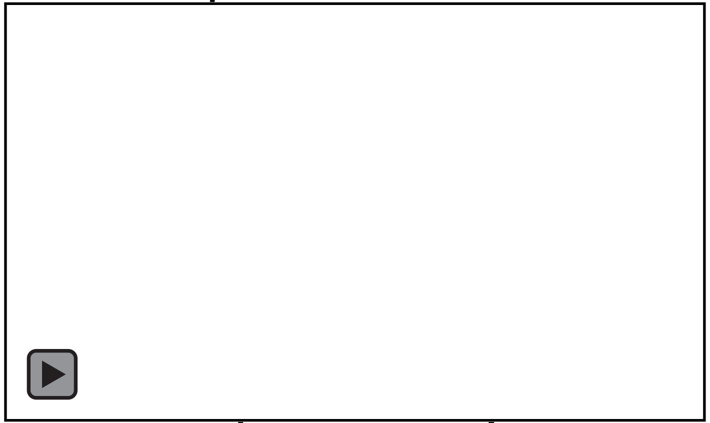


Tappy iOS Tap Latency Results: CPU Load by Power Modes



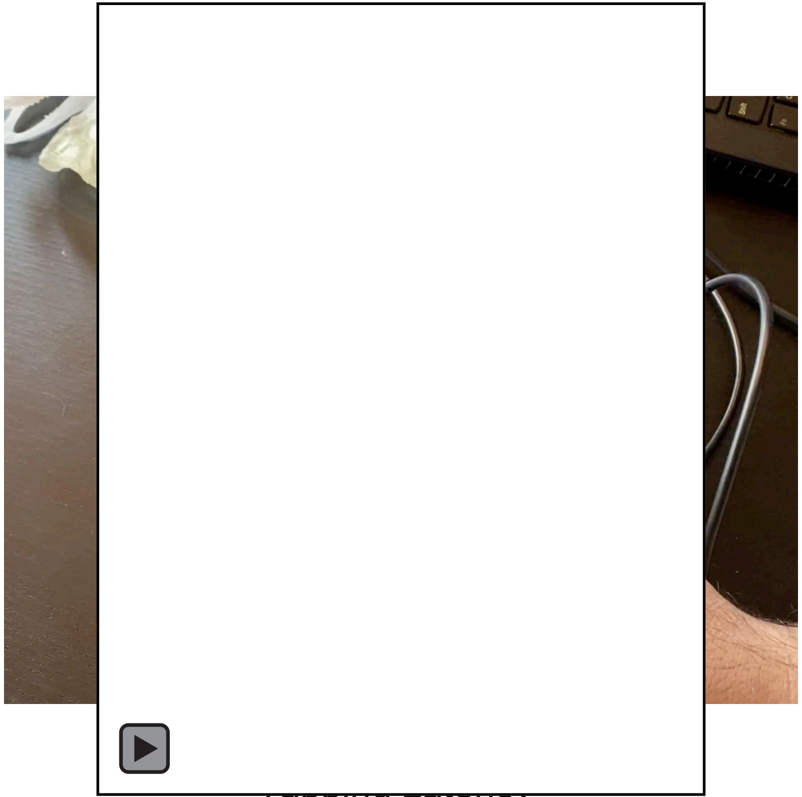
Latency and Timing Assessment Robot (LaTAR Bot)

- LaTAR Bot Outcomes:
  - ❖ Tapping Latency
  - ❖ Display Latency
  - ❖ ~~Physical Tapping Latency~~

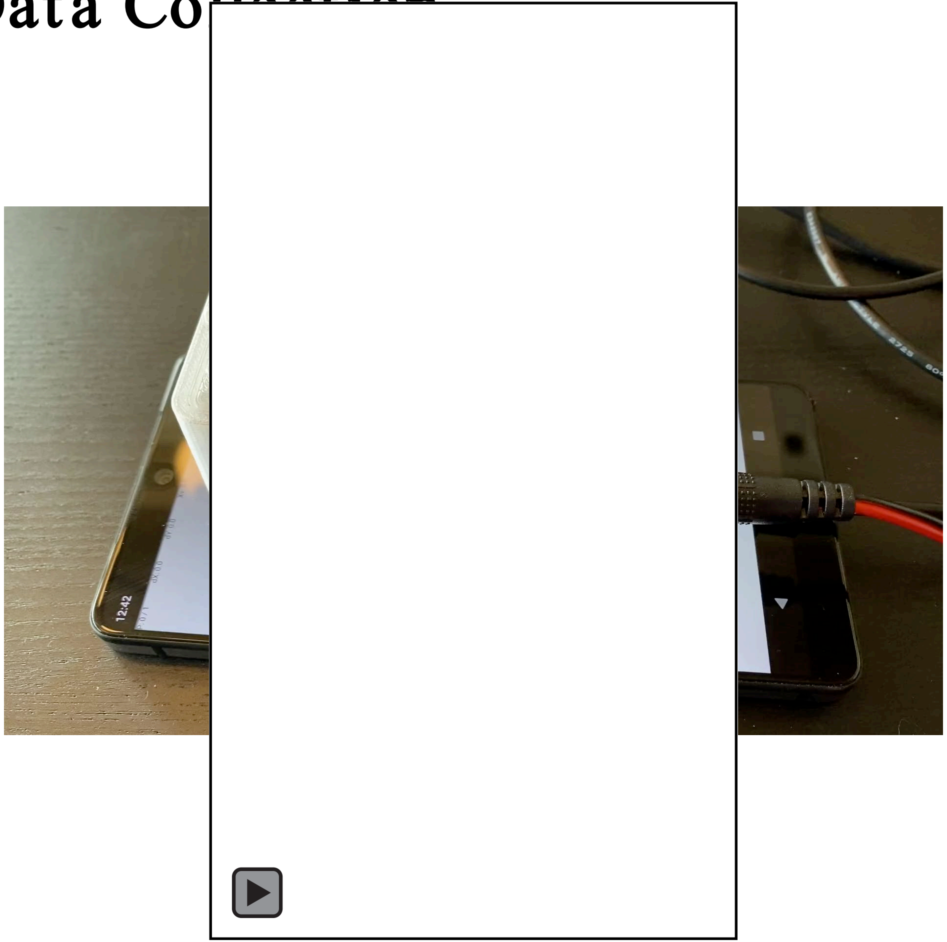


Nicosia et al, *2022 Beh Res Meth*

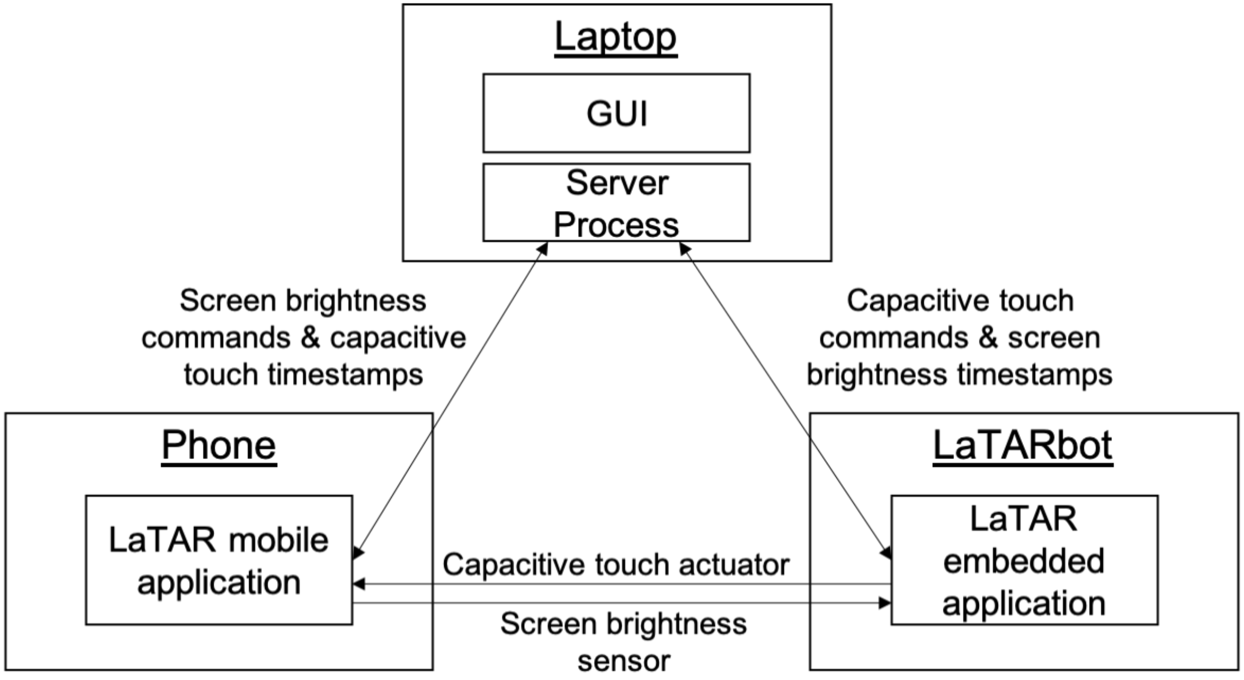
LaTAR Bot Data Collection



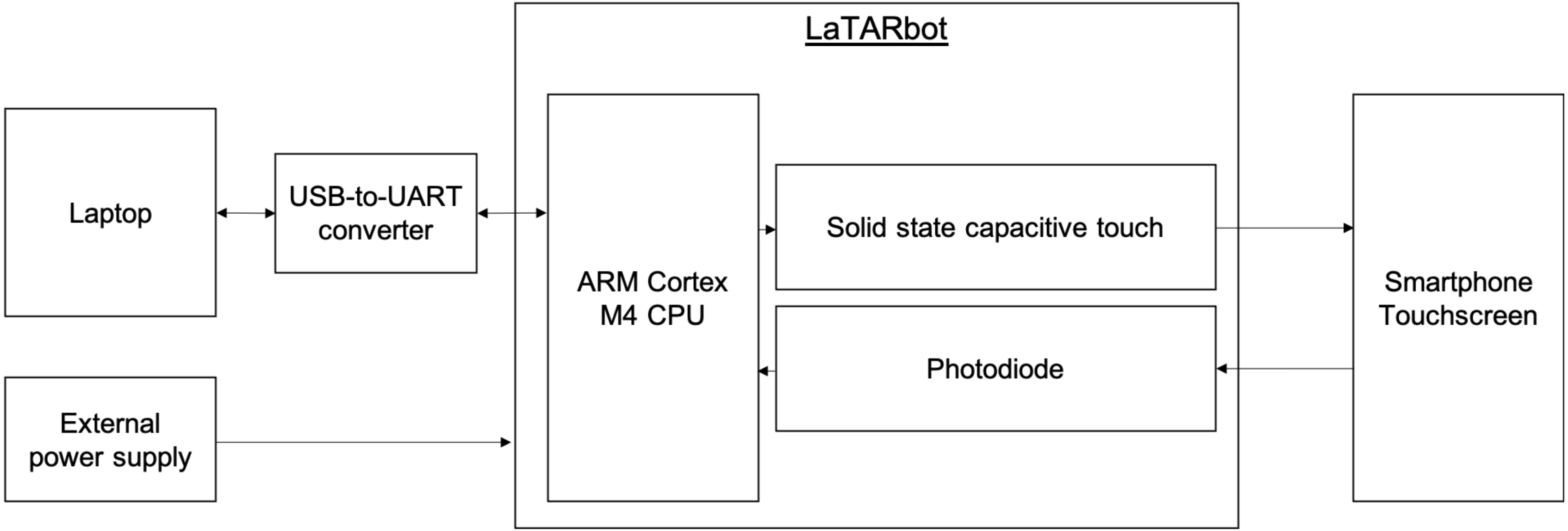
Tapping Latency



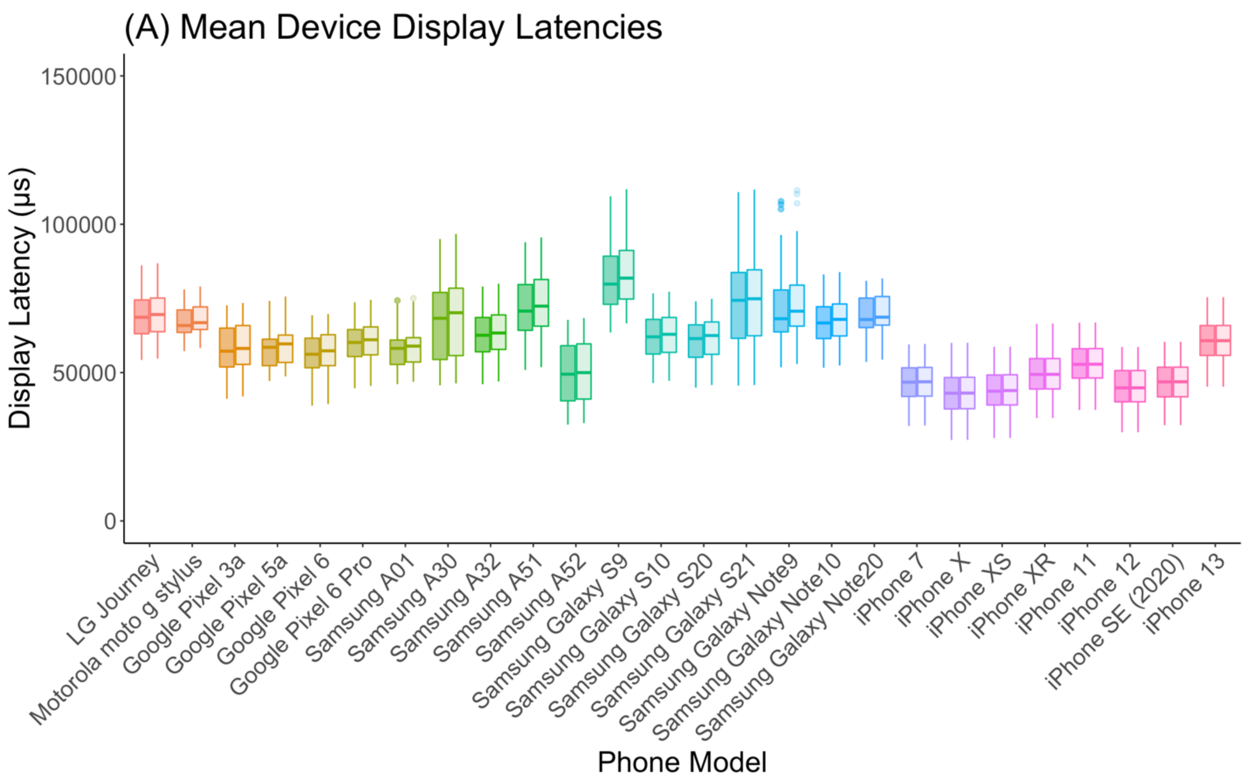
LaTAR Bot Configuration



LaTAR Bot Apparatus



Display Latencies for 26 Popular Smartphones



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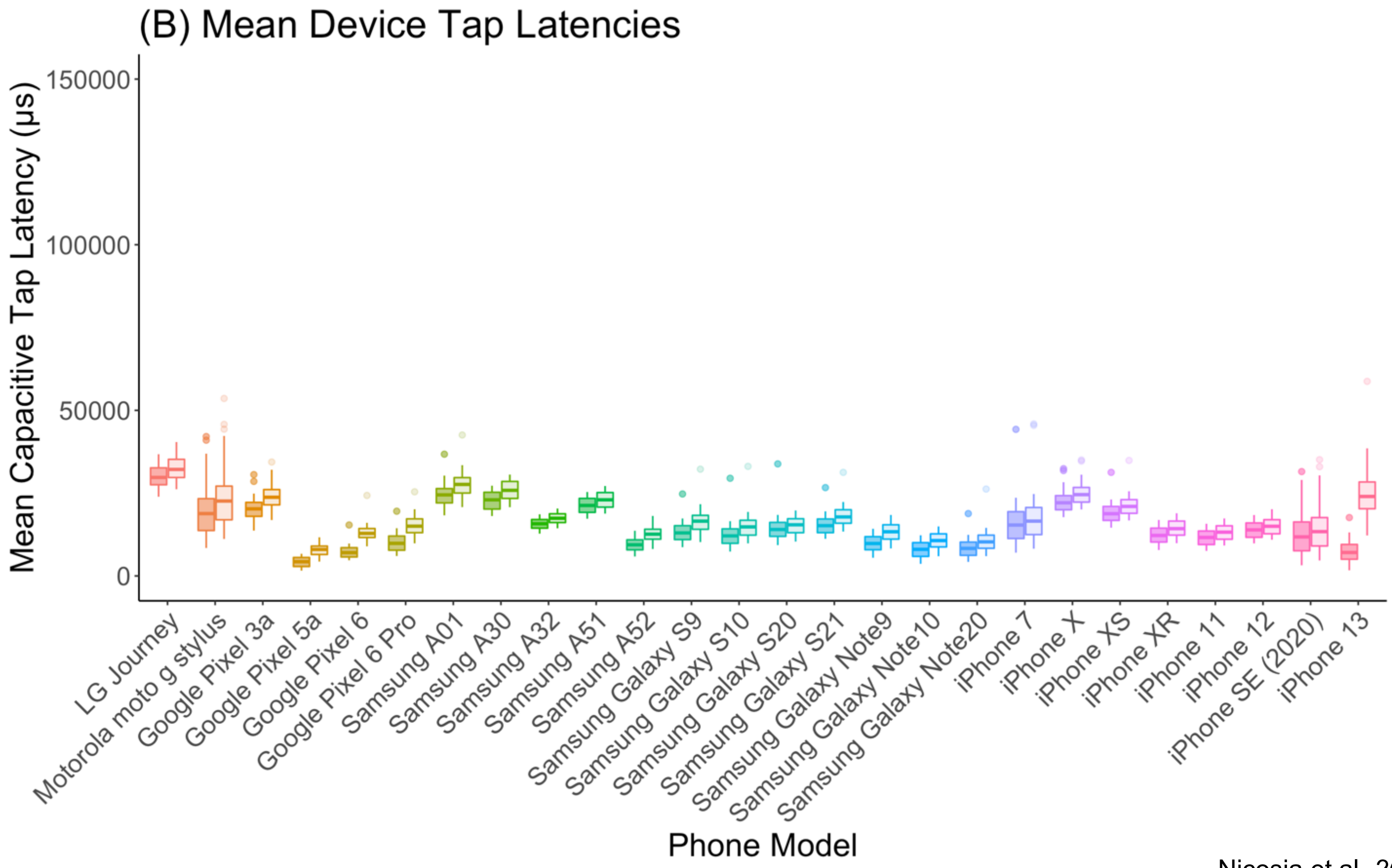
Tap Latencies for 26 Popular Smartphones



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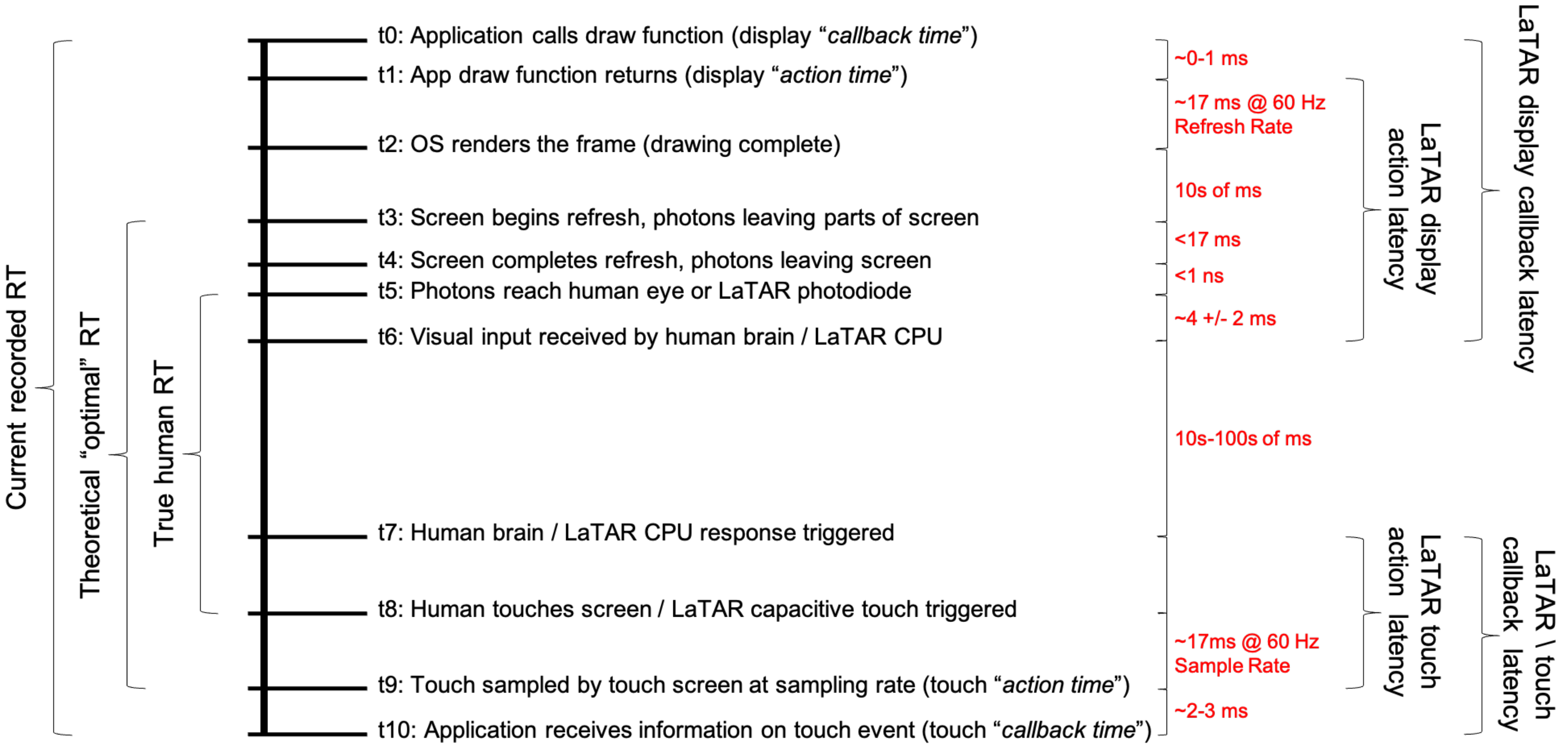
How is this useful for clinical research?

Optimal Response Times (in Theory)



Nicosia et al, *2022 Beh Res Meth*

Guidelines for BYOD Studies

(A) BYOD Study Design Choice		**Potential Effect on Response Times**
Within-Person	Mid-Study Change to Same Device	mild
	Mid-Study Change to Same Manufacturer	moderate
	Mid-Study Change to Different Manufacturer	severe
	Mid-Study OS Software Update	moderate
Between-Person	Same Device, Same OS	mild
	Different OS Versions (Same Device)	moderate
	Different Devices (Same Manufacturer)	moderate
	Different Devices (Different OS and/or Manufacturers)	severe

(B) BYOD Study Design Tradeoffs

Response Time Precision	**Participant Sampling Pool**	**Cost**	**BYOD Design**
~105 ms total device variability *max - min for all devices in the study*	Large	$	Full BYOD
~70 ms total device variability *max - min for iOS only devices in the study*	Moderate	$$	Selective BYOD
~17 ms total device variability *theoretical total latency variability of device with 120 Hz refresh & sampling rate*	Small	$$$	Device Provided

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Questions?

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