Wheels, Walking, and In Between: An engineer's approach to examining mobility outcomes for young children with disabilities

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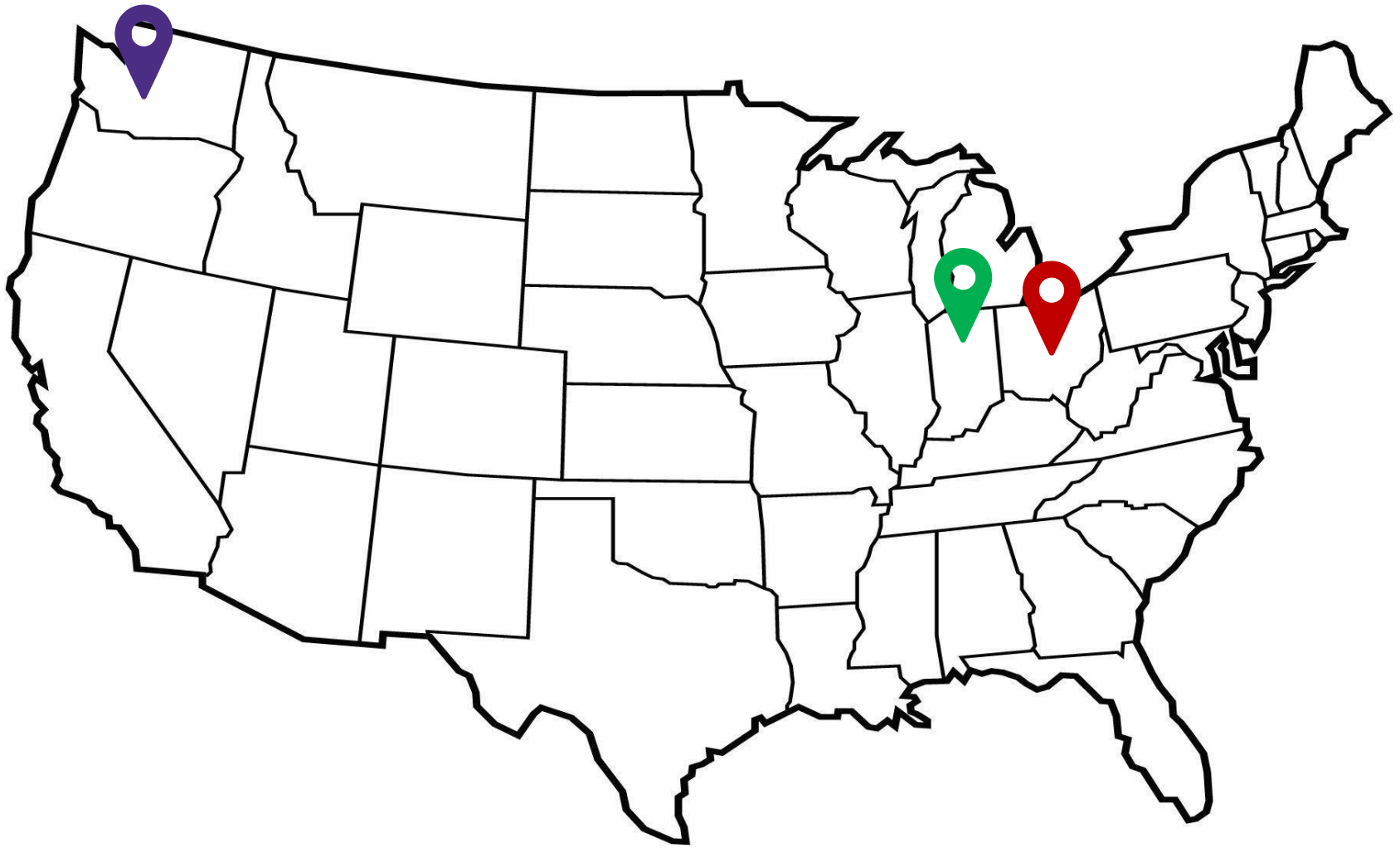
Hi, I'm Mia!



Columbus, OH
- First research job: Nationwide Children's

South Bend, IN
- Bachelor's in Mechanical Engineering

Seattle, WA
- PhD in Mechanical Engineering

Hi, I'm Mia!

daughter

Go Dawgs!

she/her/hers

researcher

teacher

play expert

disabled

runner

straight

partner

hangs with clinicians

student

Caucasian

maker

hard of hearing

Go Buckeyes!

engineer

friend

Go Irish!

sister

disability studies scholar

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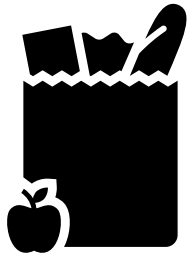
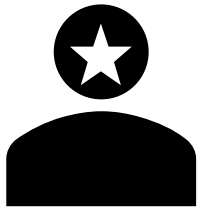
Independent mobility is critical for….

Autonomy

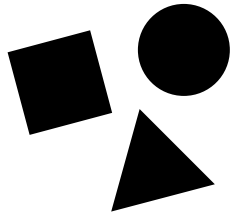


Community participation

Social engagement



Dignity



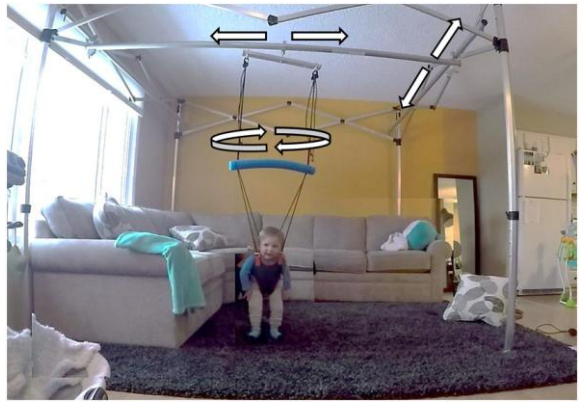
Developmental gains

Access to mobility devices is a human right.

How do we make these toddler sized?

Feldner et al. 2016, Sabet et al. 2022

Rethinking mobility devices for toddlers



Portable partial bodyweight support system

Lightweight manual wheelchairs

Crawling aids

Child-sized power wheelchairs

Hands-free gait trainer

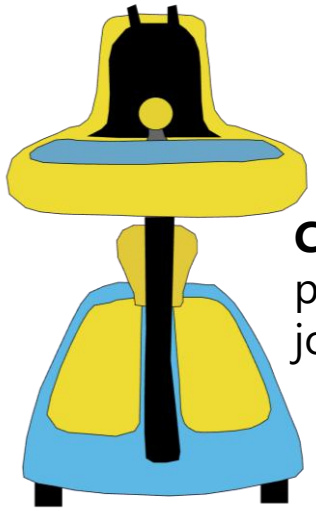
Overground exoskeletons

Adaptive tricycles

Mobility devices we are investigating today…

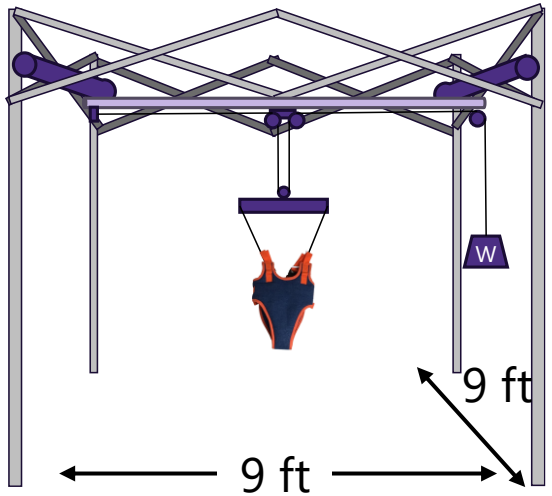
Control: switch

Modified ride-on car
Powered mobility device



Control: proportional joystick

Permobil Explorer Mini
Powered mobility device



PUMA (Enliten, LLC)
Partial bodyweight support system

Cost	$300	$3,000	$4,000
Attain	Adapted by volunteers	FDA approved commercial device	Commercial product
Use	5 years and under	12 – 36 months	Under 60 lbs.

Modified-ride on cars

Boosts socialization & participation

Enhances environmental engagement

Fun for children & caregivers

Advances developmental skills

- Cognition
- Expressive & receptive communication
- Fine & gross motor skills

Hospodar et al. 2023, Ziegler et al. 2025, Feldner et al. 2024

Permobil Explorer Mini

94% of children used the Explorer Mini during their first time[1]

Caregivers preferred the Explorer Mini to modified ride-on car[2]

Using the Explorer Mini more than 20 mins/3 days a week led to increases in[3]:

- Receptive communication
- Expressive communication
- Gross motor domains

[1] Plummer et al. 2020 [2] Sloane et al. 2023 [3] Logan et al. 2023

Portable Mobility Aid for Children (PUMA)

Families are comfortable using device and children enjoy using[3,4]

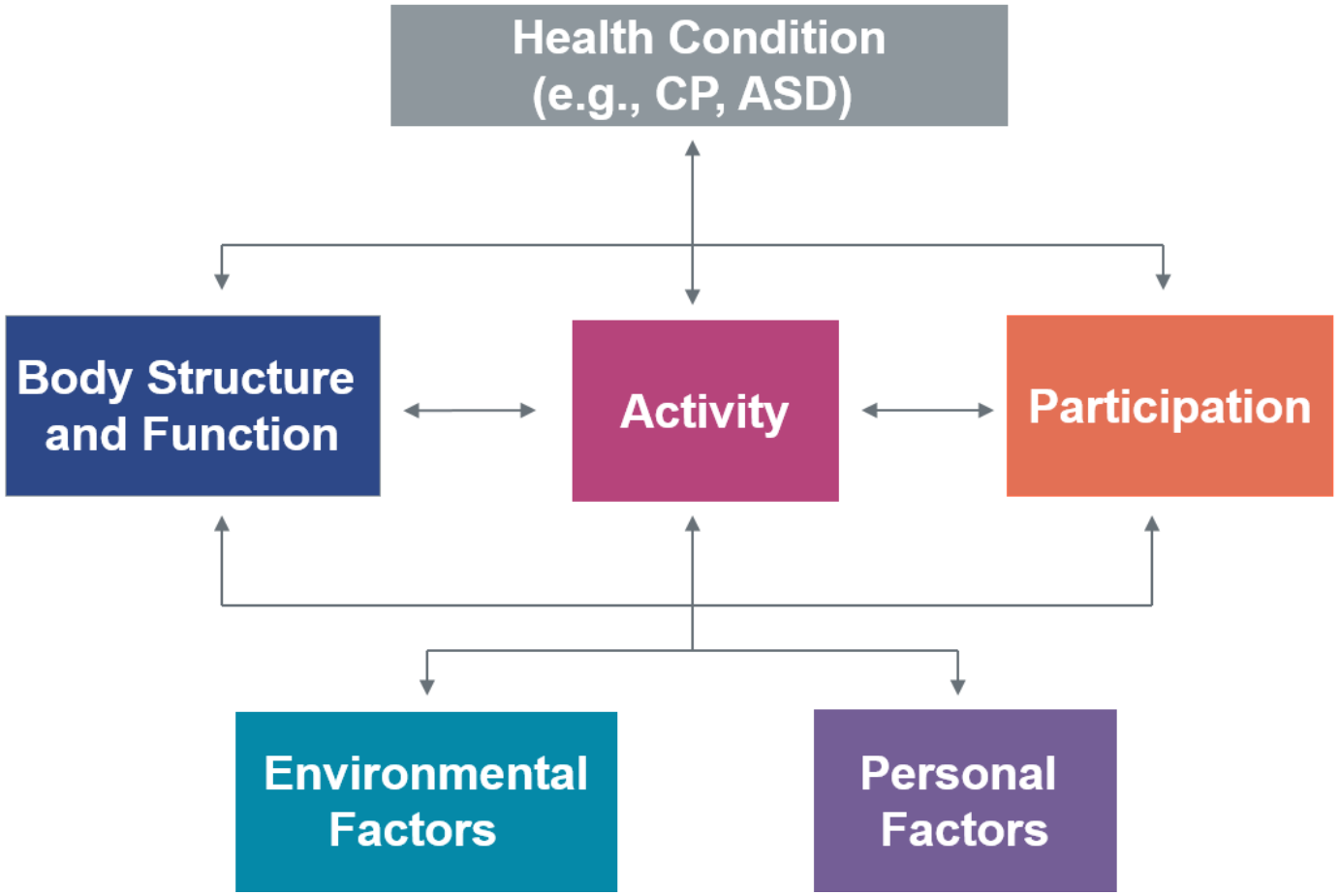
Increases in locomotor activity and decreased transition times[1]

Achieving motor milestones beyond their skillset with PBWS[2,3,4]

Increase in gross motor function with PBWS[1,5]

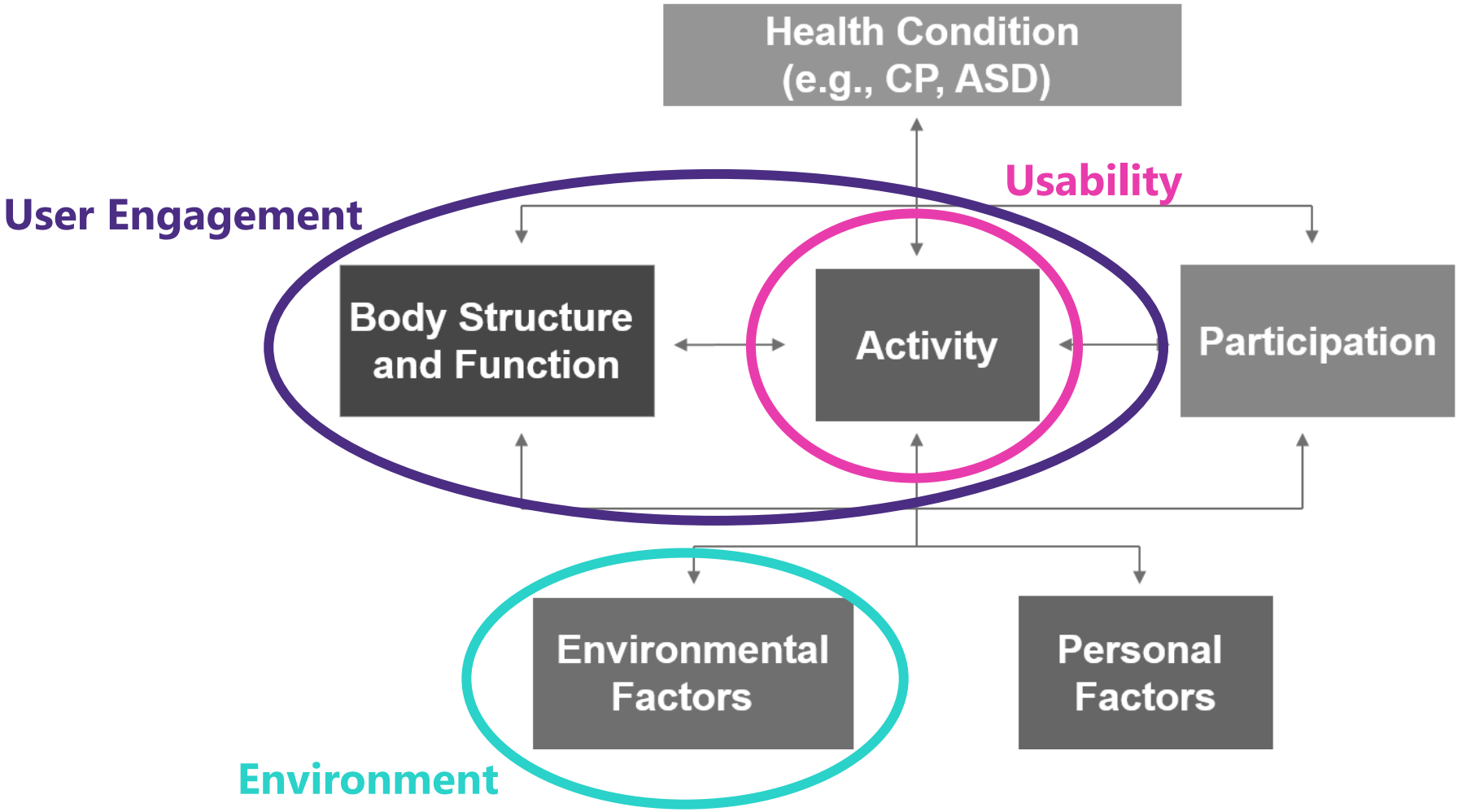
[1] Kokkoni et al. 2018 [2] Kokkoni et al. 2020 *Ped PT* [3] Kokkoni et al. 2020 *J NeuroEng and Rehab* [4] Iammarino et al. 2024 [5] Abuatiq et al. 2024

What factors influence mobility device use?



Feldner et al. 2016, Logan et al. 2018, Zaino et al. 2024, CanChild

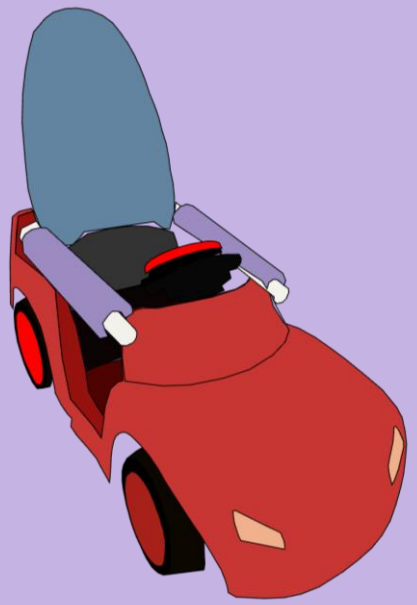
What factors influence mobility device use?



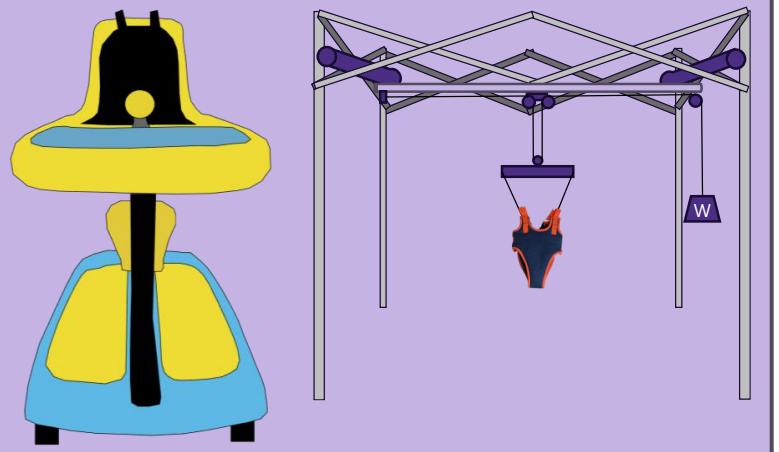
Factors that influence mobility device use…

Usability: *How families adopt mobility aids*

Environment: *Where a child uses their mobility aid*



User Engagement: *How body meets the device and enables participation*



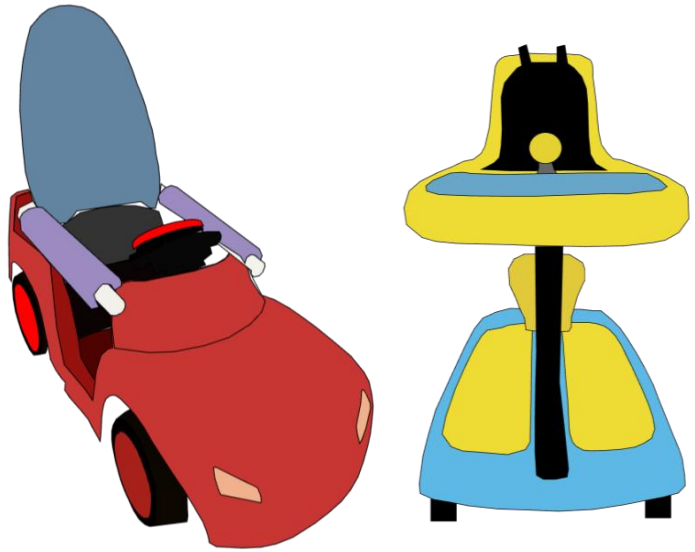
Usability

How families adopt mobility aids

Project goals

Compare outcome measures as measured by three tracking methods.

Compare use between the Explorer Mini and modified ride-on car.



How do we measure usability?

Explorer Mini Use Daily Log

Participant ID _____

Date	Location	Time Start	Time Stop	Time engaged	General activities & Notes	Fun Index (1-10)

Caregiver-reported activity logs

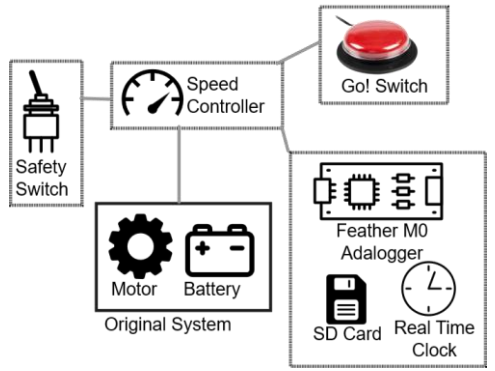
How do we track device use?

Caregiver-reported activity logs

Explorer Mini Use Daily Log

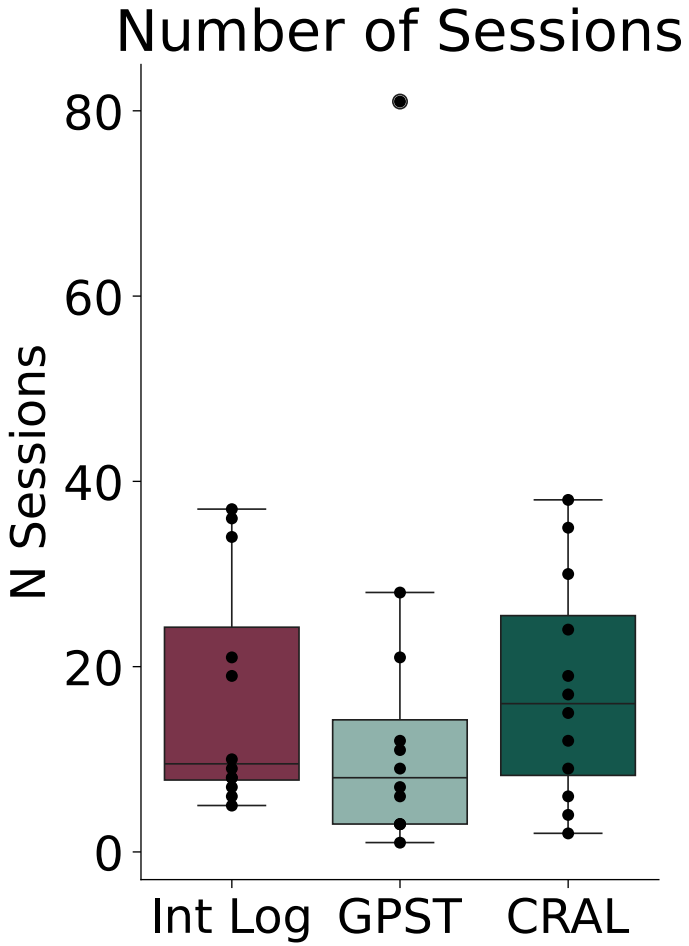
Participant ID _____

Date	Location	Time Start	Time Stop	Time engaged	General activities & Notes	Fun Index (1-10)



Integrated Logger

GPS Tracker



Measuring use of two devices in home environments

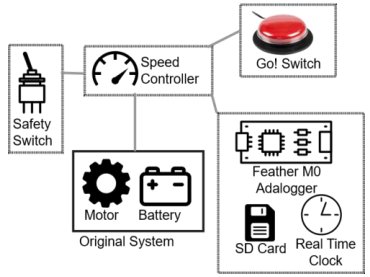
12 children with cerebral palsy

Use each device for 8 weeks

1. Caregiver-reported activity would differ from technology-measured activity.
2. Explorer Mini would be used more than the modified ride-on car.

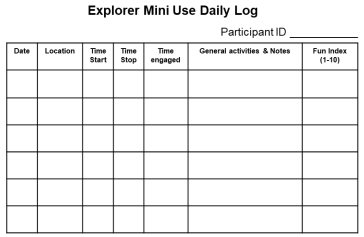
Permobil Explorer Mini

Modified Ride-on Car



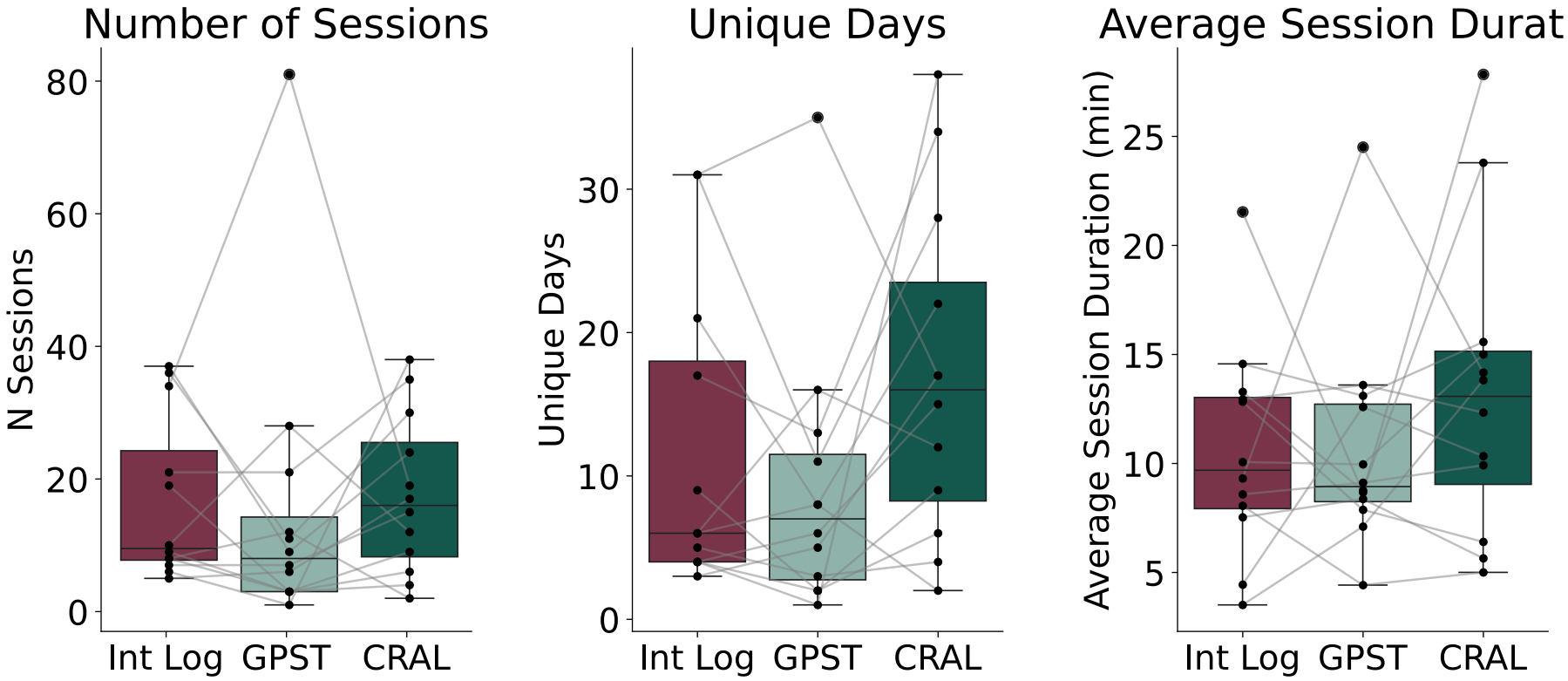
Integrated Logger

GPS Tracker



Caregiver-reported activity logs

Are there differences between tracking methods?



- No significant differences between tracking methods
- Differences in how play sessions are defined: Caregiver vs. technology

MROC Integrated Logger

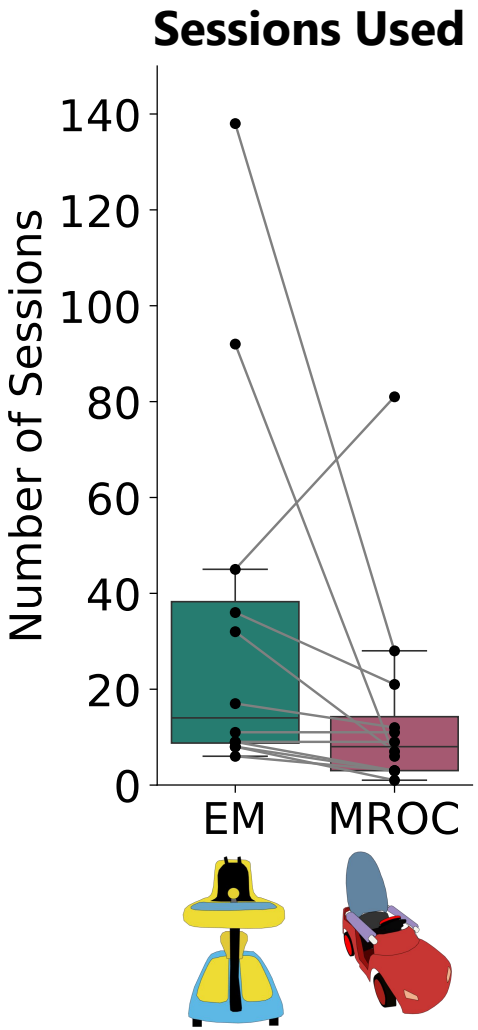
GPS Tracker

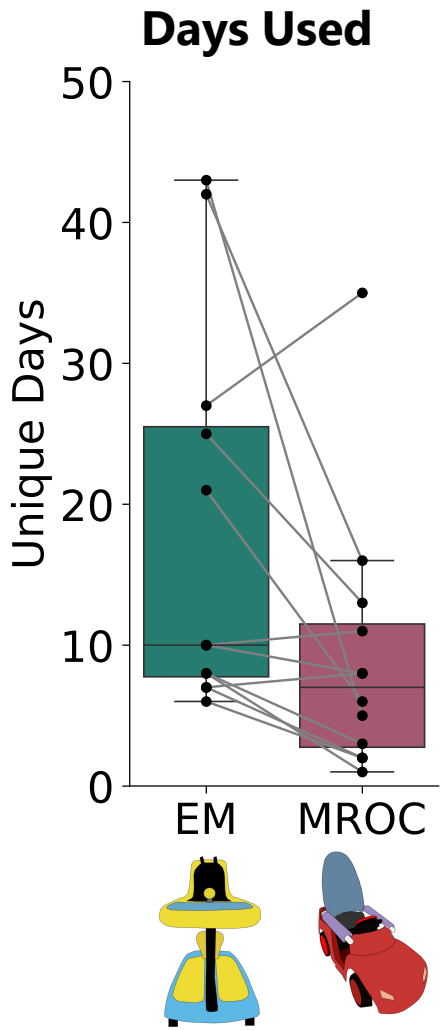
Caregiver-Reported Activity Log

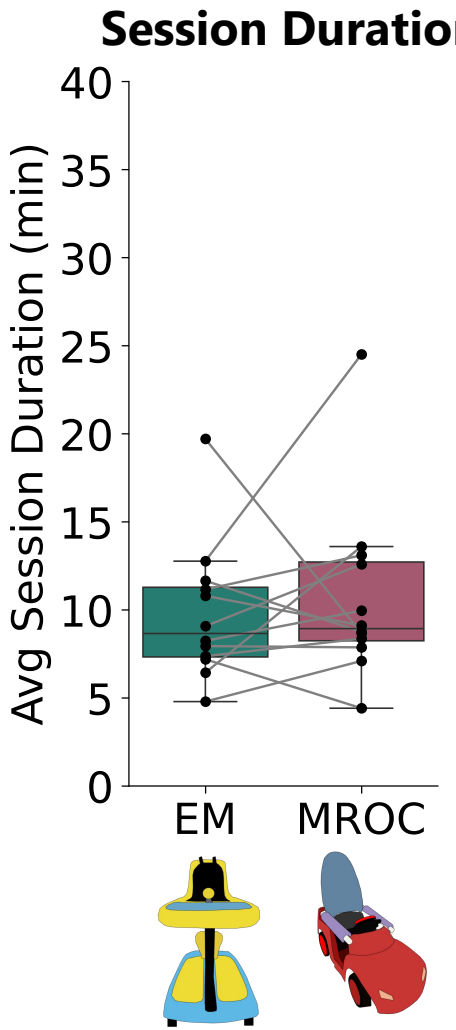
Use between the devices

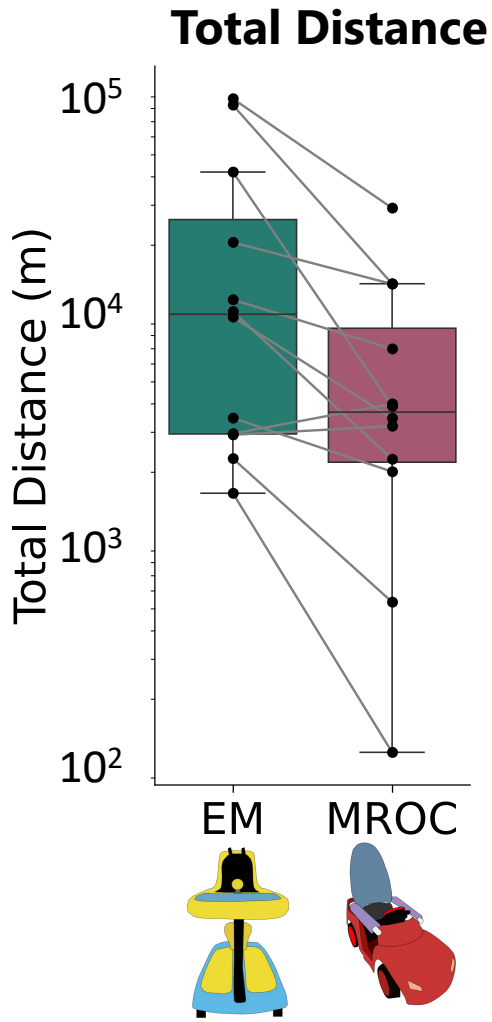
EM: Explorer Mini

MROC: Modified Ride-on Car









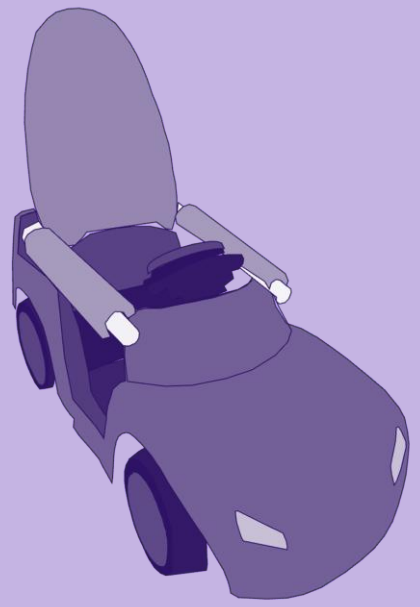
Factors that influence mobility device use…

Usability: *How families adopt mobility aids*

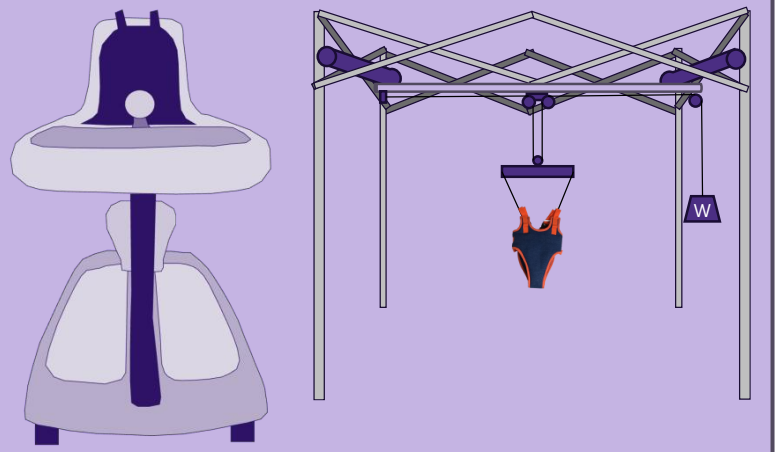
- Quantitative tracking methods and caregiver-reported metrics may capture different things.
- No significant differences in use between Explorer Mini and modified ride-on car.

Importance of trialing devices.

Environment: *Where a child uses their mobility aid*



User Engagement: *How body meets the device and enables participation*



The Physical Environment

Where a child uses their mobility aid



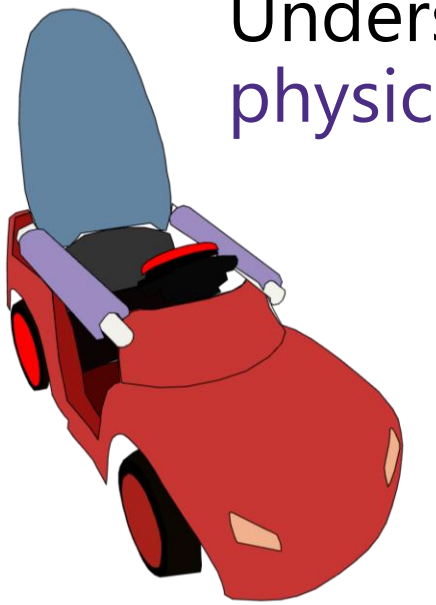



Feldner et al. 2018, Barreto et al. 2024, Abuatiq et al. *In Review*

Project goals

Understand how children use a modified-ride on car over a year.

Understand the relationship between the physical environment and device use.



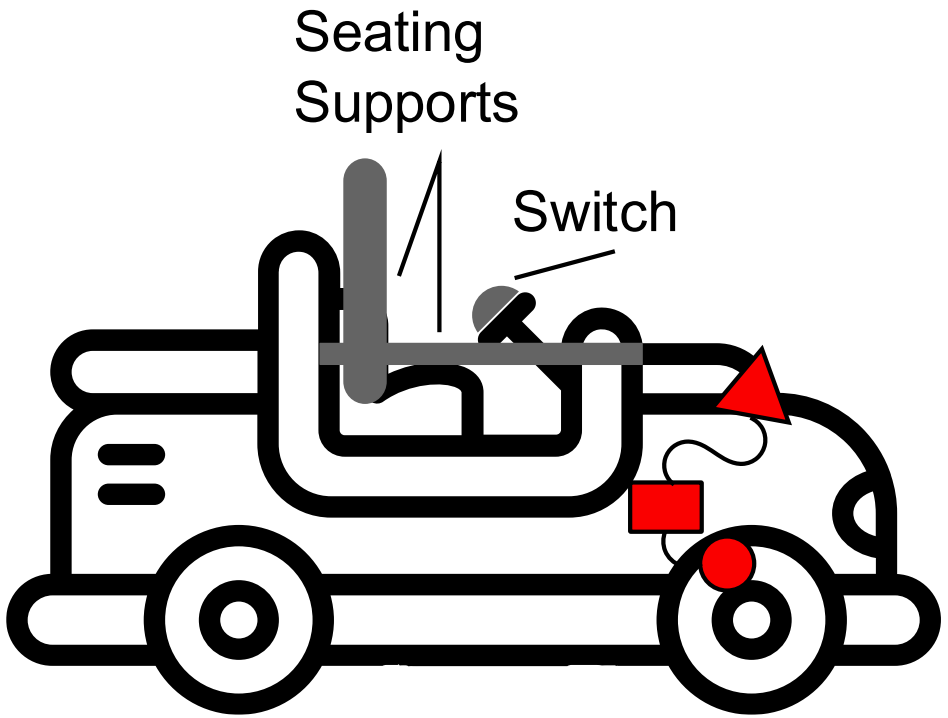
Measuring device use in the community

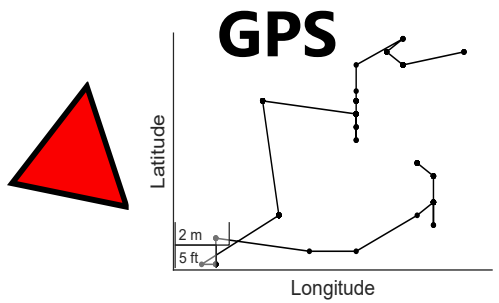
14 children + families

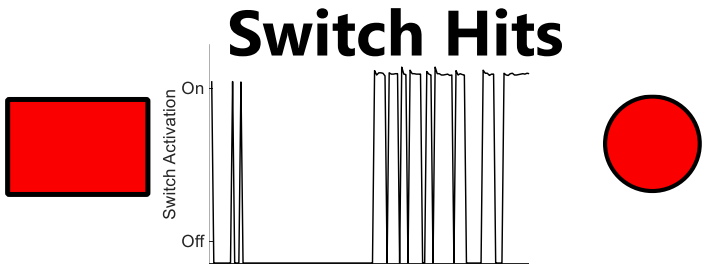
Use device as they want for a year

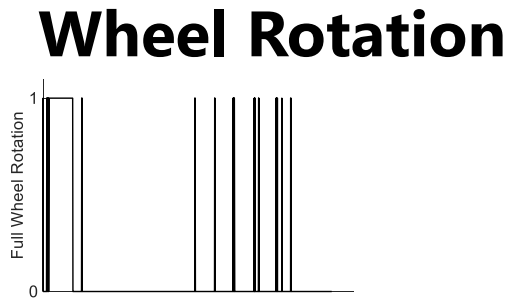
Hypotheses:

1. Families primarily would use the devices near their homes.
2. Families would use the device more if they lived near "driving destinations".

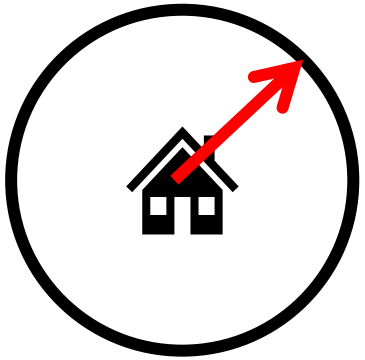


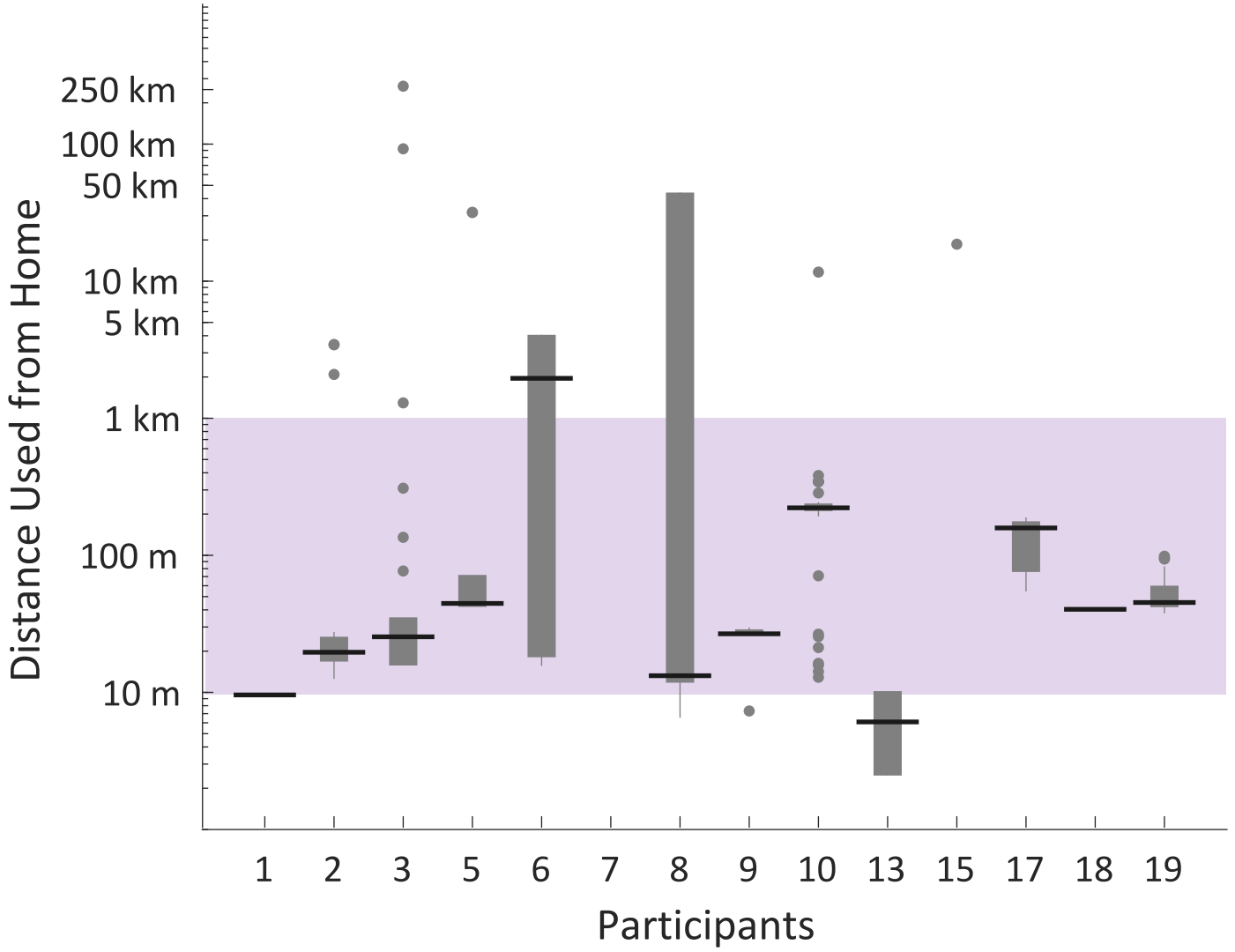






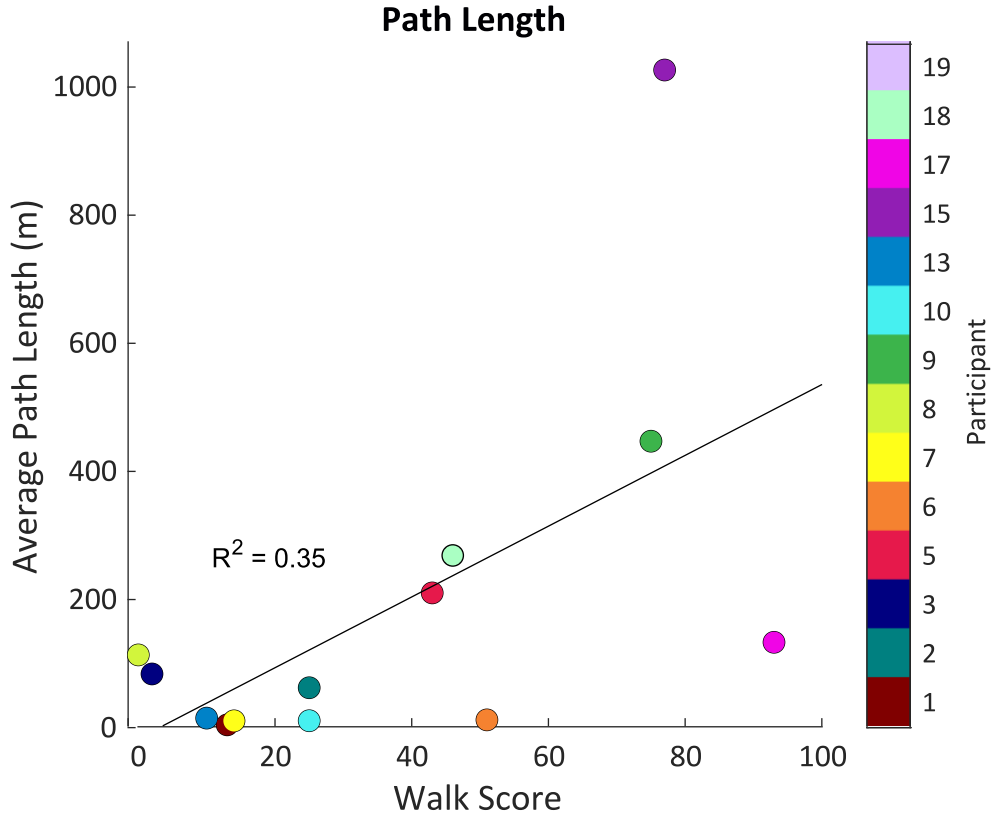
Where do young kids use mobility devices?



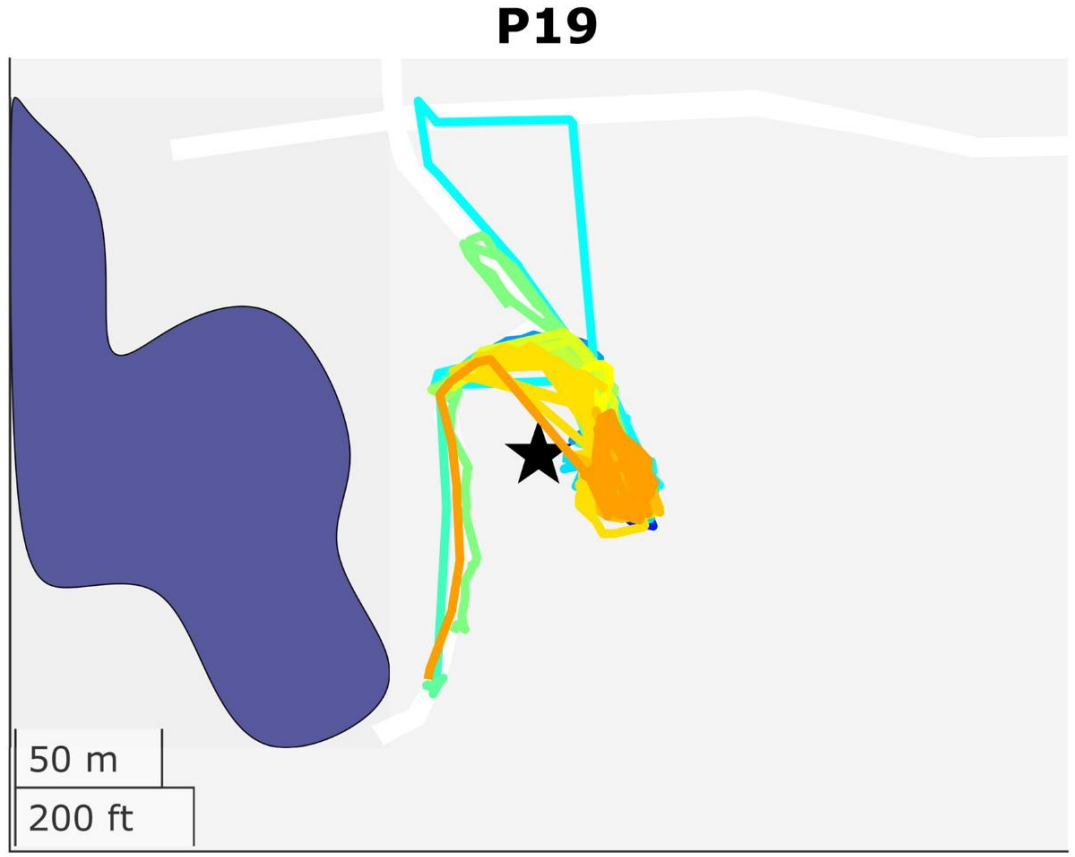


Kids primarily use mobility aids in and near home.

Places to go increases distance travelled.

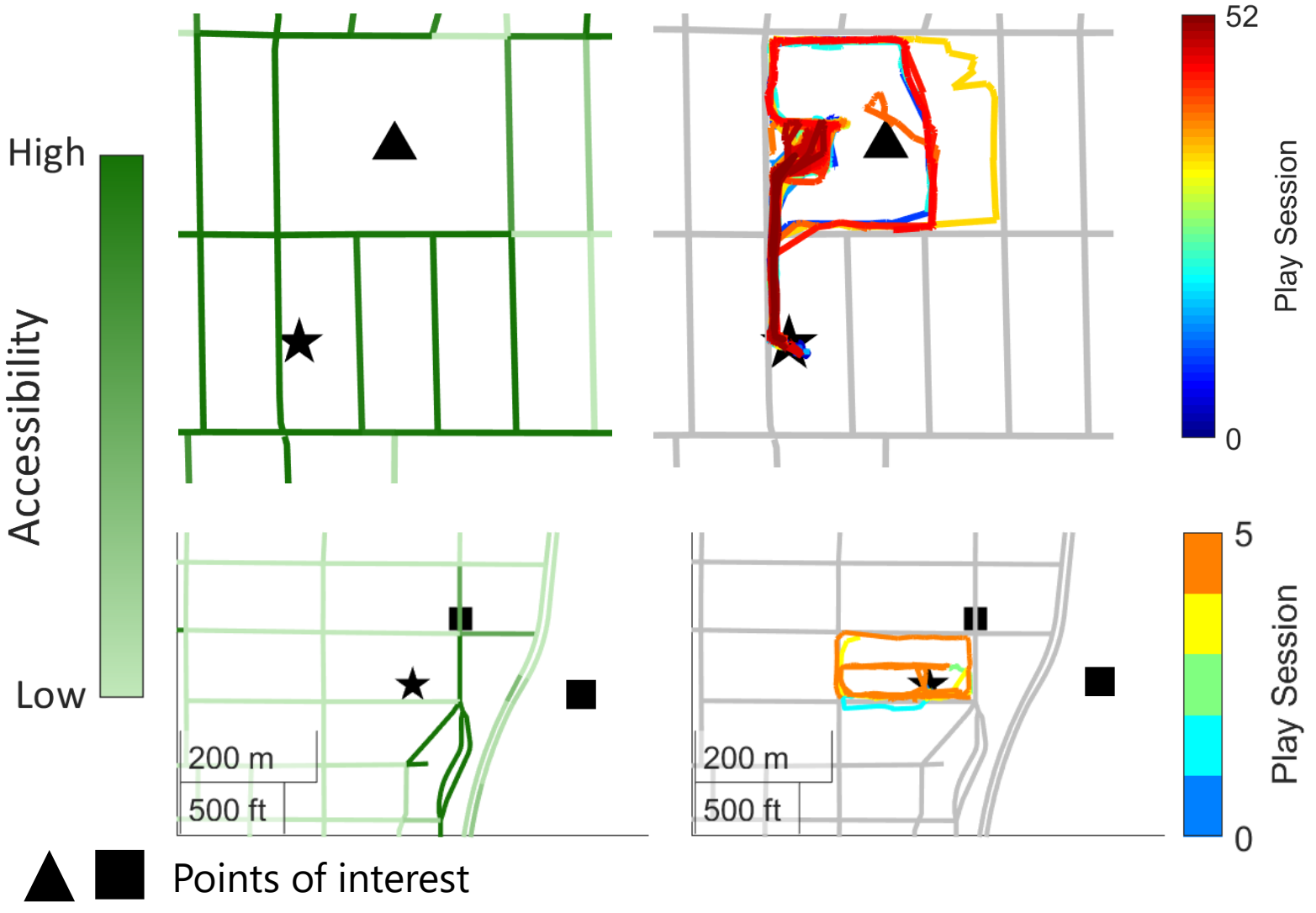


Increased pedestrian friendliness



High Walk score

Accessible paths impact young kids too.



Factors that influence mobility device use…

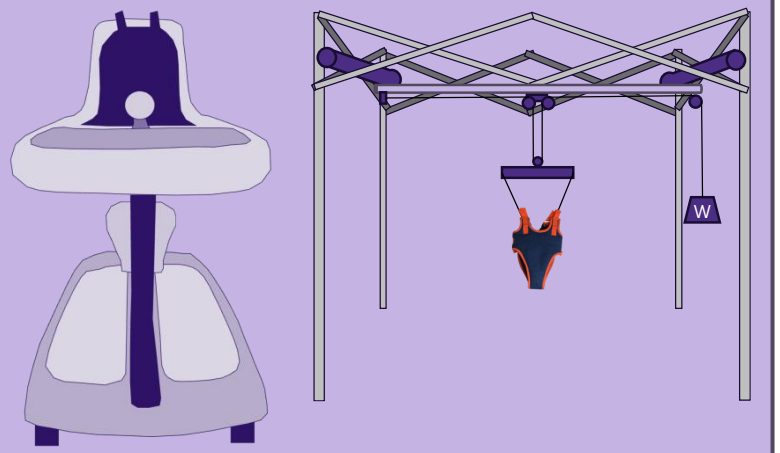
Usability: *How families adopt mobility aids*

Environment: *Where a child utilizes a mobility aid*

- Young kids use mobility devices close to home.
- Children drove more in pedestrian-friendly neighborhoods and when in proximity to accessible paths.

Identify accessible areas for children to use mobility devices.

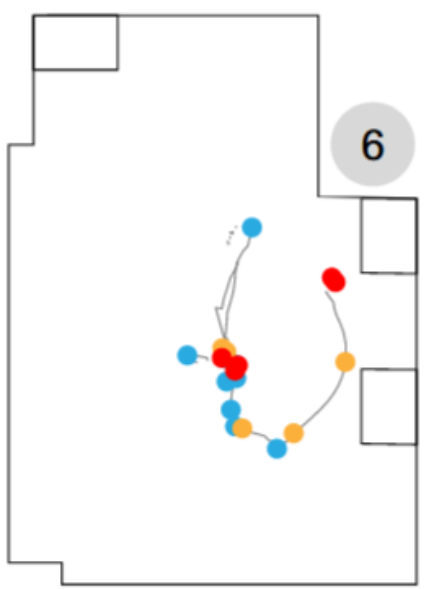
User Engagement: *How body meets the device and enables participation*



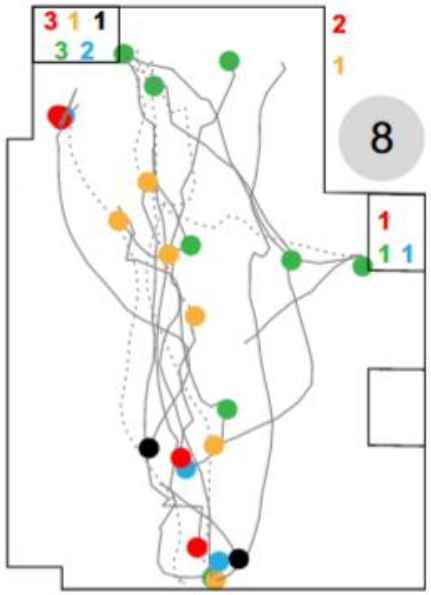
User Engagement

How body meets the device and enables participation

Impact of changing mobility



Crawling



Walking

Can kids travel further with mobility devices?

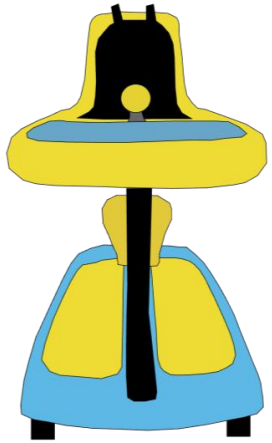
How does muscle activity change with mobility device use?

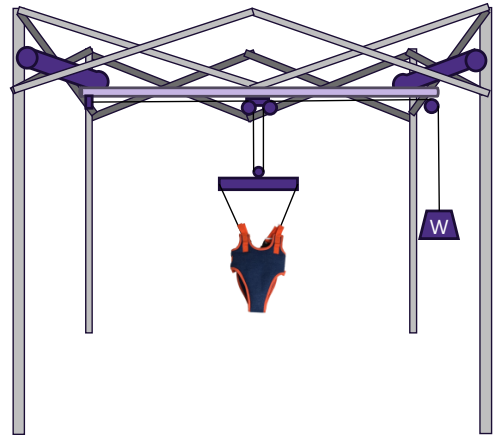
How do families perceive different types of devices?

Project goals

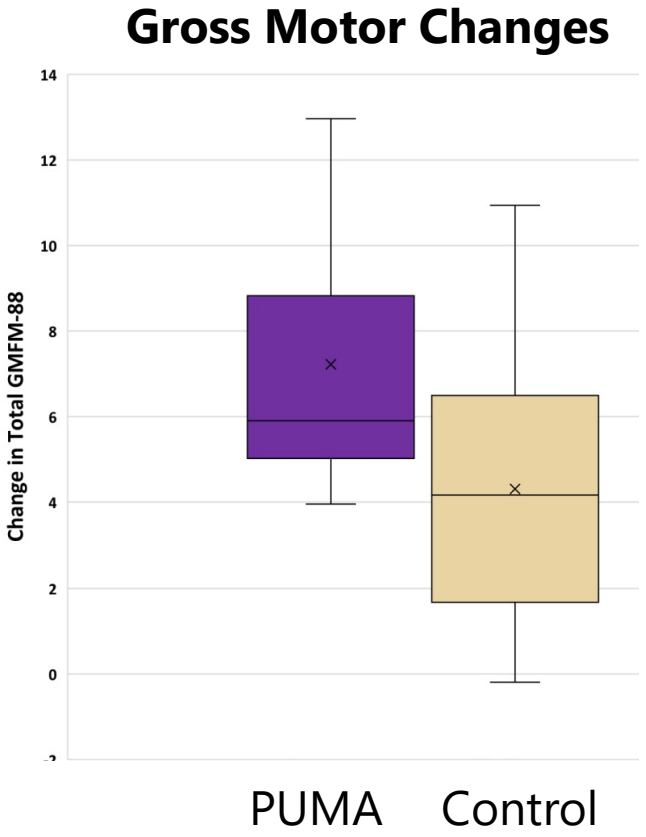
Measure how using mobility aids impacts a child's movement and muscle activity.

Understand caregiver perceptions on the use of mobility aids by pre-ambulatory children with developmental disabilities and delay.

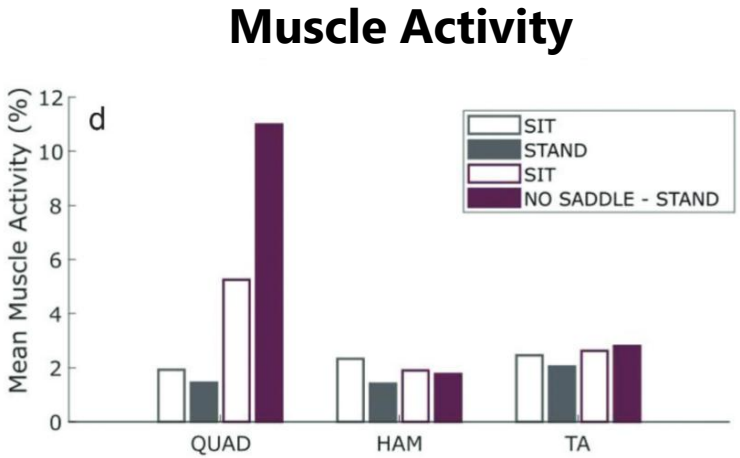




Mobility aids & body function



Increases in gross motor function using PUMA



Increased muscle activations without Explorer Mini seat

Comparing modes of mobility

No devices

PUMA

Explorer Mini with Static Seat

Explorer Mini with Dynamic Seat

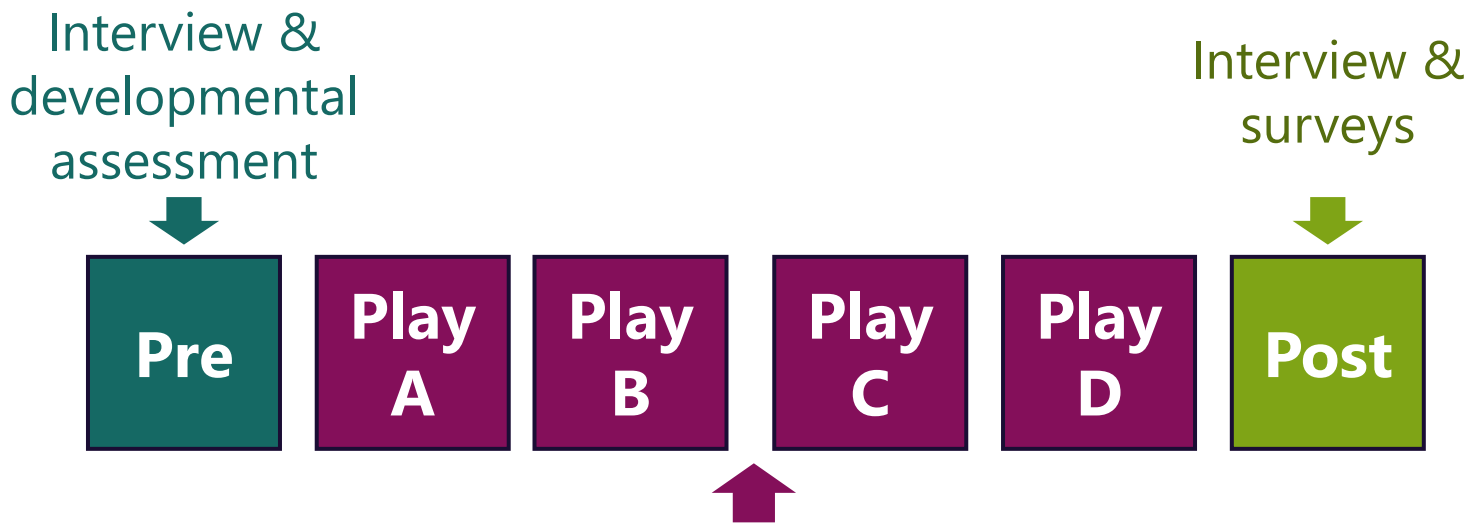
Measuring user engagement with mobility aids


Increased exploration &
caregiver's preferred device


Highest muscle activity due to
novel motor environment

Measuring user engagement with mobility aids

Lab-based sessions observing movement, muscle activity, and body posture with and without mobility aids.



Who can participate?

Children who…

- can **sit independently**, but are **not yet walking**
- have a condition that affects **mobility** and **muscle tone**

Participant	Condition	Age (mo)	Mobility
P01	Down syndrome	14	Sitting
P02	Down syndrome	25	Cruising
P03	Down syndrome	22	Crawling
P04	Down syndrome	15	Cruising
P05	Cerebral palsy	36	Sitting
P06	Hypotonia	12	Nonmobile

Where we play

Play space set up for crawling and cruising in the PUMA

Play space set up for rolling around in the Explorer Mini

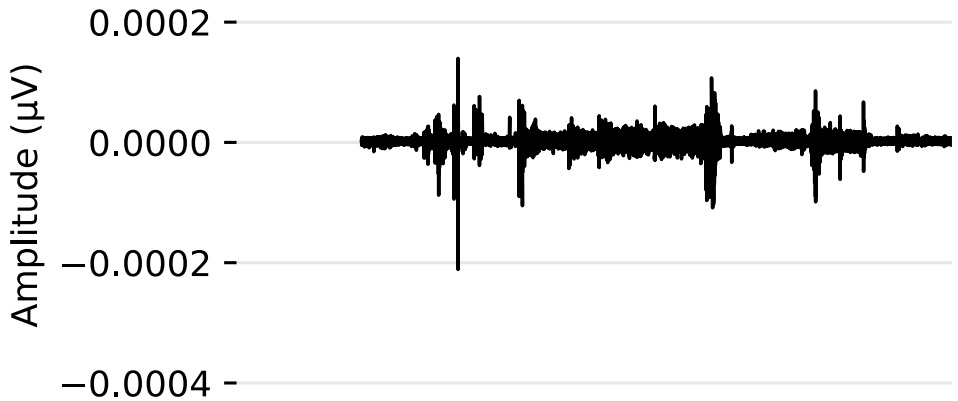
Outcome measures

NEUROMECHANICS

- Lower limb muscle activity (EMG)

EMG + IMU

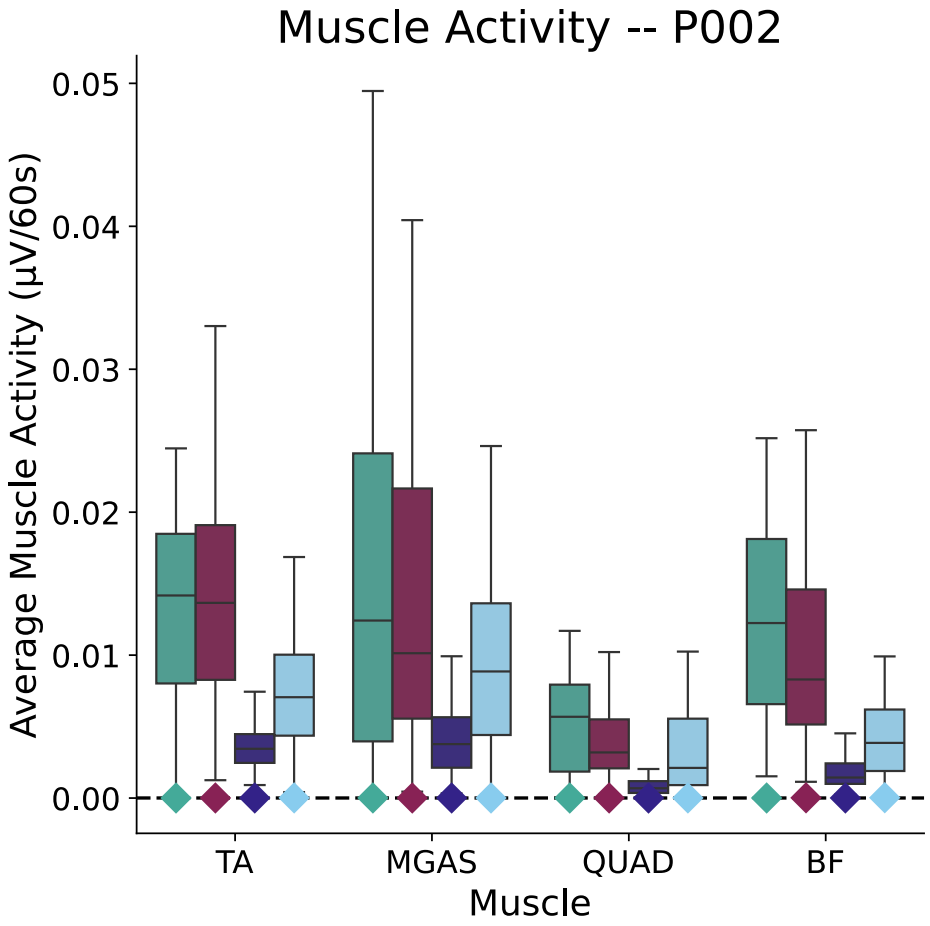
Measuring a toddler's muscle activity

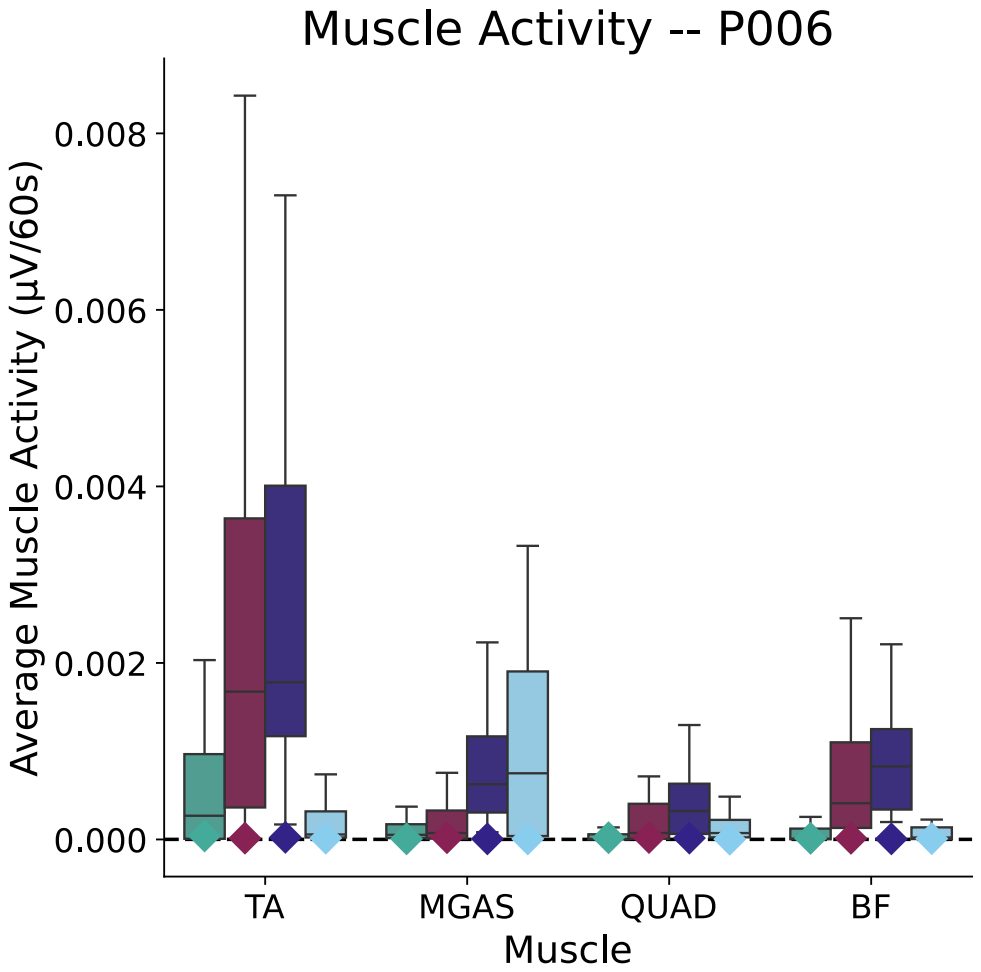


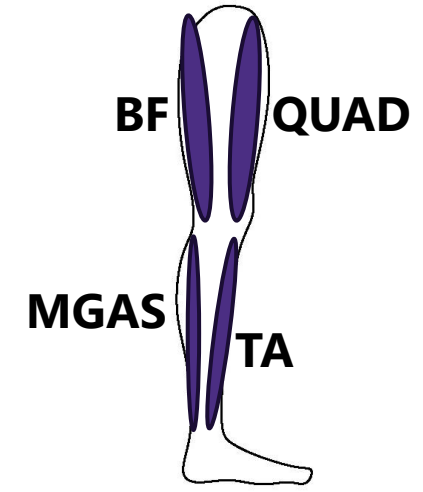
Place wearable sensors on child

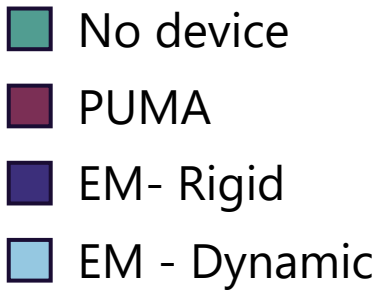
Record changes in electrical activity

Muscles are active across conditions.









Outcome measures

NEUROMECHANICS

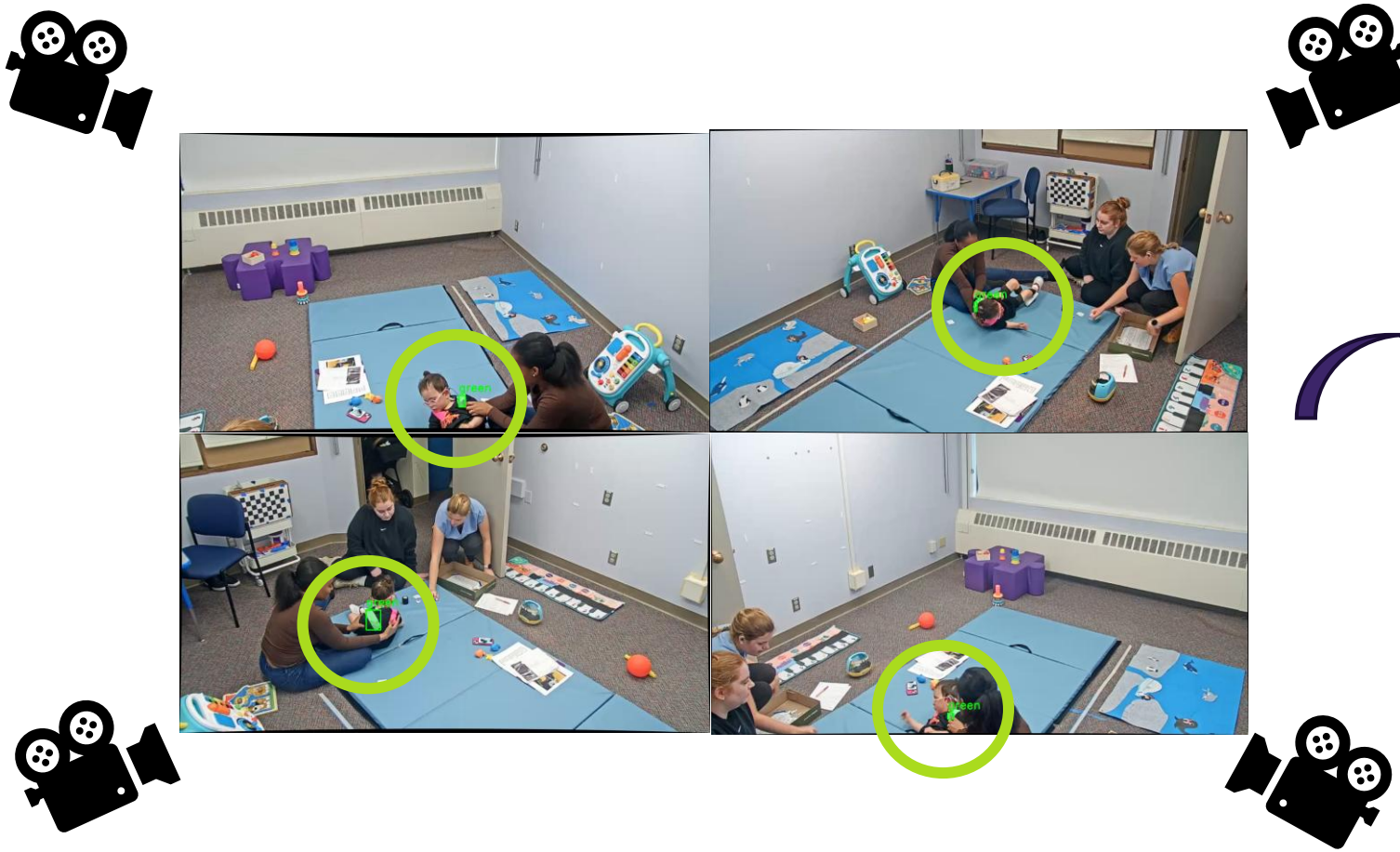
- Lower limb muscle activity (EMG)
- Leg position (IMUs)

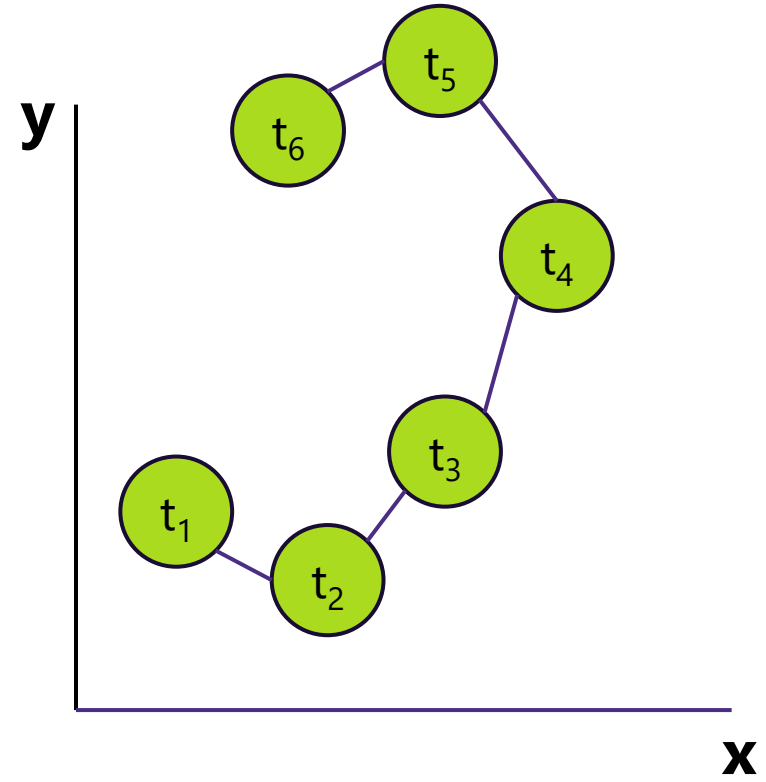
EXPLORATION

- Motion Capture

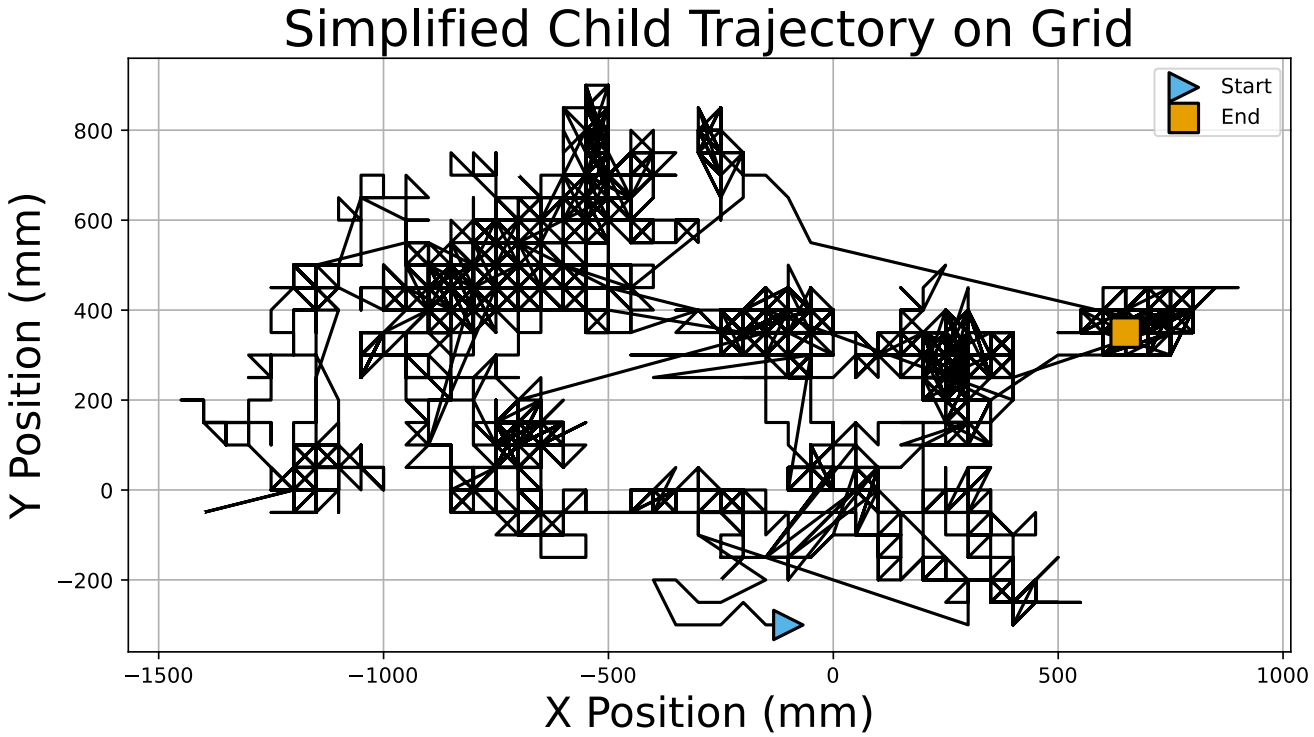
Tracking green and pink tape on the child

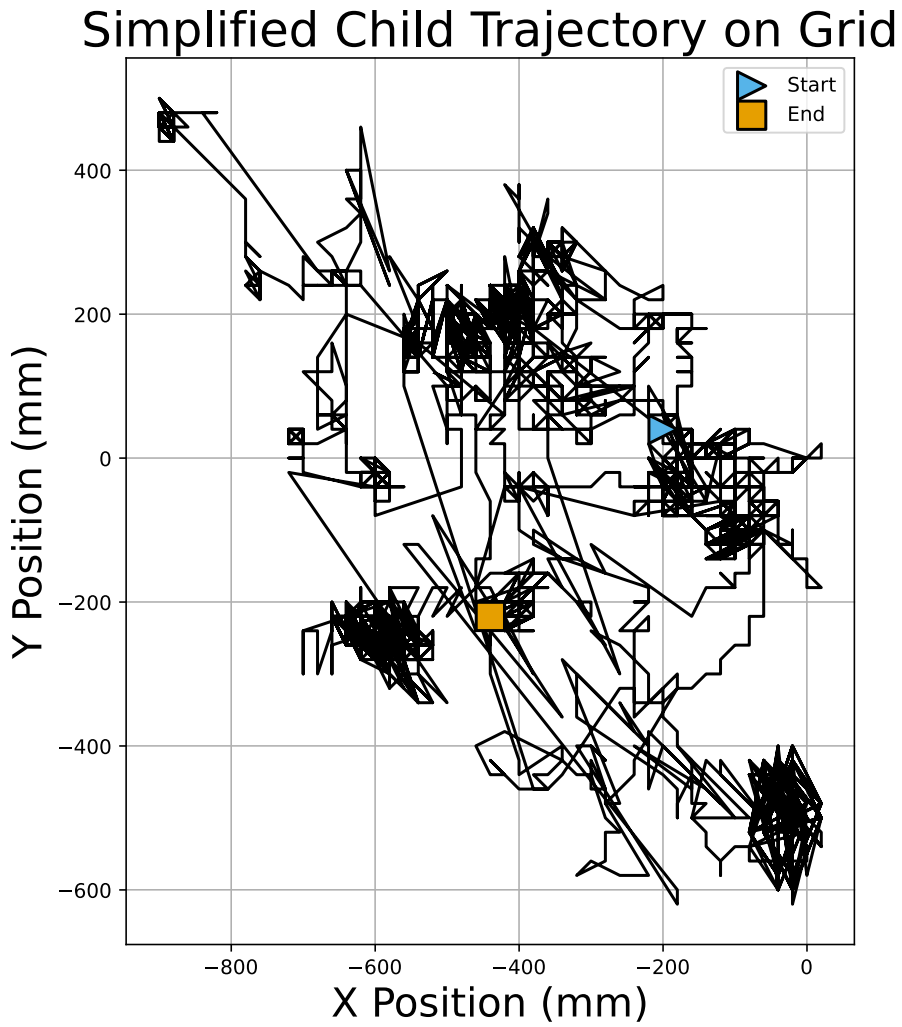
Tracking where a child goes...





Tracking where a child goes





Outcome measures

NEUROMECHANICS

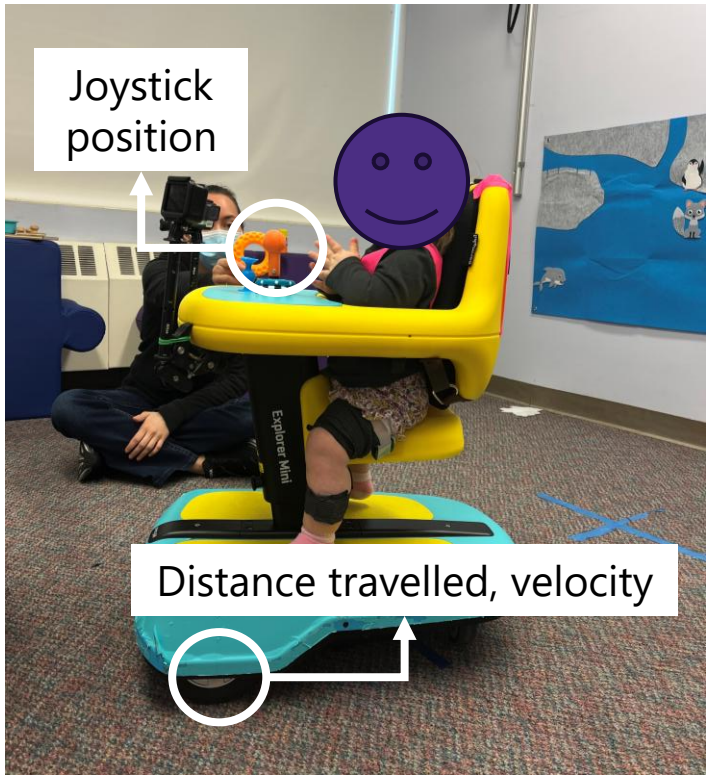
- Lower limb muscle activity (EMG)
- Leg position (IMUs)

EXPLORATION

- Motion Capture

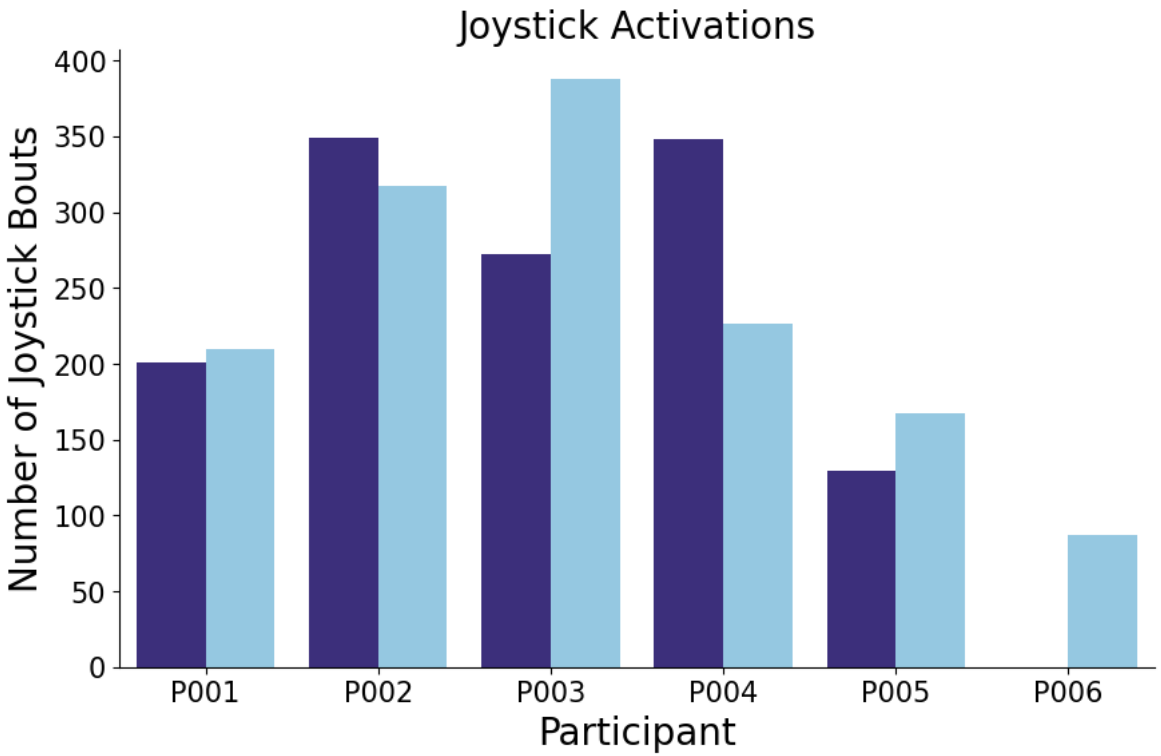
INTERACTION METRICS

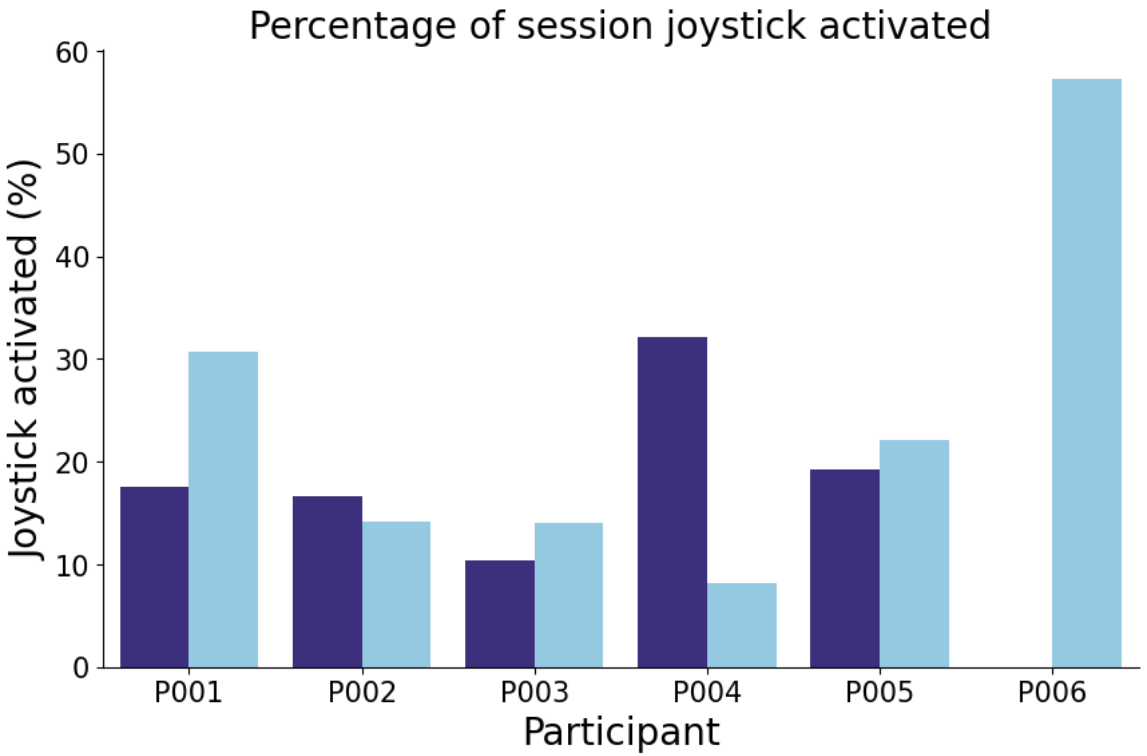
- Explorer Mini integrated logger



Measuring joystick interactions

Neutral *Joystick activation*





Explorer Mini Rigid Seat

Explorer Mini Dynamic Seat

Outcome measures

NEUROMECHANICS

- Lower limb muscle activity (EMG)
- Leg position (IMUs)

EXPLORATION

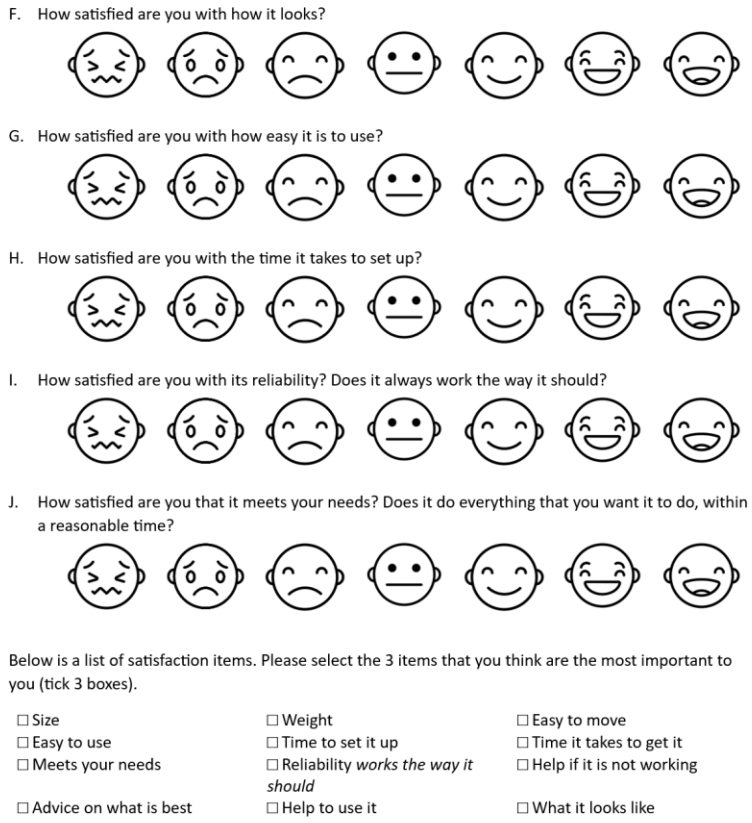
- Motion Capture

INTERACTION METRICS

- Explorer Mini integrated logger

CAREGIVER PERCEPTIONS

- Interviews
- Surveys



F. How satisfied are you with how it looks?

G. How satisfied are you with how easy it is to use?

H. How satisfied are you with the time it takes to set up?

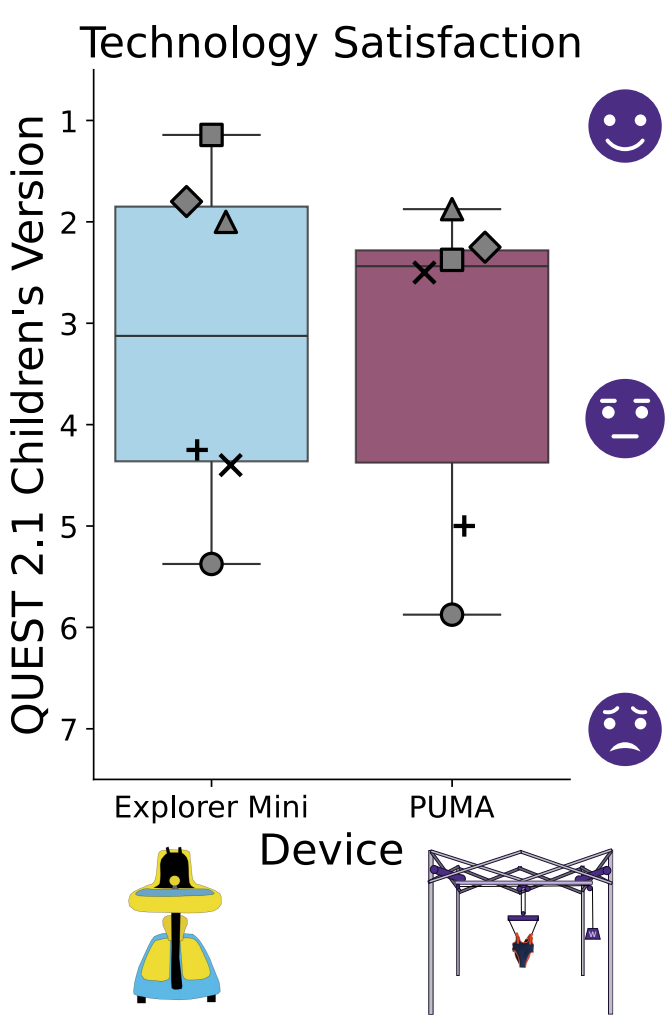
I. How satisfied are you with its reliability? Does it always work the way it should?

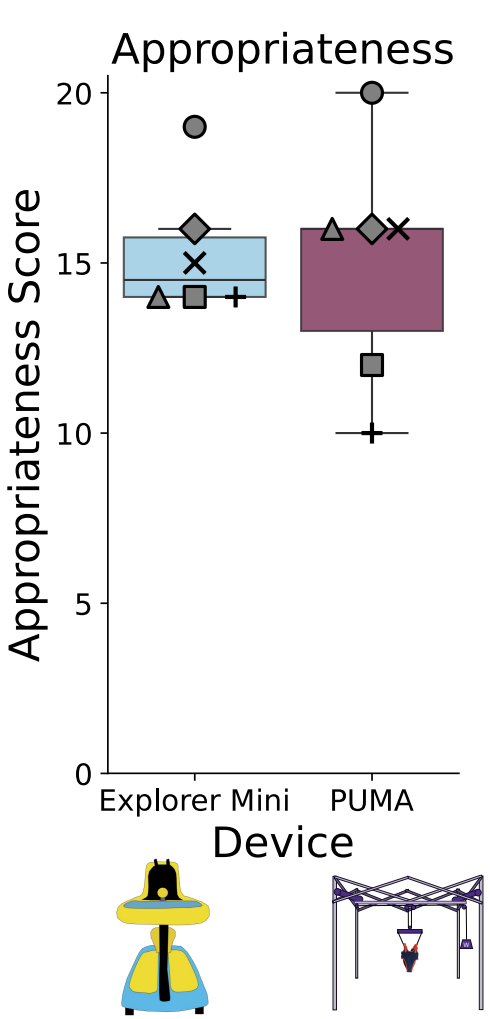
J. How satisfied are you that it meets your needs? Does it do everything that you want it to do, within a reasonable time?

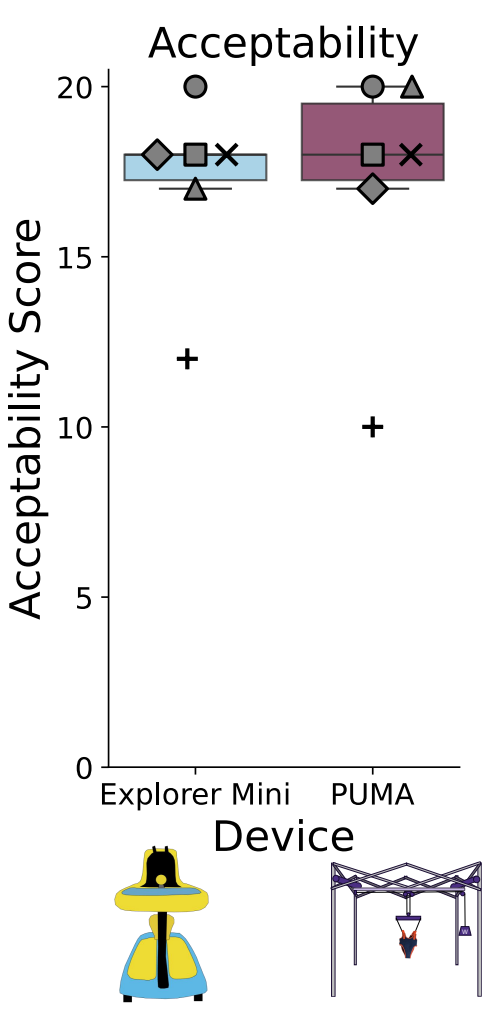
Below is a list of satisfaction items. Please select the 3 items that you think are the most important to you (tick 3 boxes).

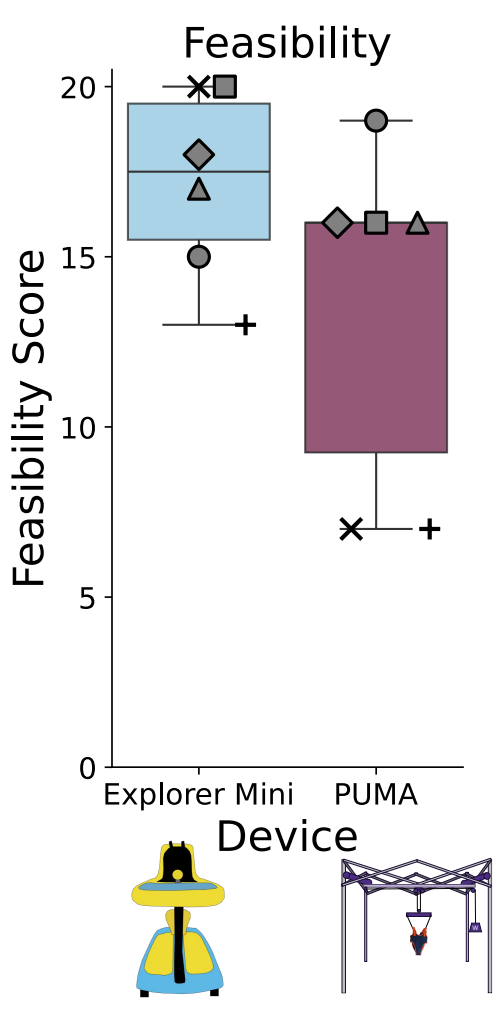
☐ Size	☐ Weight	☐ Easy to move
☐ Easy to use	☐ Time to set it up	☐ Time it takes to get it
☐ Meets your needs	☐ Reliability *works the way it should*	☐ Help if it is not working
☐ Advice on what is best	☐ Help to use it	☐ What it looks like

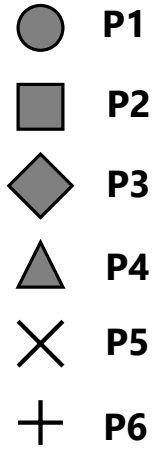
Families feedback on mobility devices.











What we have heard from families…

The Explorer Mini is a fun way to move and learn.

"It was the **freedom it gave her** to move around to get to places quickly … I think she found it **more fun**."

PUMA as a step toward independent walking.

"Cause that one [PUMA], I feel like gives them more of independence because it's their **actual leg power holding them up**."

Incorporating and adjusting to mobility aids can be challenging.

"Just because it's not something you could like . . . oh **we're going to go to the grocery store, let's take the PUMA.**"

Building confidence in motor ability with mobility aids.

"You know building that confidence of like, **your legs are stronger than you think** they are type of deal."

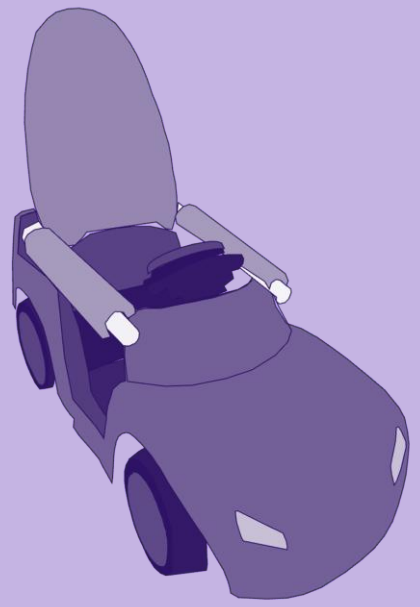
Supporting mobility together as a family.

"My goal with the walker is to **take it with us when we go places** like the grocery store or you know to the park."

Factors that influence mobility device use…

Usability: *How families adopt mobility aids*

Environment: *Where a child uses their mobility aid*



User Engagement: *How body meets the device and enables participation*

- Muscles are active in mobility devices.
- Families preferred the PUMA.
- Mobility devices may support different therapy goals.

Need for access to multiple devices.

Factors that influence mobility device use…

Usability: *How families adopt mobility aids*

- Quantitative tracking methods and caregiver-reported metrics may capture different things.
- No significant differences in use between Explorer Mini and modified ride-on car.

Importance of trialing devices.

Environment: *Where a child uses their mobility aid*

- Young kids use mobility devices close to home.
- Children drove more in pedestrian-friendly neighborhoods and when in proximity to accessible paths.

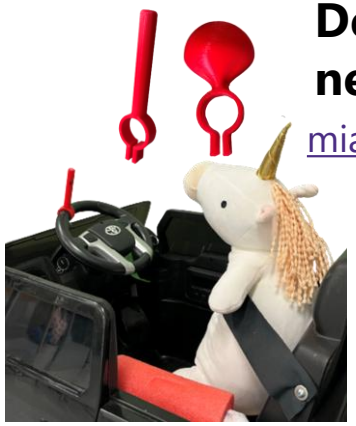
Identify accessible areas for children to use mobility devices.

User Engagement: *How body meets the device and enables participation*

- Muscles are active in mobility devices.
- Families preferred the PUMA.
- Mobility devices may support different therapy goals.

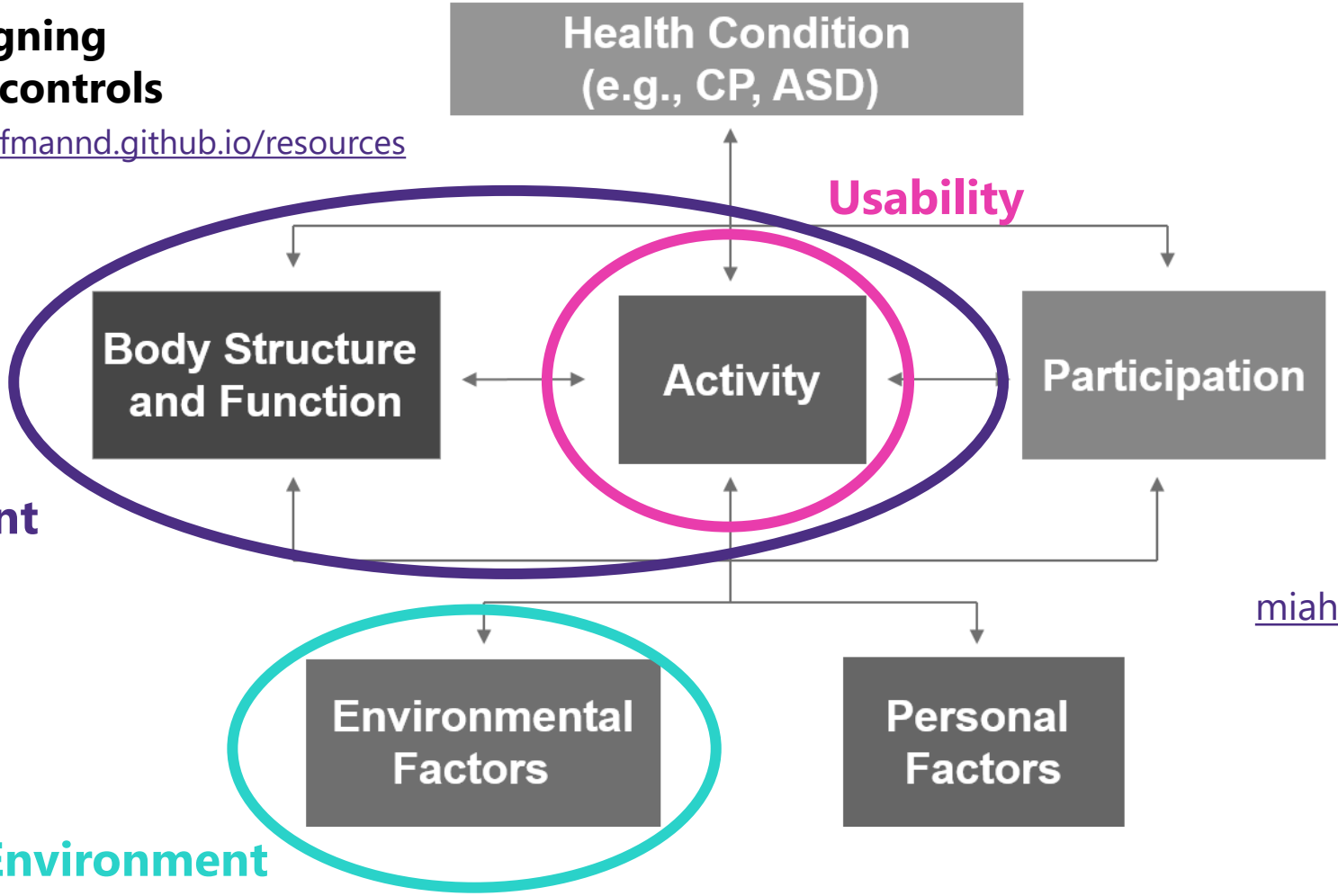
Need for access to multiple devices.

What factors influence mobility device use?



Designing new controls

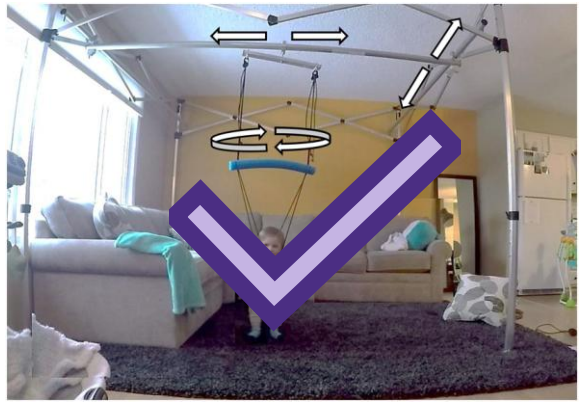
miahoffmannd.github.io/resources



Low-cost ways to play

miahoffmannd.github.io/switchkit

Rethinking mobility devices for toddlers



Portable partial bodyweight support system

Lightweight manual wheelchairs

Crawling aids

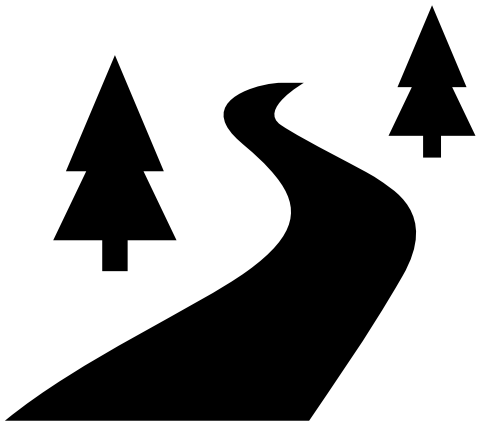
Child-sized power wheelchairs

Hands-free gait trainer

Overground exoskeletons

Adaptive tricycles

Rethinking assistive technology for kids

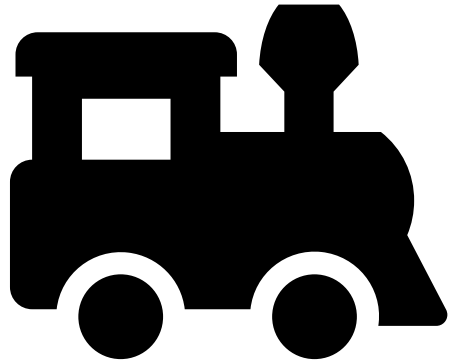


Understand how families utilize new mobility devices in the community.

Mobility

Advocate for access to assistive technology for kids.

Accessibility



Develop new technologies to support play and participation.

Play

Thanks to my wonderful collaborators…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Aislinn Knight


Katie Belen Leija


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Thank you!

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NSF NIH CREATE Center for Research and Education on Accessible Technology and Experiences UNIVERSITY of WASHINGTON