

mRehab is the future: the upper limb perspective

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SCHOOL OF MEDICINE

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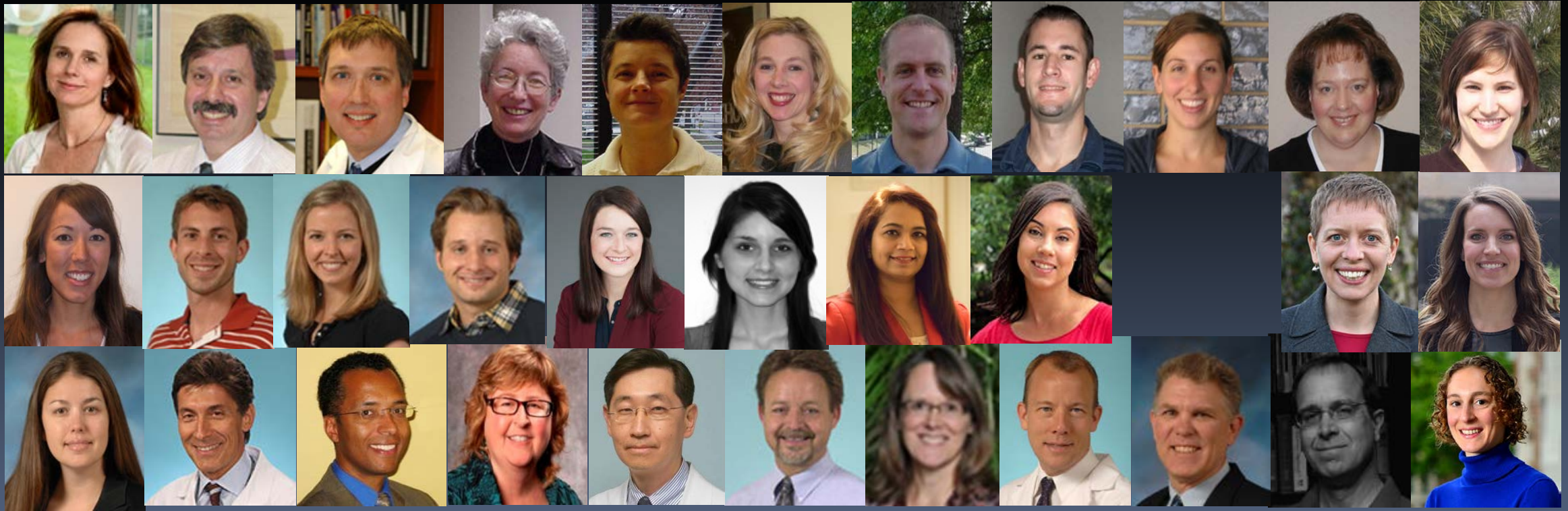
Authorship

Lang and Birkenmeier 2013, AOTA Press Inc.

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Topics

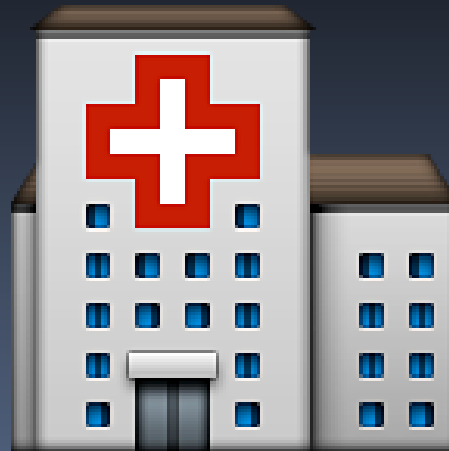
1. The purpose of rehabilitation is to improve performance in daily life
2. We can measure performance in daily life with wearable sensors
3. Data from daily life are full of surprises:
4. We will be better at this in the future.

Why would you go to (& pay for) your rehab appointments?

Definitions from WHO ICF, 2002



UL impairment
(ROM, spasticity, strength)



UL capacity
(capable of doing in-clinic)



UL performance
(use in daily life)

88% of self-identified goals are for better performance of activities in daily life (Waddell et al. 2015)

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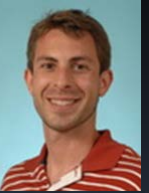
Data are easy to collect, but it is hard to figure out what to do with it...



for 24 or more hours

Accelerometry is a valid, reliable measure of upper limb performance

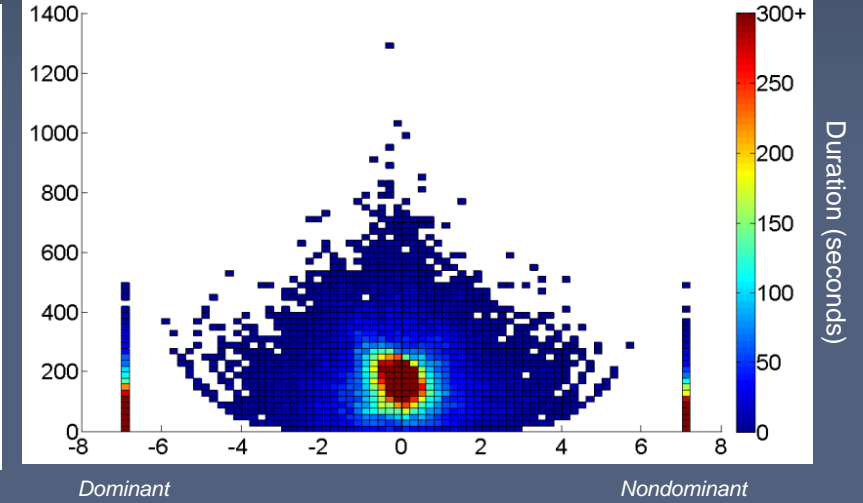
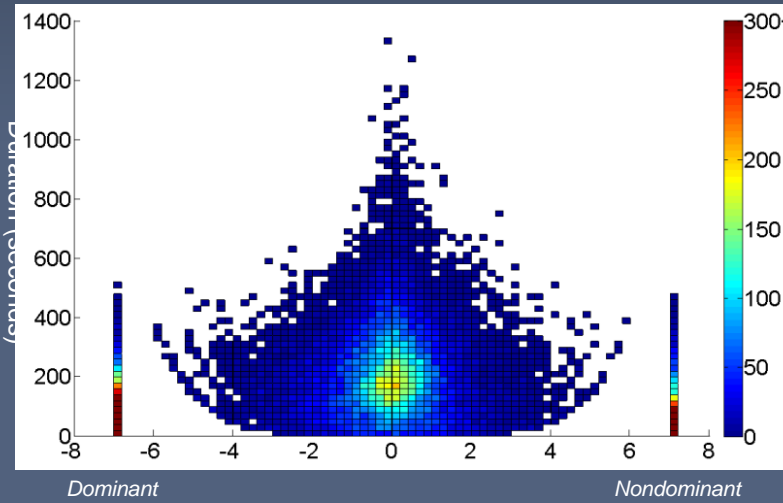
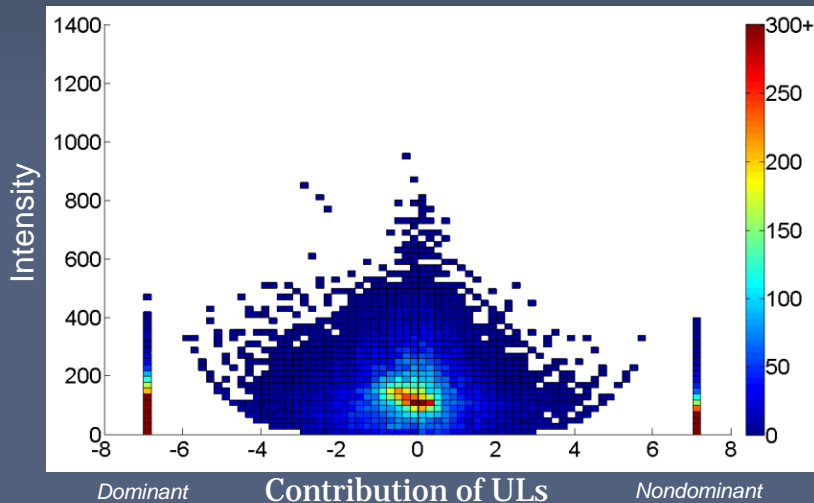
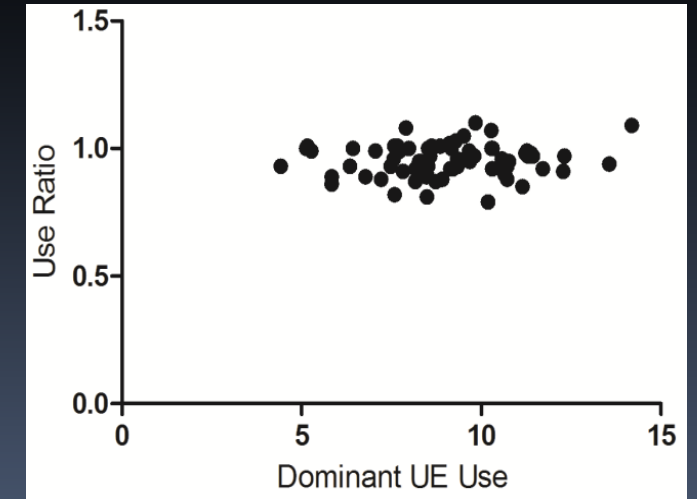
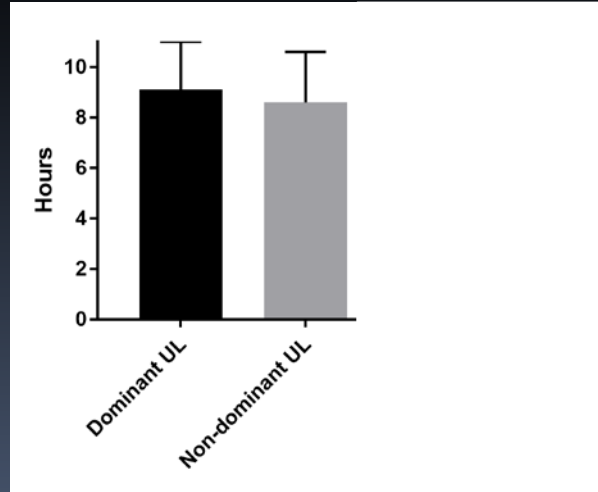
(Uswatte et al. 2000, 2005, 2006; Welk et al. 2004; Lang et al. 2007, 2012; Rand & Eng 2010; Van der Pas et al. 2011; Michielsen et al. 2012)



UL activity in daily life is bilateral



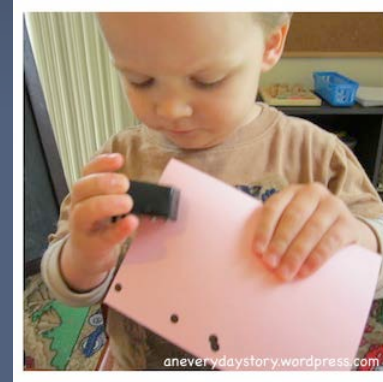
N = 74 community dwelling adults
Bailey et al. 2014a, 2014b



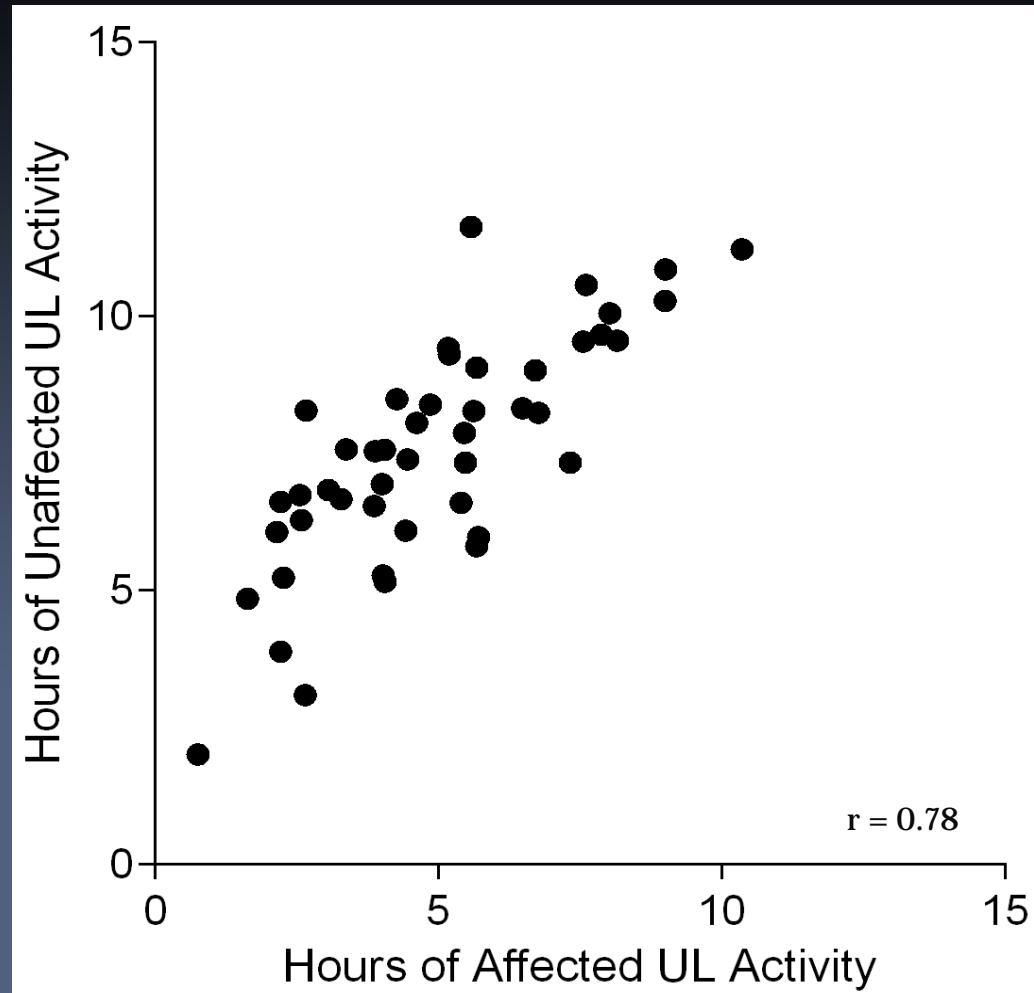
Bailey et al. 2015

Program in Physical Therapy

UL activity in daily life is bilateral



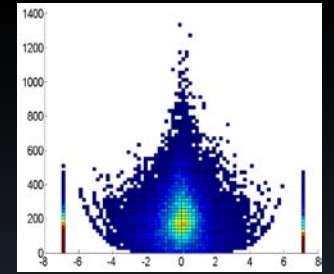
An early indicator that out-of-clinic measurements are critical



After stroke, hours of use with each limb are **POSITIVELY** correlated

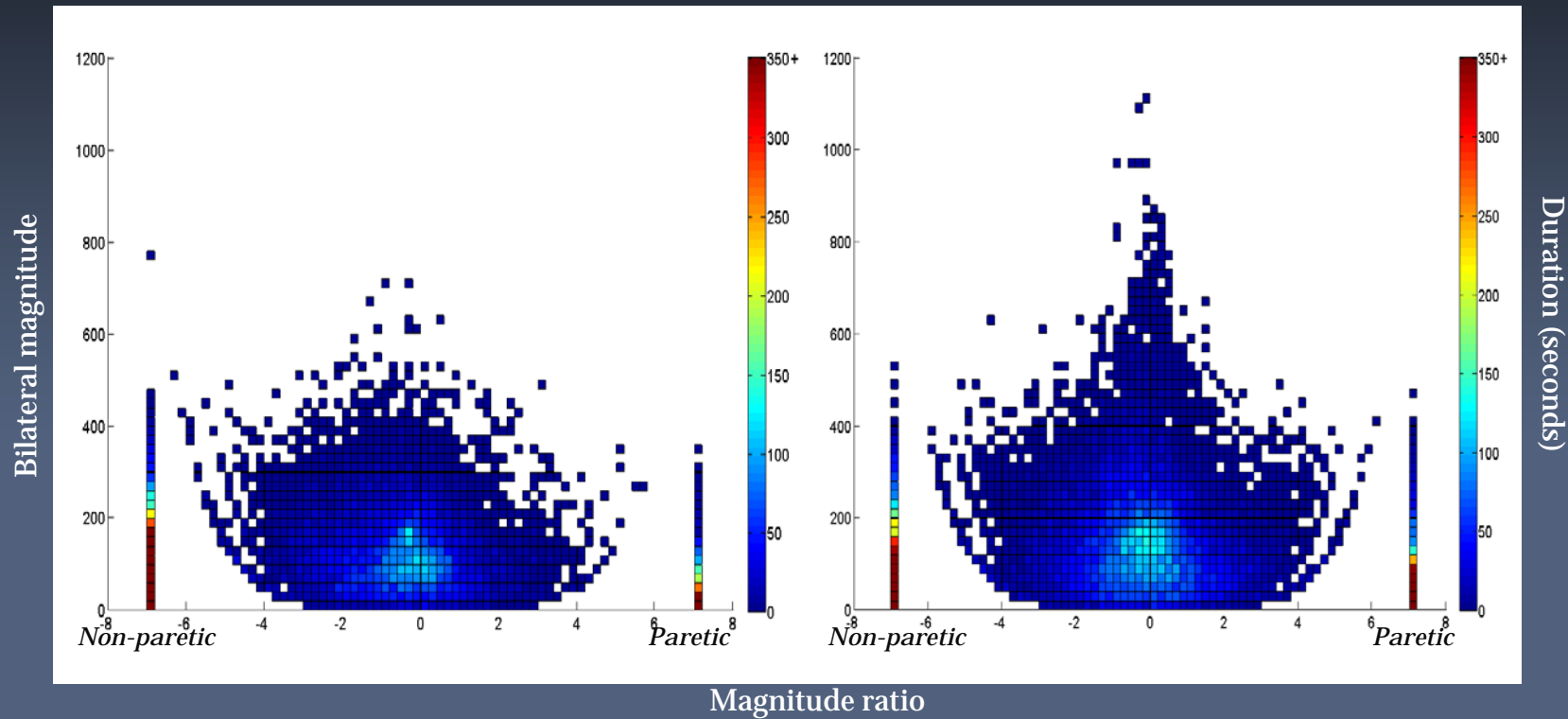
Lang et al. 2009; Bailey et al. 2015

Performance measures are responsive to change



Moderate paresis 10 days post stroke

Then again 33 days post stroke, after IRF stay

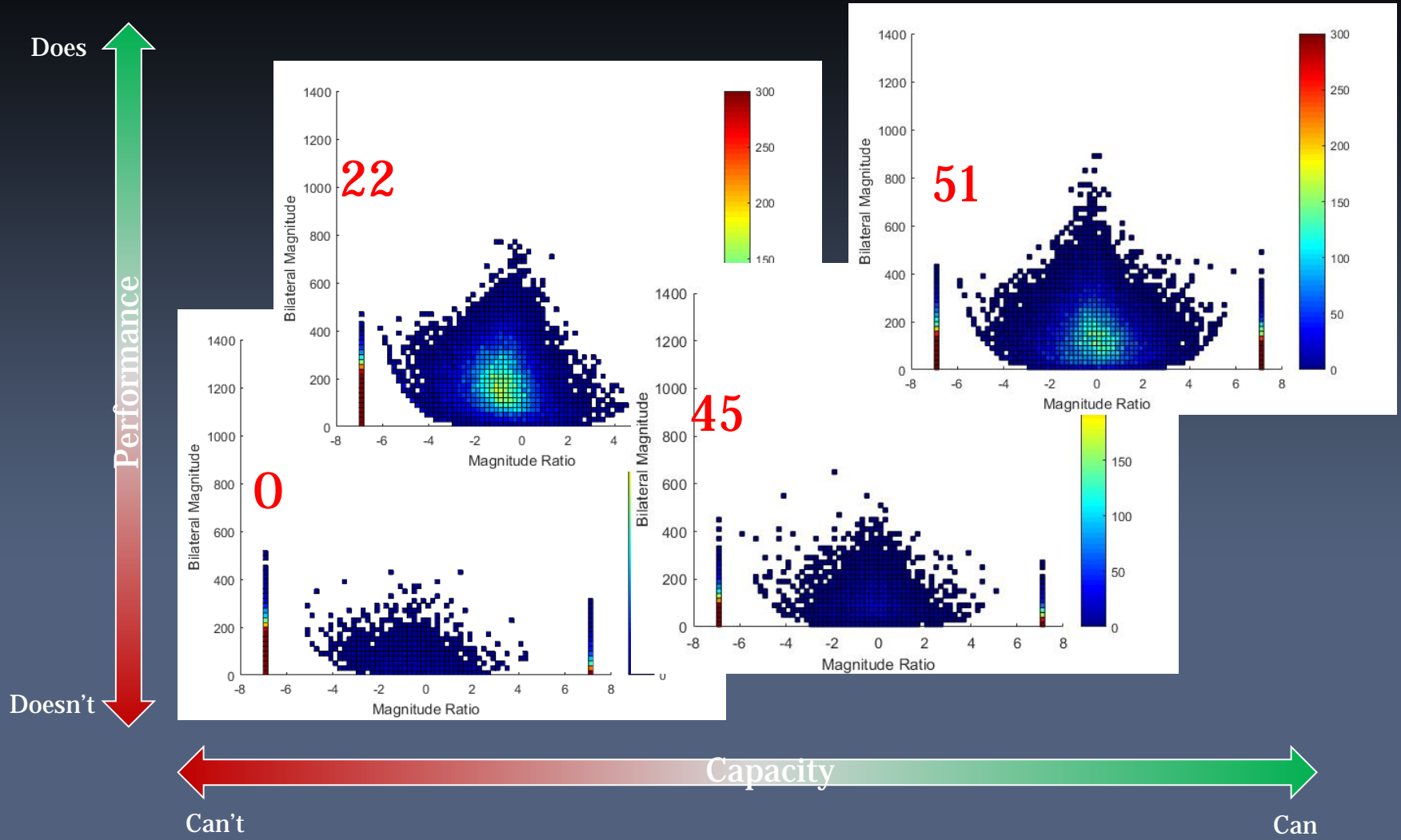


Data from Waddell et al. 2014; also see Urbin et al. 2015

Topics

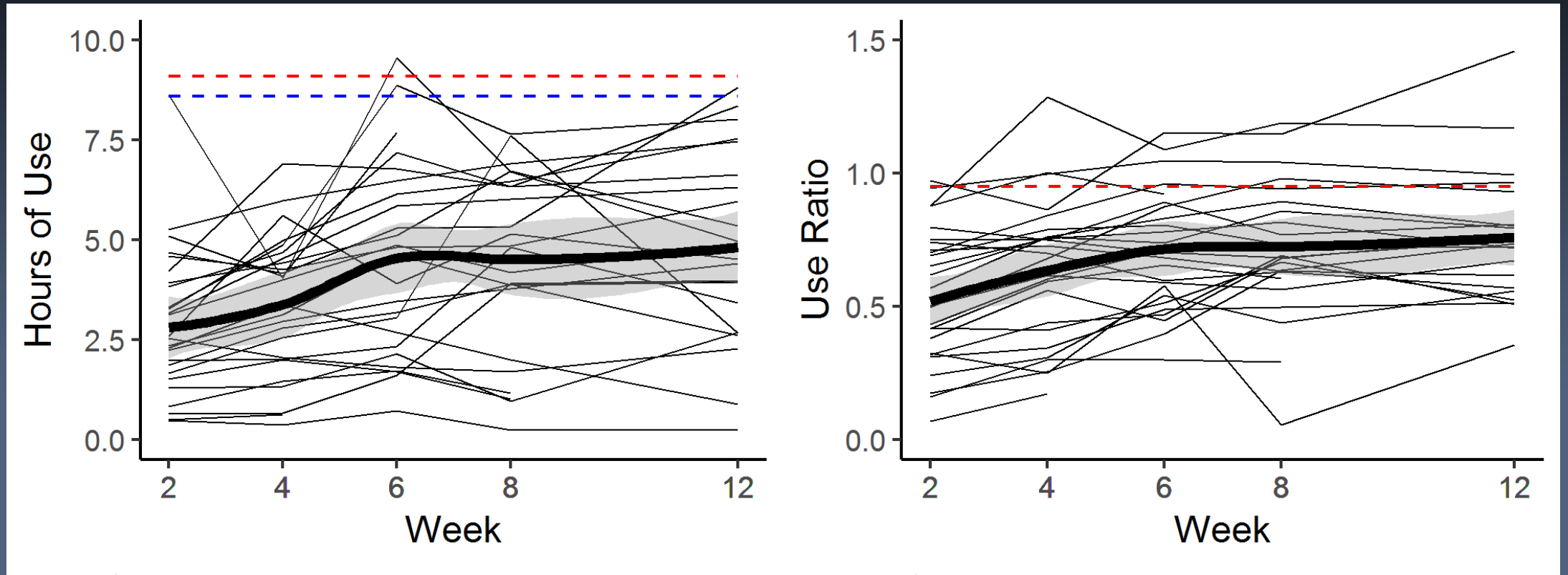
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Capacity may not \neq Performance post stroke



Examples from preliminary data,
n = 56

Performance trajectories early after stroke are highly variable



Waddell et al. in review

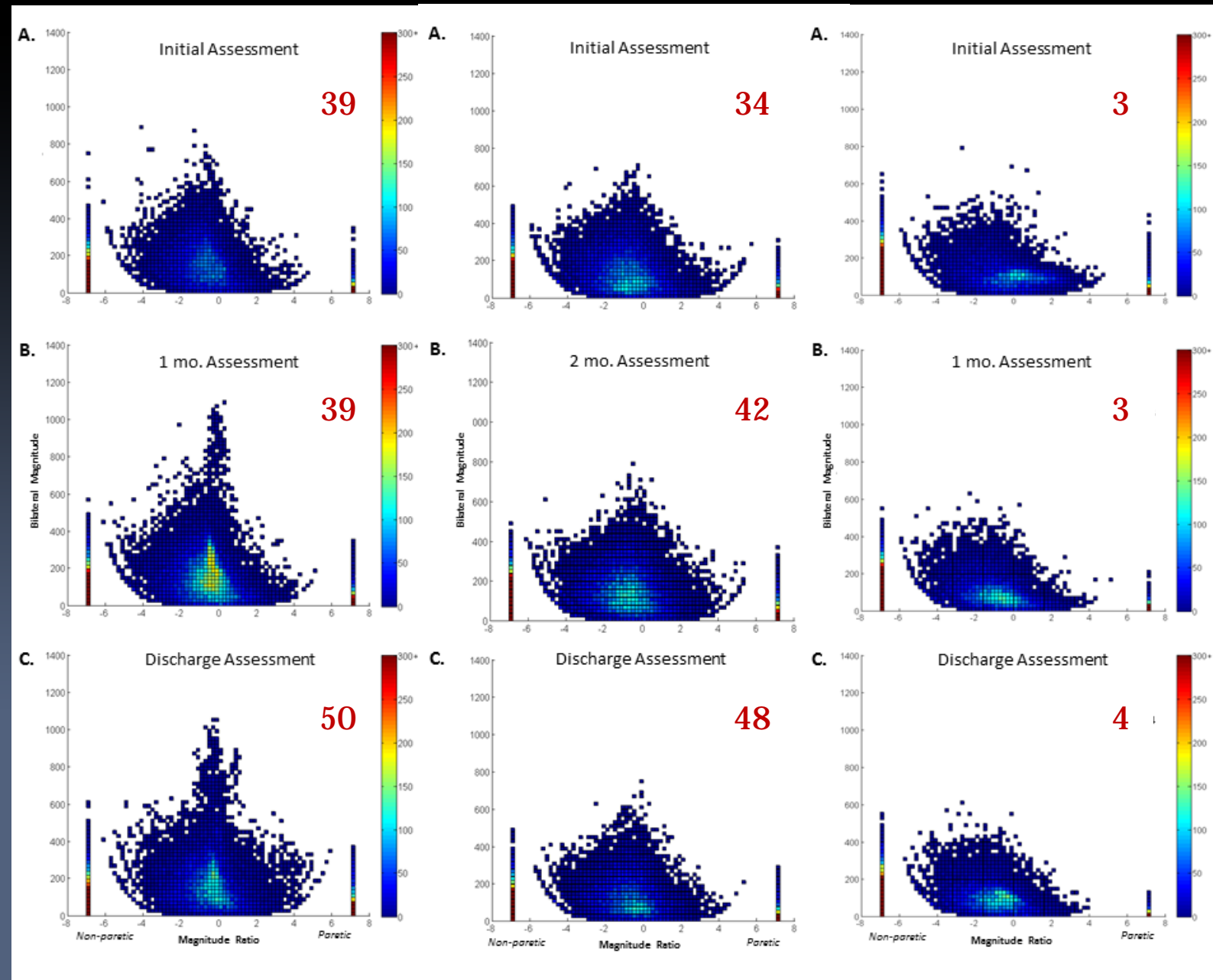
Δ Capacity may not = Δ Performance

Ex 1, capacity Δ ,
performance Δ

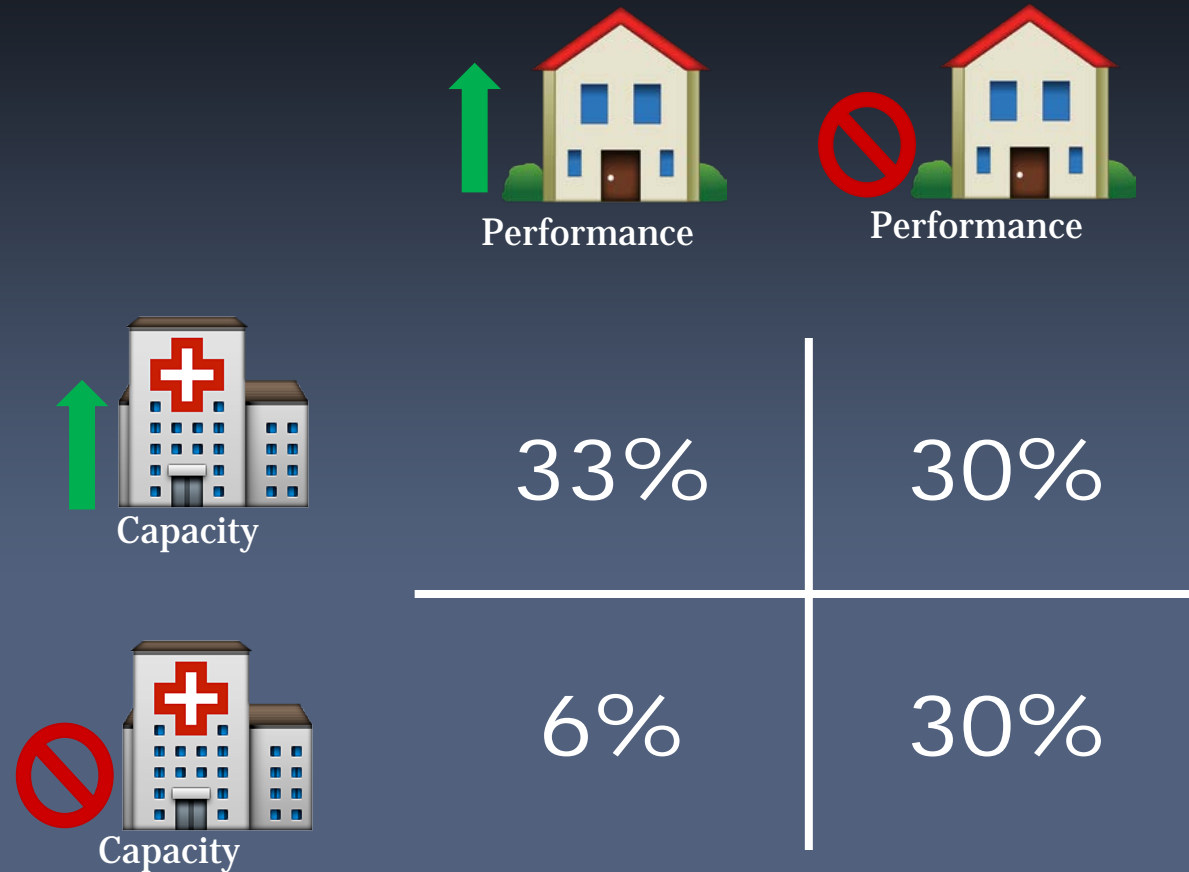
Ex 2, capacity Δ ,
no performance Δ

Ex 3, no capacity Δ ,
no performance Δ

Outpatient sample, Doman et al. 2016

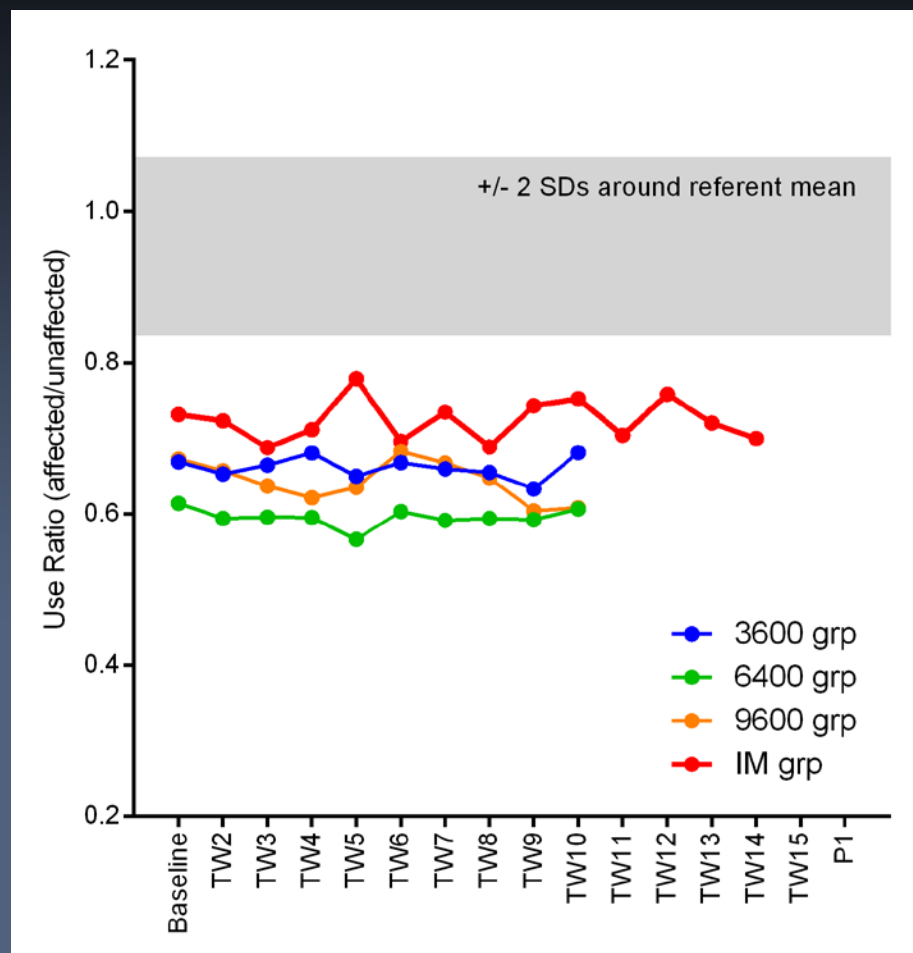


Sensor data may question the clinician view of 'success'



Preliminary data; N=93 participating in outpatient therapy at 5 clinics around the USA

No change in performance in our Phase II RCT ≥ 6 mo. post stroke



Examined 6 accelerometer metrics

	<i>Slope*</i>
Use Ratio	-0.0005 ± 0.0009
Hours Aff. Use	-0.027 ± 0.01
Bilateral Magnitude	-0.15 ± 0.09
Magnitude Ratio	-0.023 ± 0.013
Aff. Magnitude	-0.03 ± 0.06
Aff. Variability	-0.04 ± 0.05

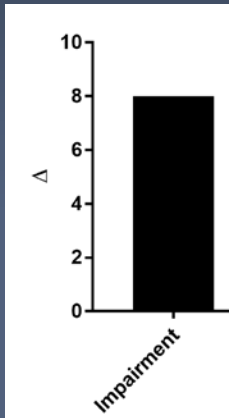
*Mean ± SE for all groups combined, none are different from zero

Waddell et al., 2017

Change in one domain \neq change in another domain



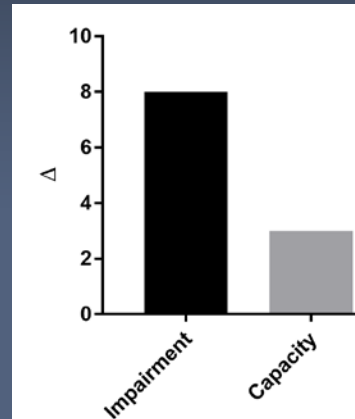
UL impairment
(ROM, spasticity, strength)



Δ Impairment



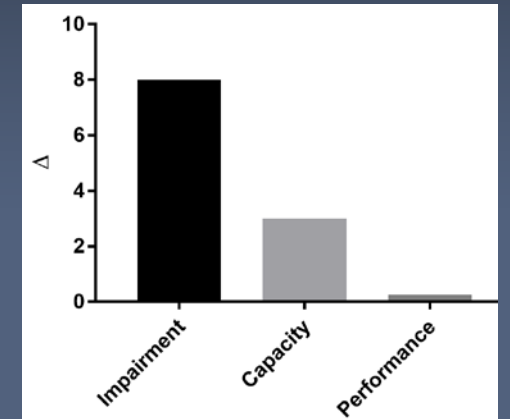
UL capacity
(capable of doing in-clinic)^{1,2,3}



Δ Capacity



UL performance
(use in daily life)^{4,5,6}



Δ Performance

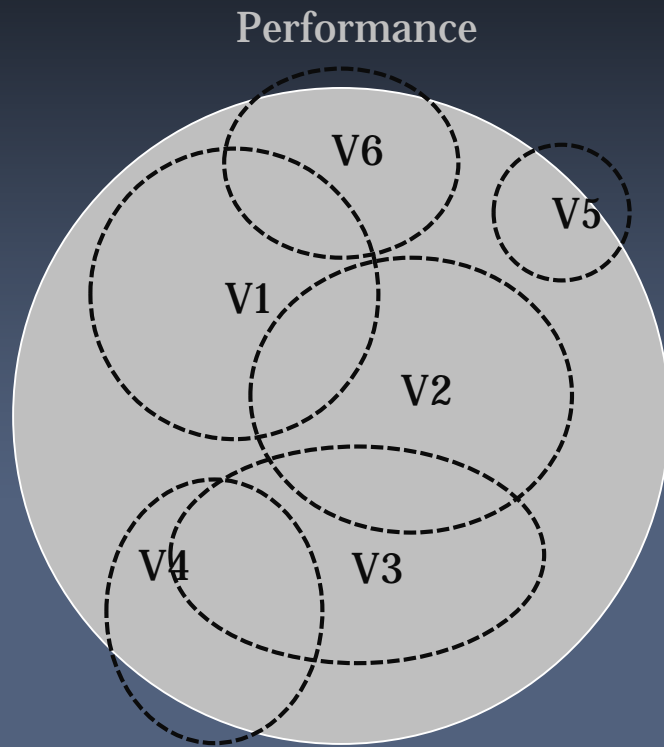
¹Dromerick et al., 2009; ²Wolf et al., 2006; ³Lang et al., 2017; ⁴Rand & Eng, 2015; ⁵Waddell et al., 2017; ⁶Lemmens et al., 2014

Topics

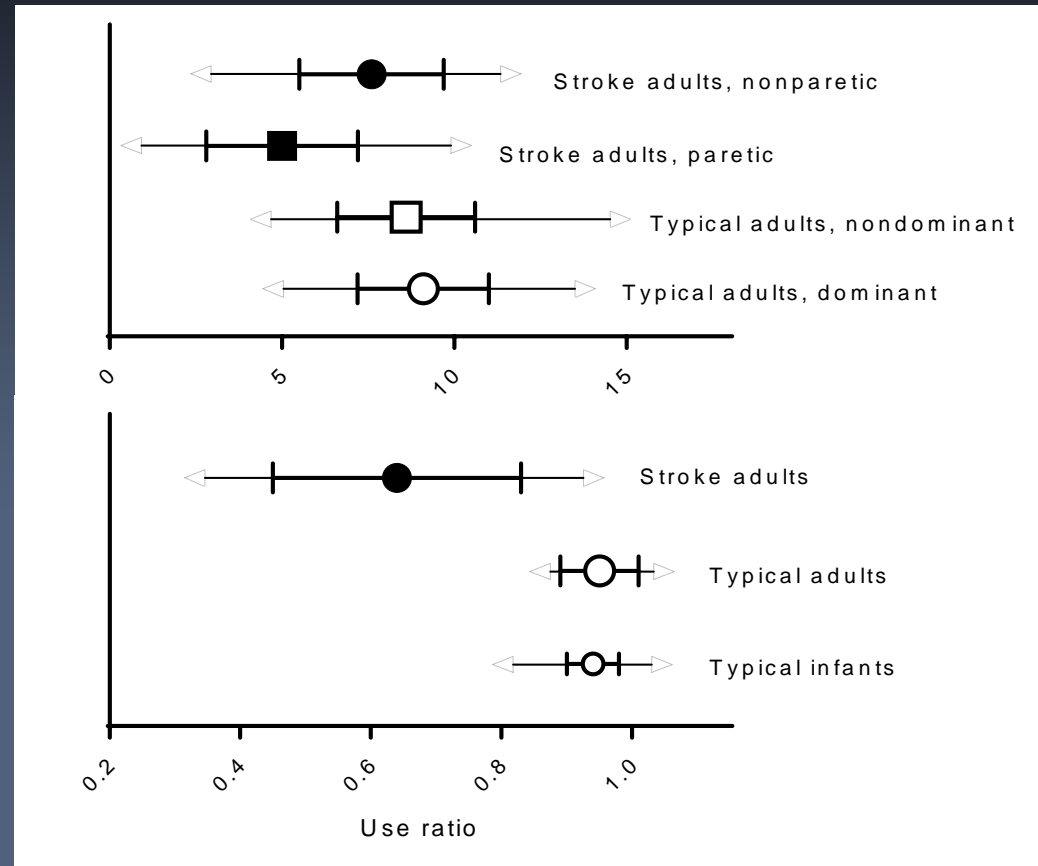
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 - Success of services may not be what we thought (in both directions)
 - Performance will be hard to budge
4. We will be better at this in the future.

Accelerometer variables are good but far from perfect...

Narrowly distributed variables help to discriminate better than widely distributed variables



Conceptual picture of how different variables might capture performance

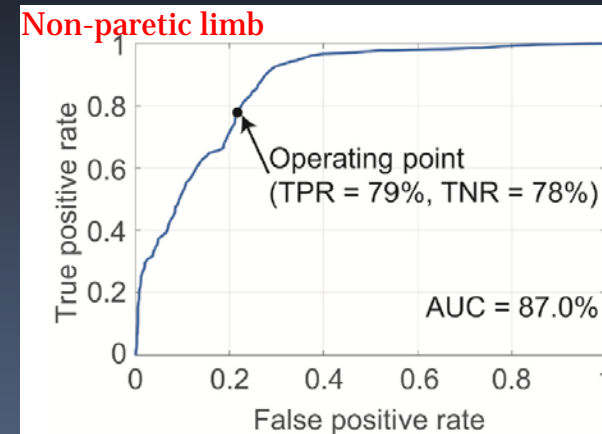


Smith & Lang 2019

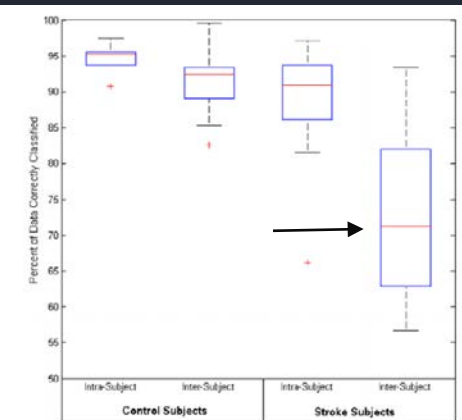
What sensors can and cannot tell us right now

We are still in the lab!

Construct measured	Present capability
Duration of limb activity	✓
Relative activity of one limb to the other	✓
Intensity of activity	✓
Relative contribution of limbs during bilateral activities	✓
Average magnitude of activity on one limb	✓
Variation of activity on one limb	✓
Distinguishing 'functional' vs. 'non-functional mvts	✗
Specific mvts or activities being performed	✗
Compensatory movement patterns	✗
Perception of ease of movement	✗



Lee et. al. 2018



Tran et al. 2018

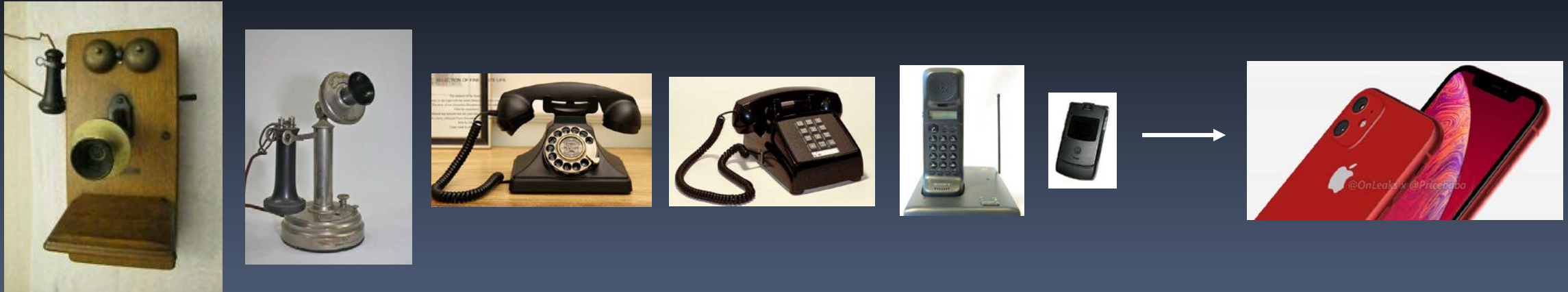
7 sensors TABLE XIV: Performance in Stroke

Primitive	Sensitivity	Specificity	PPV	NPV
Rest	0.76	0.98	0.81	0.98
Reach	0.76	0.94	0.86	0.89
Transport	0.72	0.81	0.62	0.94
Retract	0.78	0.95	0.87	0.90
Ove. Perf.¹	0.75	0.92	0.79	0.93

Guerra et al. 2017

It is early in the process

e.g. the telephone



- *Future sensors and algorithms will probably be beyond what we imagine in the present*
- *Wearable sensor data opens new questions (and problems)*
- *Just because we can measure it won't mean that behavior will change!*

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