Stress from Swipes

- **Can we measure stress from mouse swipes?**

Stress Challenges

- OBESITY: 51% of obese people eat too much due to stress; 33% eat to manage stress
- CARDIOVASCULAR HEALTH: 3x increase in hypertension & 2.2x increase in cardiovascular mortality in high stress jobs
- **STRESS MANAGEMENT: 69% say it is important but only 32% do it well (lack of awareness/will power)**

[Kivimaki et al] Work stress and risk of cardiovascular mortality: prospective cohort study of industrial employees (2002)
[Pickering] Mental Stress As a Causal Factor in the Development of Hypertension and Cardiovascular Disease (2001)
American Psychological Association, Stress in America (2010)

Affect Sensing

- Stress

- Pain

- Depression/Mental Illness

Stress

"Stress/arousal" is a complex regulatory mechanism affecting almost every functional unit in the body.

There are two important chemical channels:

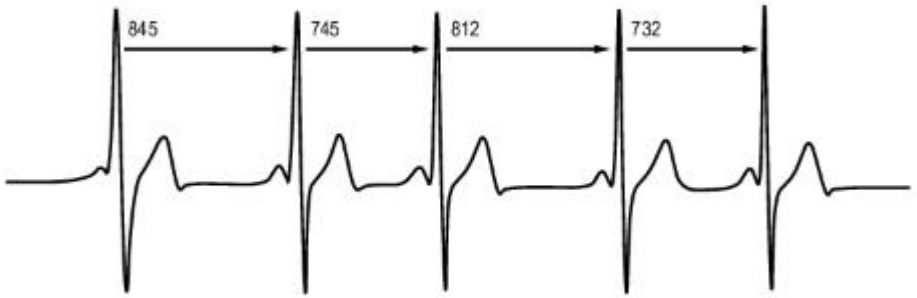
- **Fast (seconds):** (epinephrine or adrenaline), the "rush" we get from excitement, fear, surprise,… "fight or flight"
- **Slow (minutes):** (cortisol), what we typically feel when "stressing out" about a deadline, finances, health etc… not "rest and digest"

Effects:

- **Fast:** Heart rate increases, breathing speeds up, pupils dilate, memory retention improves, emotions intensified.
- **Slow:** Heart Rate Variability changes, GSR response, breathing changes, muscle tension.

Heart-Rate Variability (HRV)

Stress causes specific variability in the ECG inter-beat time interval.



There are several measures of this, some more direct (RR variance) while others are more complex ("LF/HF ratio"). Biological arguments have been made that LF/HF ratio directly measures the SNS/PSNS activity ratio, or "fight-flight / rest-digest" ratio.

LF and HF are respectively the Low- and High-frequency energies of the inter-beat interval spectrum.

HRV is the (pseudo) "gold standard" non-chemical stress measure.

Stress from Arm Movement

- **Can we determine stress from mouse usage data?**

MouStress

D. Sun, P. Paredes and J. Canny

CHI 2014

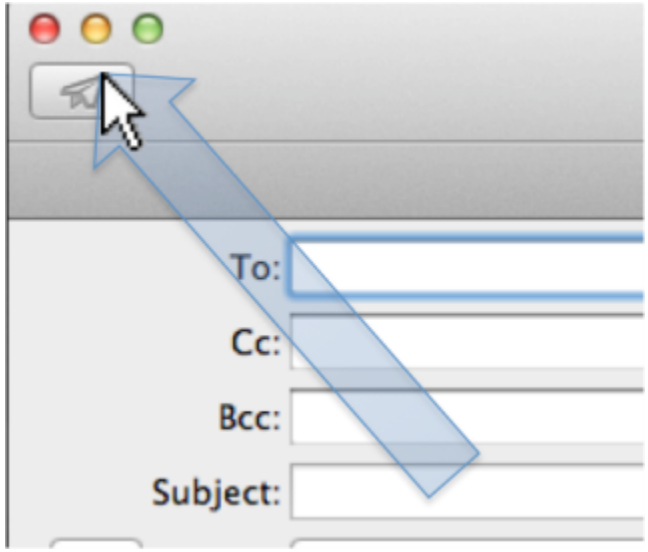
Stress-induced increases in muscle tension in neck/shoulder and arm muscles are well-known in the literature, and specifically while using a mouse [1], [2].

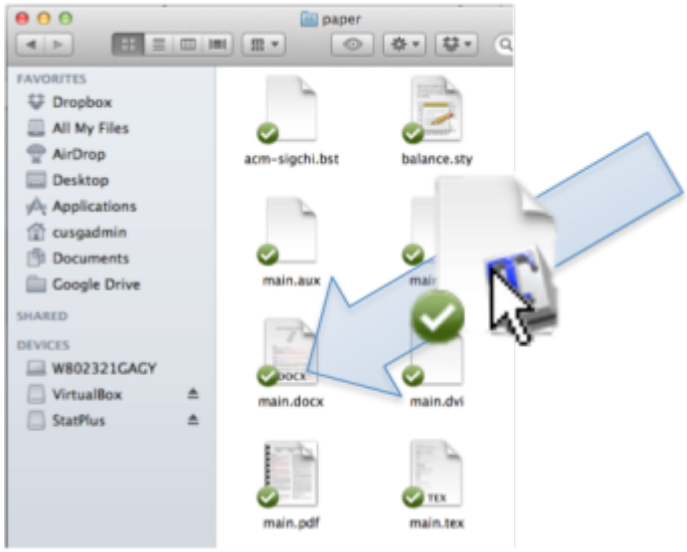
[1] Wahlstr¨om, J., Hagberg, M., Johnson, P., Svensson, J., and Rempel, D. *Influence of time pressure and verbal provocation on physiological and psychological reactions during work with a computer mouse*. European journal of applied physiology 87, 3 (2002), 257–263.

[2] Visser, B., De Looze, M. P., De Graaff, M. P., and Van Die¨en, J. H. *Effects of precision demands and mental pressure on muscle activation and hand forces in computer mouse tasks*. Ergonomics 47, 2 (2004), 202–217.

MouStress

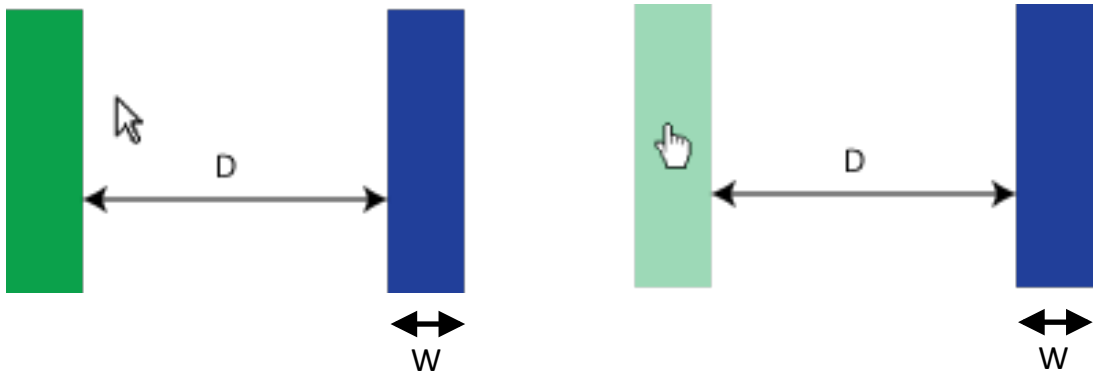
Idea: stress affects muscle tension, which will change the dynamics of mouse movements. Analyze typical mouse movements like clicking, dragging, and steering.



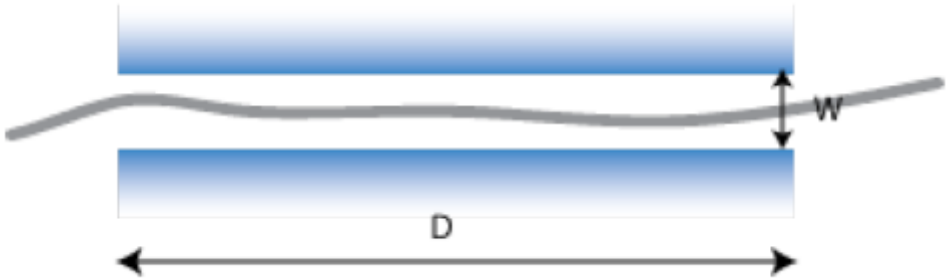


MouStress Tasks

Actual tasks were pointing, dragging and steering on exponentially-spaced and sized rectangular targets:

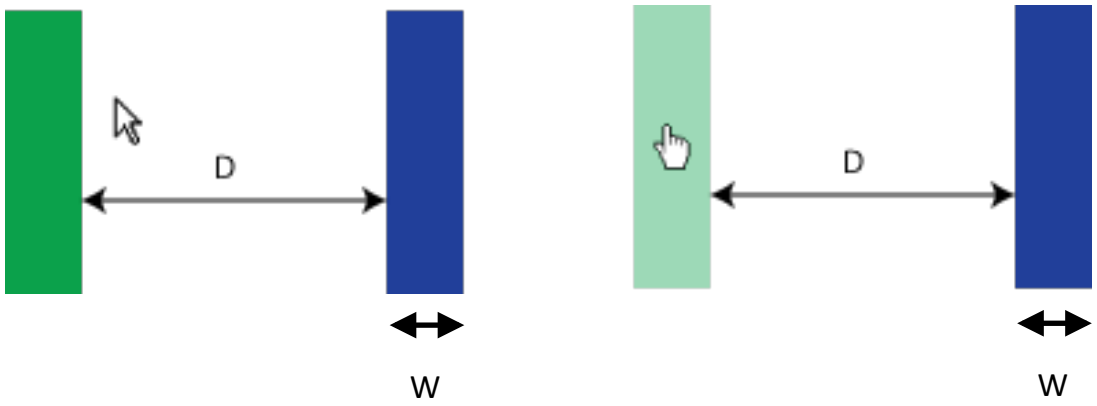


Steering involves moving the mouse through a channel:



MouStress Tasks

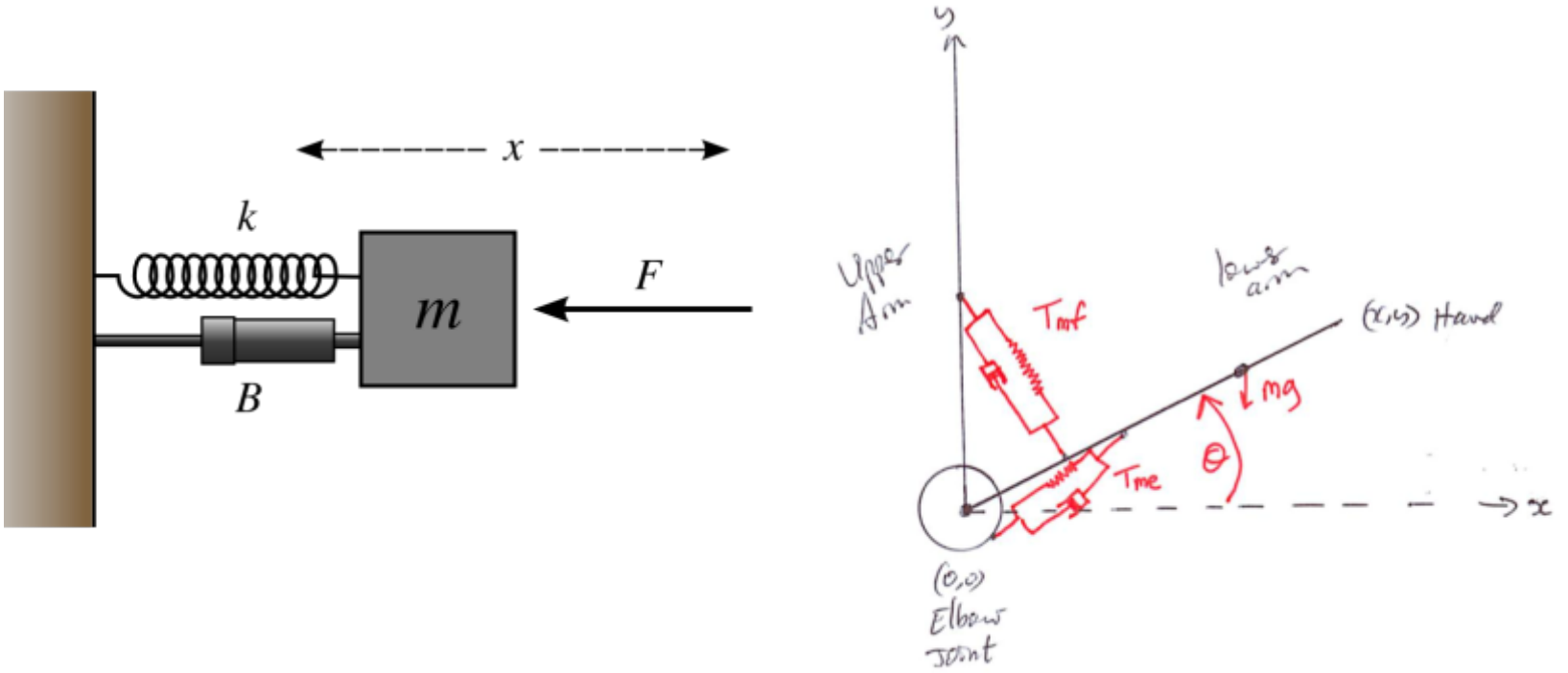
Target size and distances were set factor-of-two increments.



	Distance (px)					Width (px)			
Pointing	64	128	256	512	1024	8	16	32	64
Dragging	64	128	256	512	1024	8	16	32	64
Steering	64	128	256	512	1024	16	32	64	128

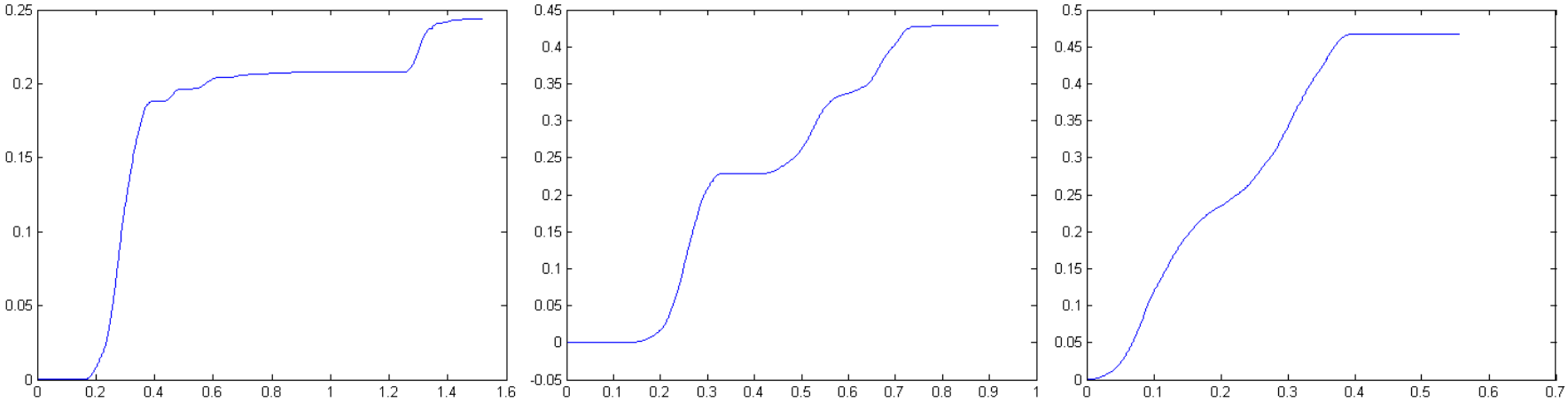
Mass-Spring-Damper Model

The Mass-Spring-Damper model treats the arm as a system with those three elements. This kind of system has a simple, second-order impulse response – at least locally.



LPC Model

We cant measure the arm parameters (mass, springs etc) directly, but if we observe the output from a second-order system, we can use a second-order LPC (Linear Predictive Coding) to get the system parameters.



Mouse x coordinates vs time for typical mouse motions

LPC Model

The parameters of the poles of the LPC model are related to the dynamic parameters via:

$$\omega_0 = \sqrt{\frac{k}{m}},\ \zeta = \frac{c}{\sqrt{mk}}$$

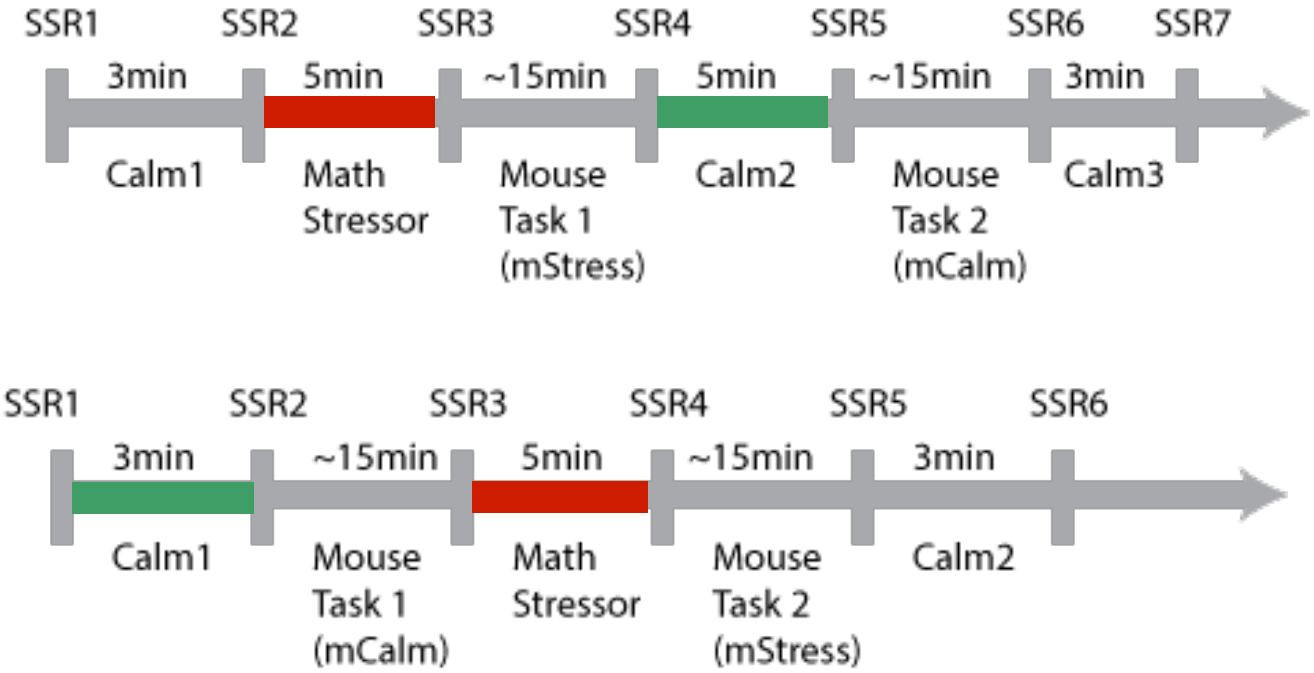
So we can:

- Observe a trajectory
- Generate a second-order LPC polynomial from those observations
- Find the roots of the LPC polynomial
- Derive the Mass-Spring-Damper parameters from the roots

In other words, we derive stiffness and damping values from the original trajectory.

MouStress Experiment

Subjects were tested in one of two counter-balanced conditions, with a stress phase and a calming phase:



MouStress

Mouse dynamic tests in detail:

Indicators	**Conditions**			
	mCalm	*mStress*	*t(48)*	*p-value*
ω_x	0.126(0.001)	0.130 (0.001)	2.83	.003*
ω_y	0.205(0.004)	0.215(0.004)	3.00	.002*
ζ_x	0.532(0.0004)	0.534(0.0003)	3.11	.002*
ζ_y	0.408(0.008)	0.414(0.008)	1.32	.097
t	1.03(0.05)	1.03(0.07)	-.02	.490

Where the Swipes come from?

- Collected Swipe data during a stress management longitudinal experiment involving an app and some machine learning algorithms

Pop-Therapy

Coping with Stress through Pop Culture

Pervasive Health 2014






Pablo E. Paredes, UC - Berkeley
Ran Gilad-Bachrach, Microsoft Research
Mary Czerwinski, Microsoft Research
Asta Roseway, Microsoft Research
Kael Rowan, Microsoft Research
Javier Hernández, MIT - Media Lab

Microsoft Research, Redmond, WA

Personalized Stress Management Problem

- **What to do?**

  Interventions

- When to do it?

  Sensing

Given that the USER perceives her/his own stress, WHAT is the best micro-intervention that matches her/his personal state?

2-Part Solution

Micro-Intervention Authoring

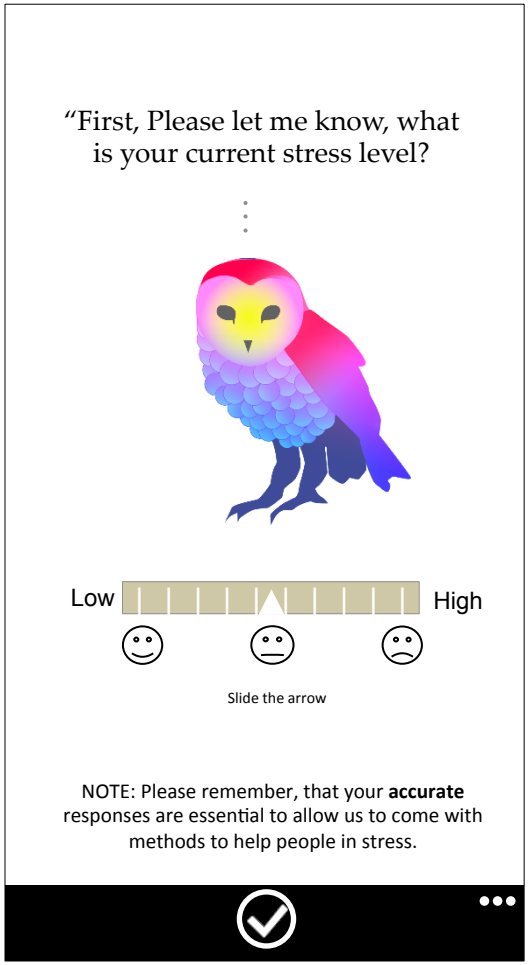
Repurposing Popular Web Apps

+

Intervention Recommender

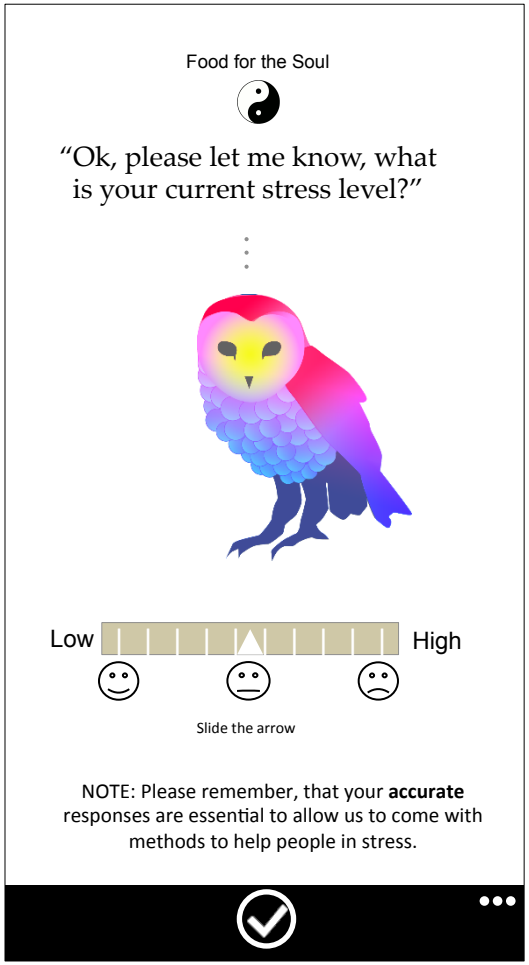
Context-driven ML personalized policies

Intervention (Quick) Process



1

2



3

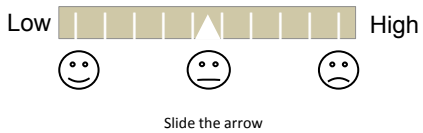
Recommender System

Context and Personal Features

Sensor/API	Feature
Calendar	Number of (free, not free) calendar records (before, during and after an intervention)
GPS (5s x 30min)	• Number of records (at home, at work, null) • Time since GPS record at work • Signal quality (average, last record) • Location (distance to home, distance to work) • Distance traveled
Time	• Time of day • Lunch or Night time
Accelerometer (5s x 30min)	• X, Y, Z average, variance (jerk) (30, 120 min) • Number of accelerometer record (20, 120 min)
Screen Lock	• Number of events • Time since last lock event

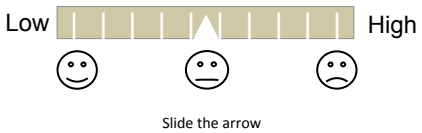
Data Type	Feature
User Trait Data (Pre-Post and Weekly)	• Personality – BIG5 (agreeableness, conscientiousness, extraversion, neuroticism, openness) • Positive and Negative Affect – PANAS • Depression – PHQ-9 • Coping Styles/Strategies – CSQ • Demographics: gender, age, marital status, income, education, employment, professional level • Social Network: Facebook usage, size of online social network and number of good friends
Self Report Data (ESM ~90min)	• Last reported energy and mood • Time since last self report • Energy and Mood (average and variance) • Number of self reports

Maximize Stress Delta (Reduction)



Stress Before Intervention

-



Stress After Intervention

Methodology

- Longitudinal → 4 weeks
- N=94 → N=20 (WP8 users)
- Compensation
  - Baseline Gratuity
  - Sweepstakes based on usage
- 2 x 2 Experiment

	Random recommendations	**Machine Learning recommendations**
Cannot self-select	22 users 1307 interventions	21 users 1176 interventions
Can self-select	26 users 1444 interventions	26 users 1550 interventions

Swipe Data

- Data: 12K swipes
- Users: 94
- Time: 4 weeks
- 1 minute before and 1 minute after swipes

Example of Swipe Data

00cc401f-f54e-b4cc-a62a-3f43ee5a2e92 8/29/2013 2:50:21 AM +00:00 DragStarted O253.125,587.5D1

00cc401f-f54e-b4cc-a62a-3f43ee5a2e92 8/29/2013 2:49:45 AM +00:00 DragCompleted O241.875,518.75D1T53.0967P236.25,518.75D1H-1.875V0T2.5001P234.375,518.75D1H-1.875V0T1.7976P232.5,518.75D1H-1.875V0T1.8371P230,518.75D1H-2.5V0T2.3325P228.125,518.75D1H-1.875V0T2.805P226.25,518.75D1H…

00cc401f-f54e-b4cc-a62a-3f43ee5a2e92 8/29/2013 2:49:44 AM +00:00 DragStarted O241.875,518.75D1

00cc401f-f54e-b4cc-a62a-3f43ee5a2e92 8/29/2013 2:49:26 AM +00:00 DragCompleted O253.75,471.25D1T19.5851P257.5,470D1H1.875V-0.625T3.4684P258.75,469.375D1H1.25V-0.625T2.4438P260,468.75D1H1.25V-0.625T18.2979P261.25,468.125D1H1.25V-0.625T25.3764P263.125,467.5D1H1.875V-…

00cc401f-f54e-b4cc-a62a-3f43ee5a2e92 8/29/2013 2:49:24 AM +00:00 DragStarted O253.75,471.25D1

Swipe Data Structure

GestureData (string): Contains a compressed string representing the gesture. The exact string depends on the value of Action but is generally in the form O#,#D#T#P#,#D#H#V#T#P#D#H#V#T#P#D#H#V#... where the #'s following O and P are the X and Y coordinates of the (O)rigin or the subsequent (P)oints in the gesture, and the # following the T is the amount of time between points, and the # following the D is the direction at that point of the gesture (0=Vertical, 1=Horizontal), and the #'s following H and V are the (H)orizontal and (V)ertical changes to that point in the gesture.

No documentation of string end, but it seems it is:

- HV#VV#
- The last P value represents the last position (repeated number)

Swipe Meta Data

Participant Key
TimeStamp
StressReport
StressAfter
SwipeStart
SwipeStop
SwipeData

Swipe Additional Meta Data
(not parsed at the moment)

Accelerometer
BackKeyPress
Button [‘add tile’, ‘done’, ‘get activity’, ‘launch’, ‘next’, ‘ok’, ‘proceed’, ‘submit’]
DoubleTap
DragComplmeted
DragStarted
Flick
GestureBegin
GestureCompleted
Hold
Tap

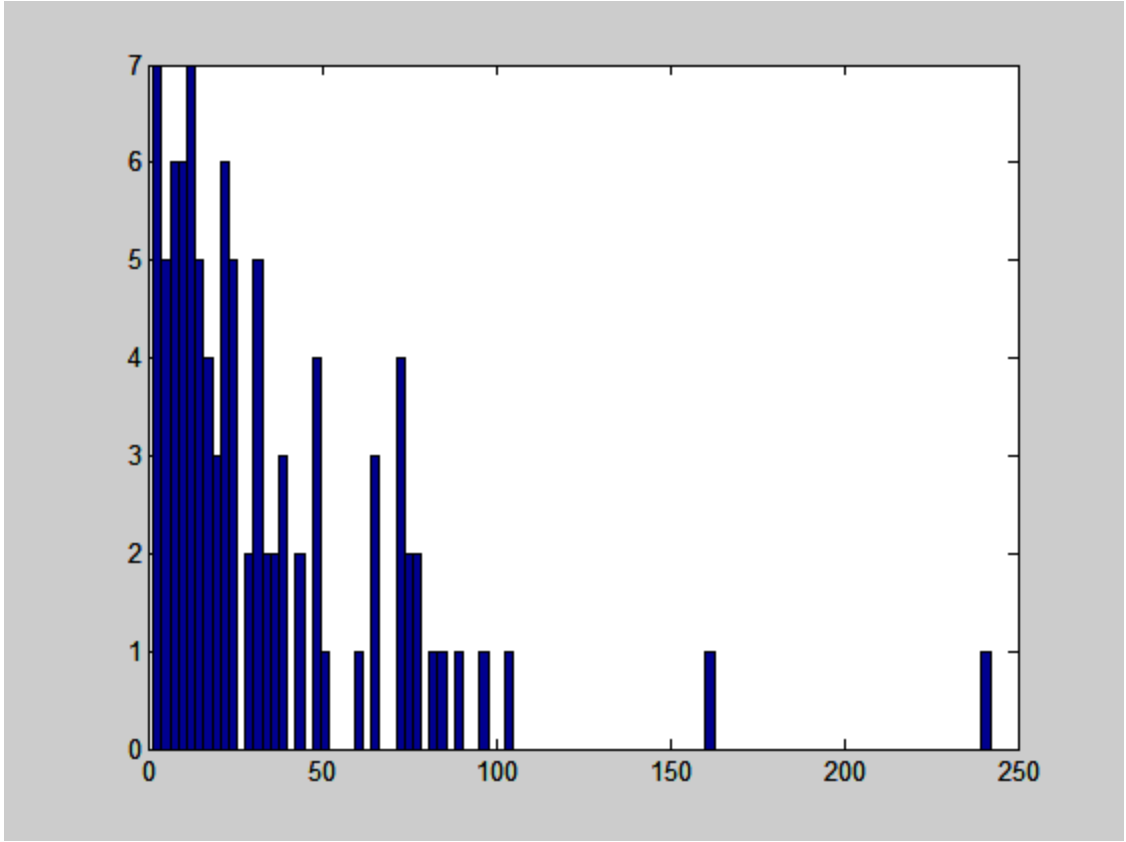
No data on screen pressure (i.e. finger surface activation) – SADLY! ☹

Broad numbers

- Number of participants: 94
- Number of records: 3164
- Number of empty records: 2
- Number of swipes: 12196

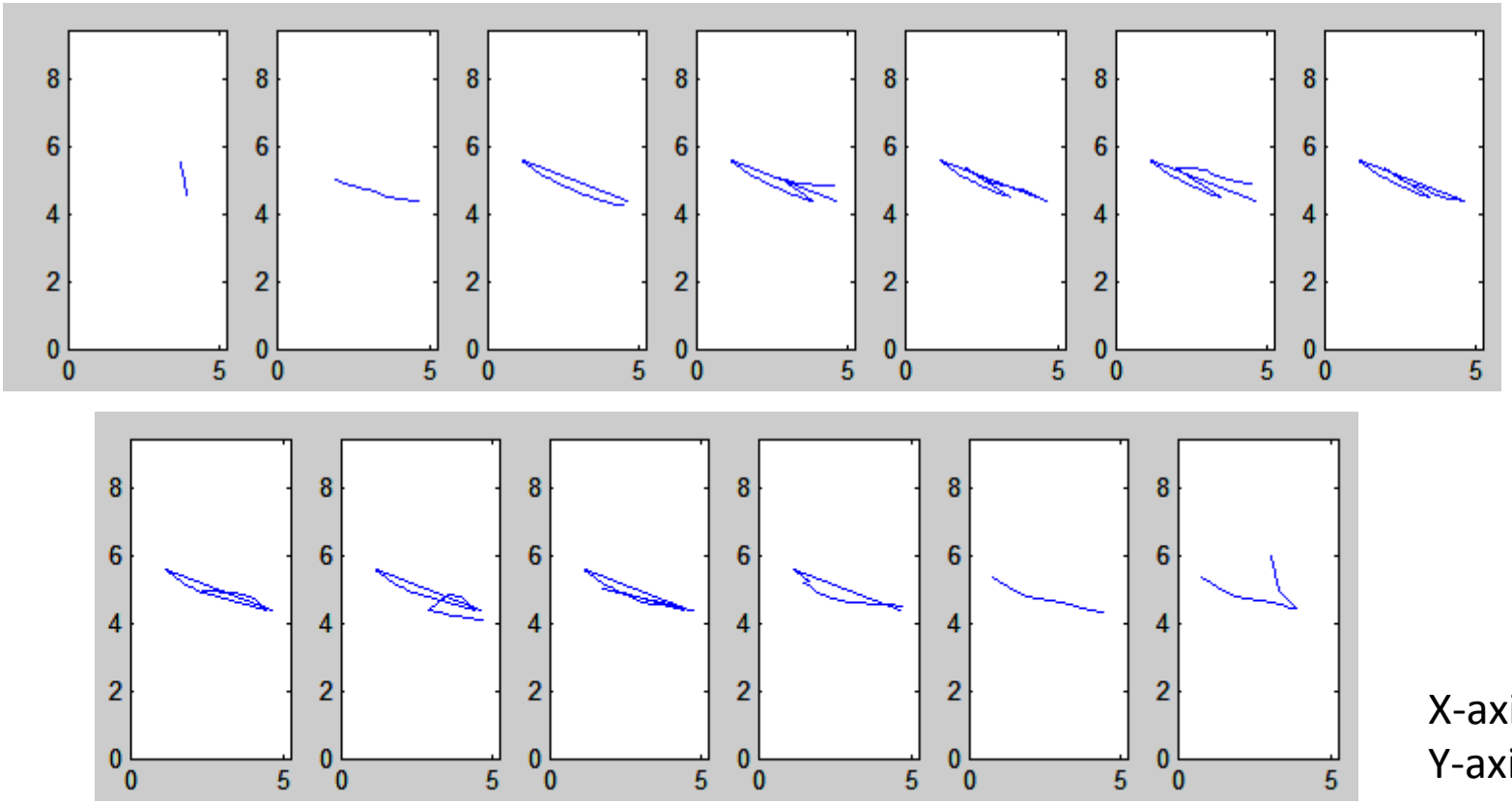
Swipes per record user

- Min: 1
- Max: 242
- Mean: 33.66
- Median: 22



Let's look at some swipes

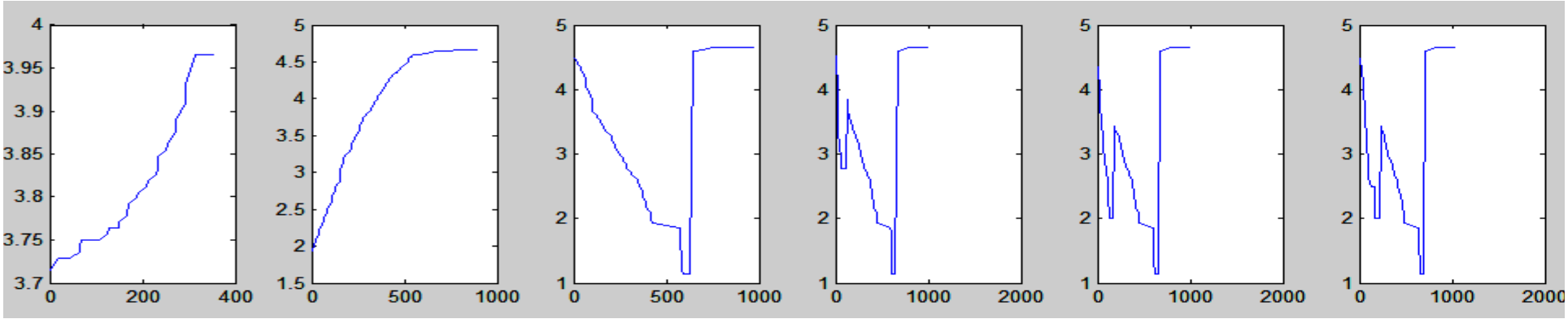
- Record 1 … 13 Swipes ... Hum!
  - Device Independent Units ➔ 1 DIU = 1/96 in



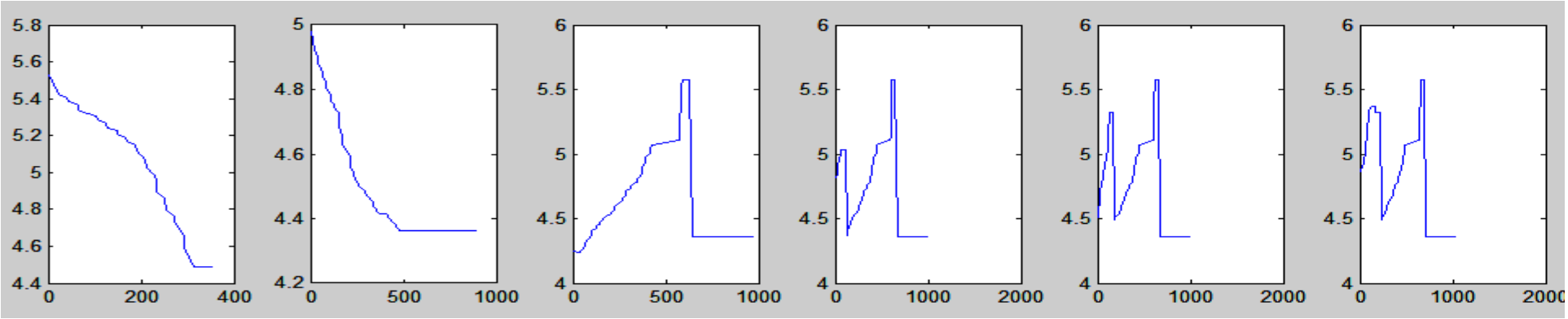
X-axis = in
Y-axis = in

Let’s see the displacements

- Displacement in x



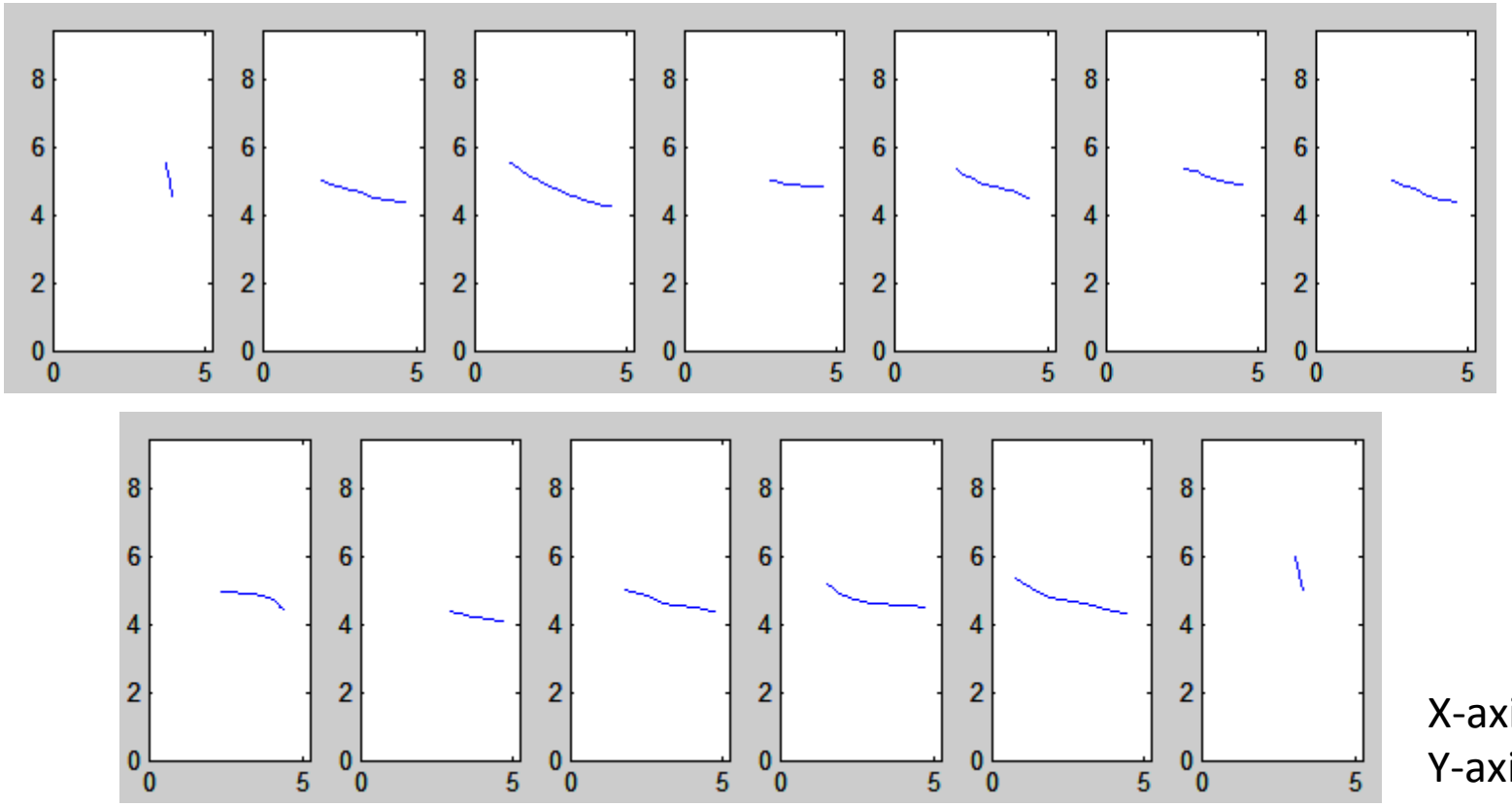
- Displacement in y



X-axis = ms Y-axis = in

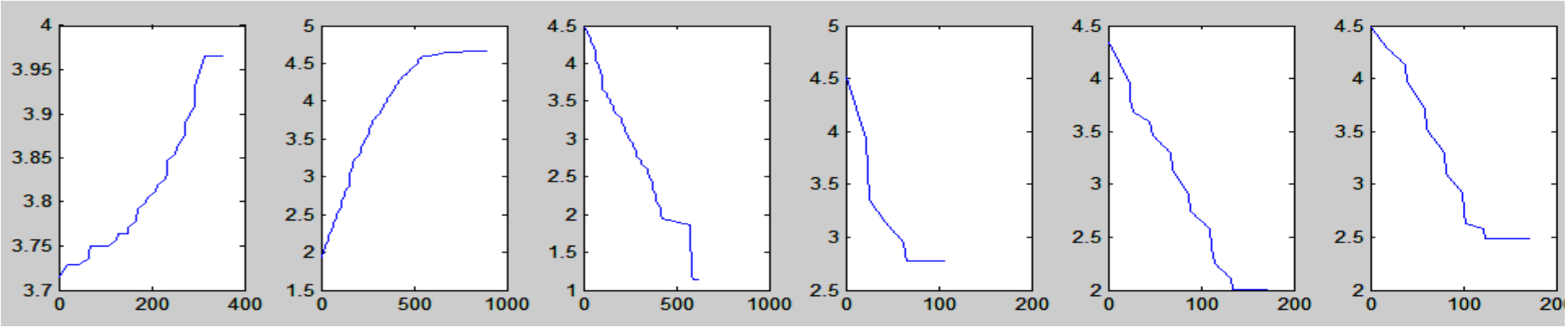
Swipes Revisited

- Record 1 … 13 Swipes … Much better
  - Although, the x-displacement seems a bit large!

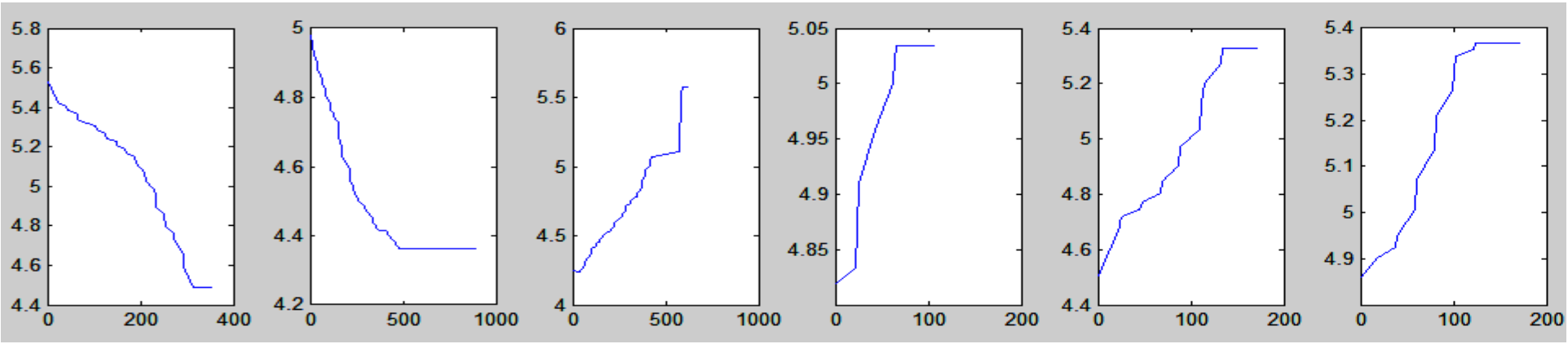


Displacements Revisited

- Displacement in x



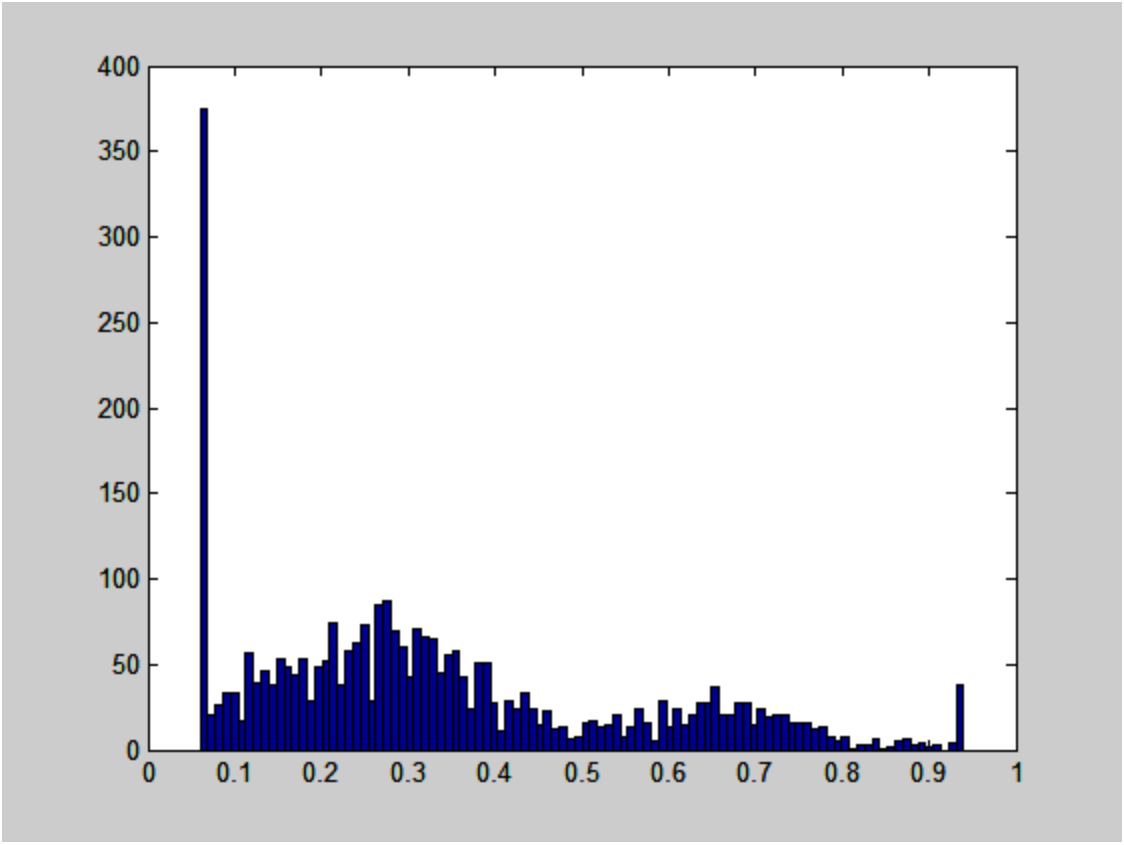
- Displacement in y



X-axis = ms Y-axis = in

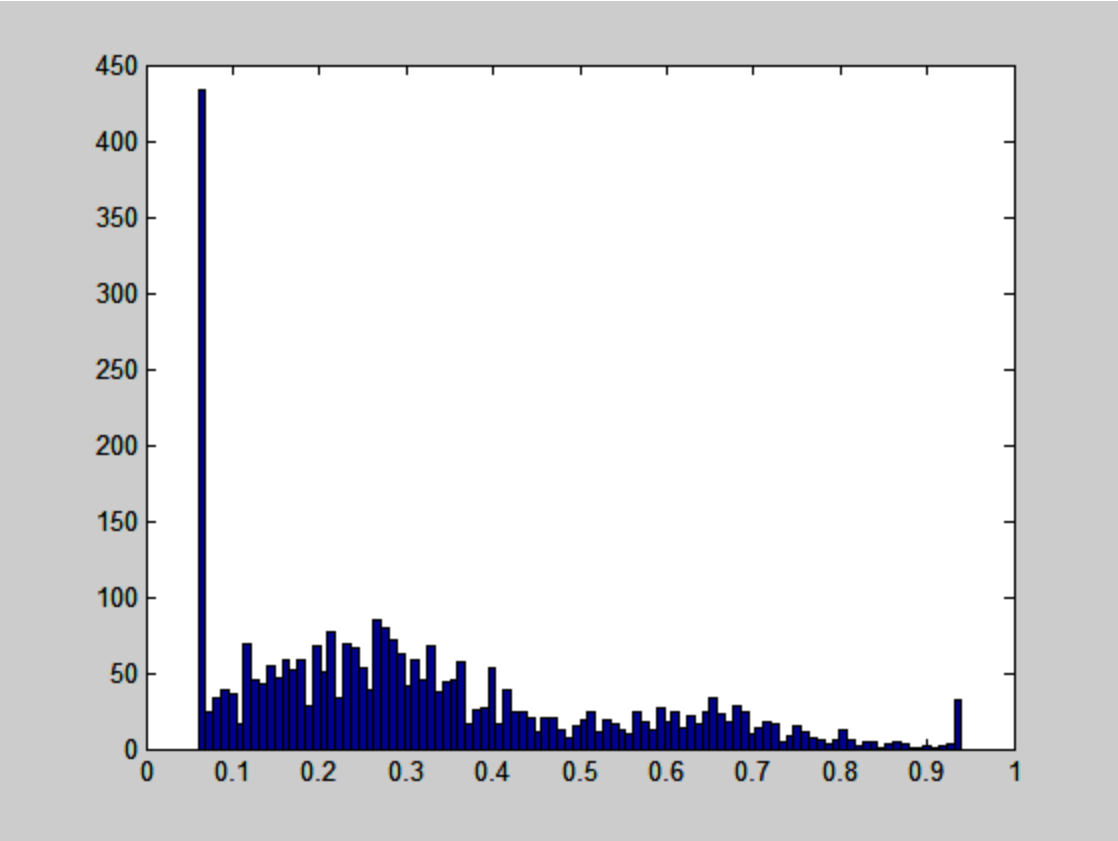
What about stress metrics?

- Stress Before (Low: 0.06 … High: 0.94)



What about stress metrics?

- Stress After (Low: 0.06 … High: 0.94)

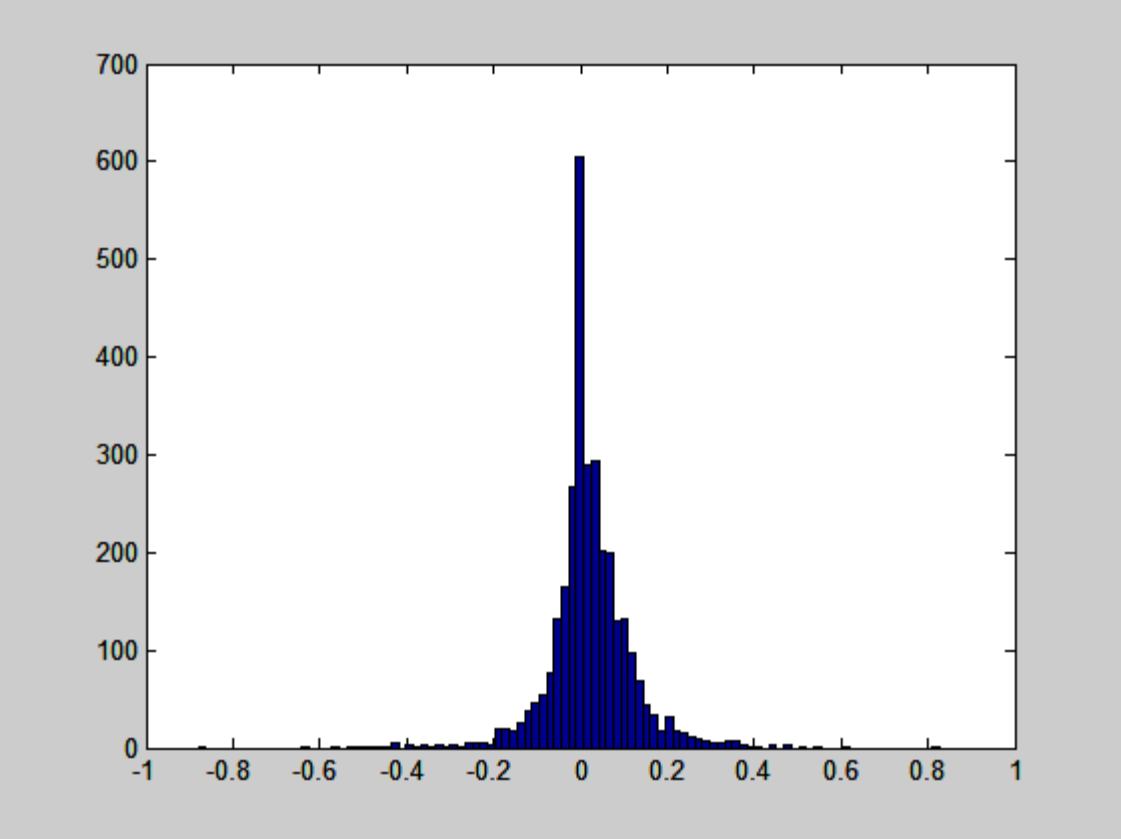


Outliers??

- Lots of people without any stress?
- People playing with the app?
  - Remember we PAID them for usage
    - We had little time and small population
  - 0.06 stress before and after = 265
  - 0.06 stress before and 0.94 after = 2
  - 0.94 stress before and 0.06 after = 26
  - Time between begin and end of intervention?

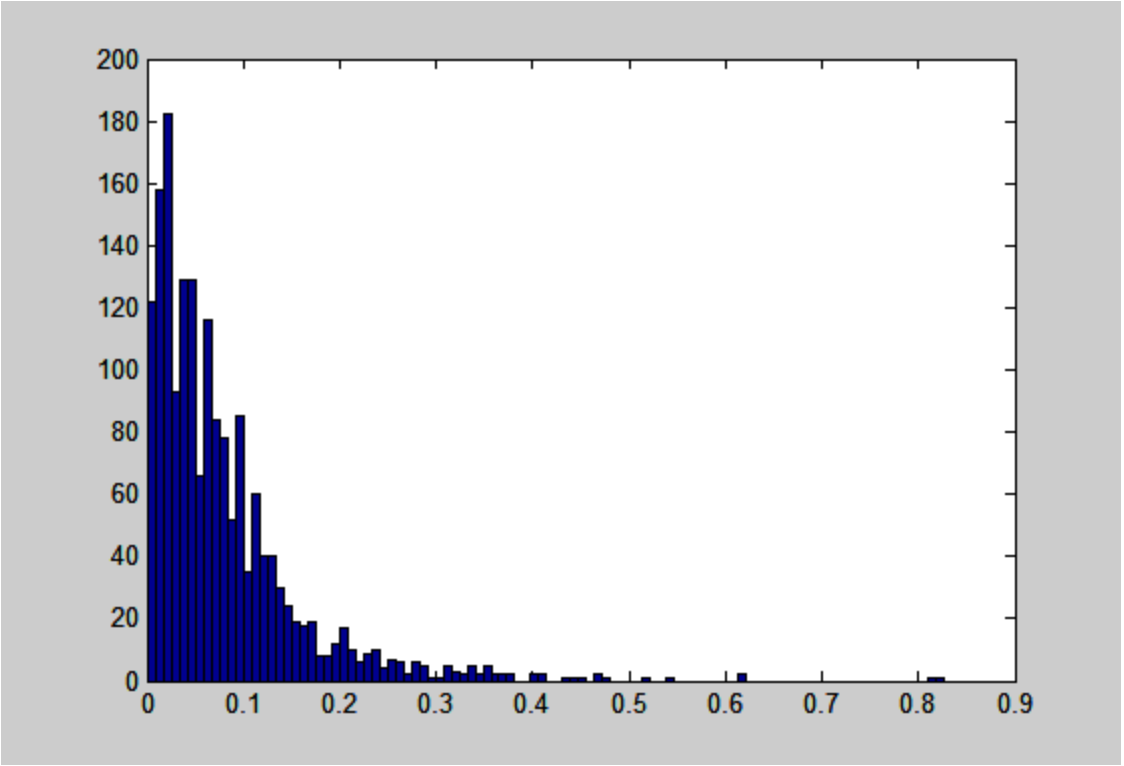
What about stress metrics?

- Delta (StressBefore – StressAfter)
  - Hum … No change: 405/3164 (12.8%)



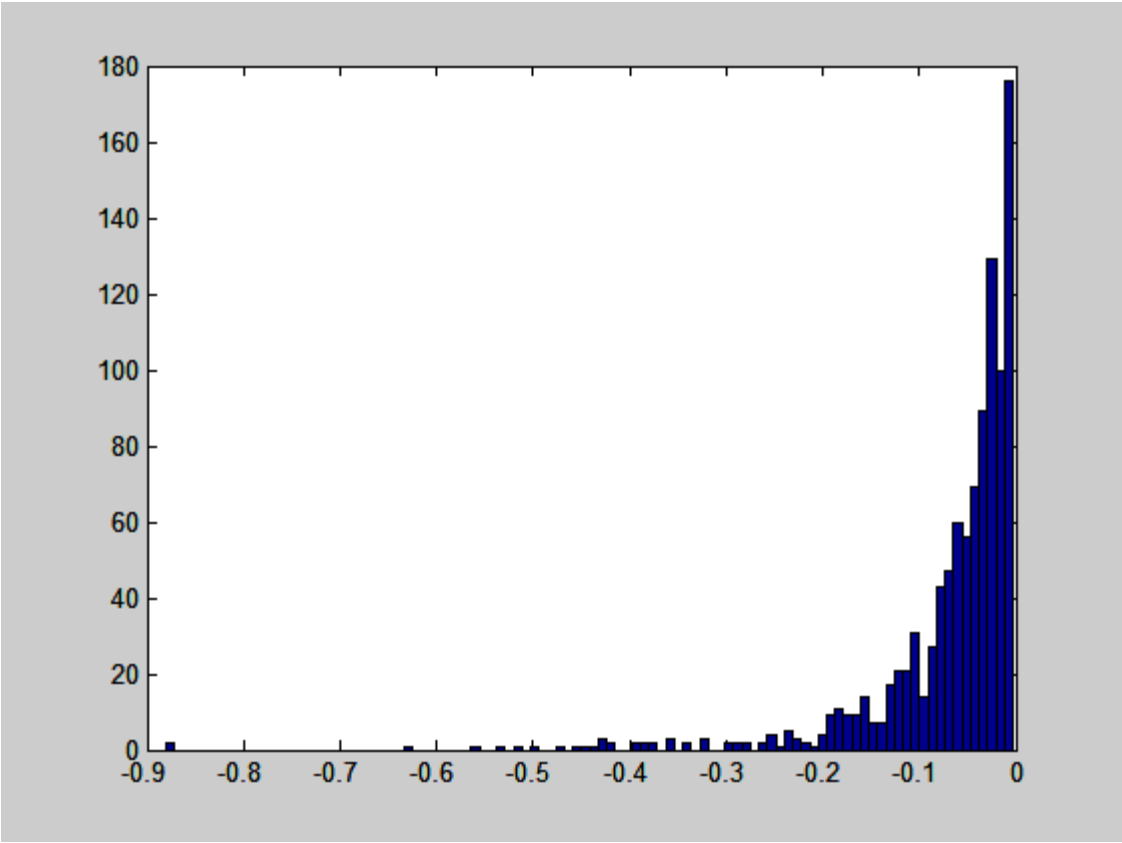
What about stress metrics?

- Stress Reduction (Delta>0)



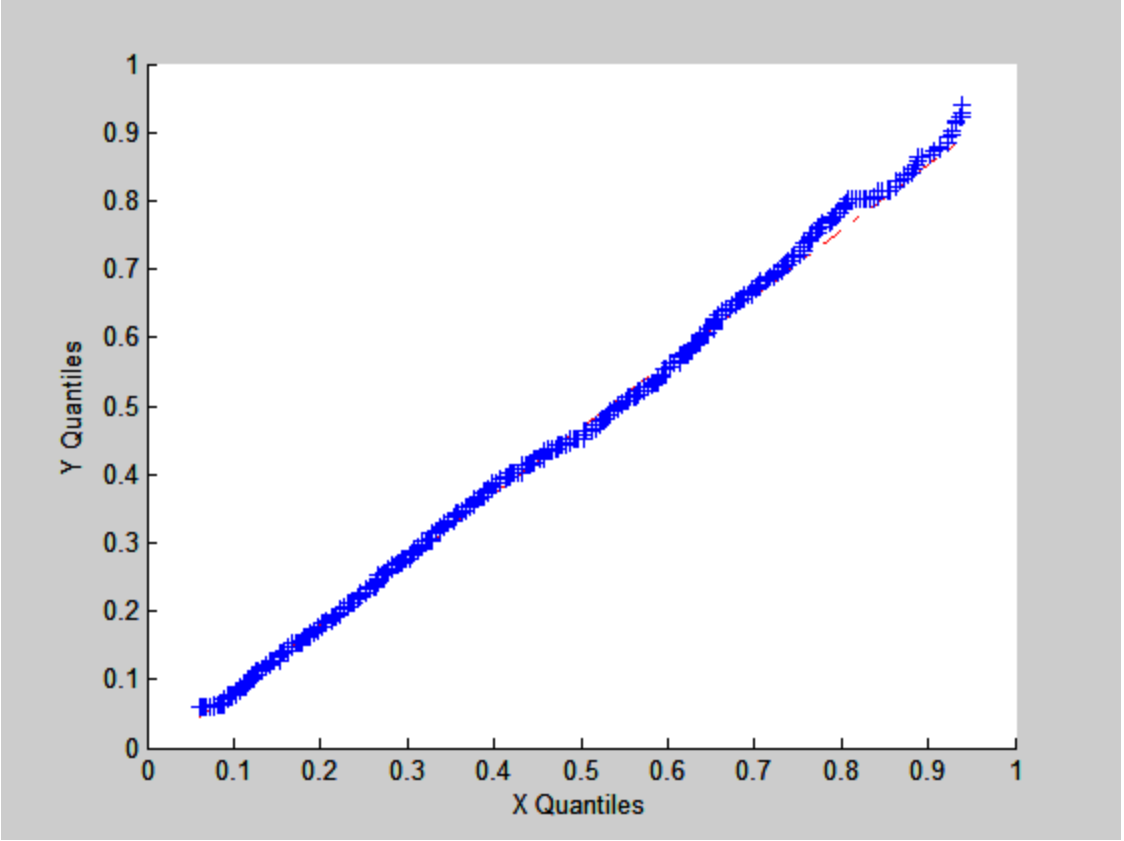
What about stress metrics?

- Stress Increase (Delta<0)



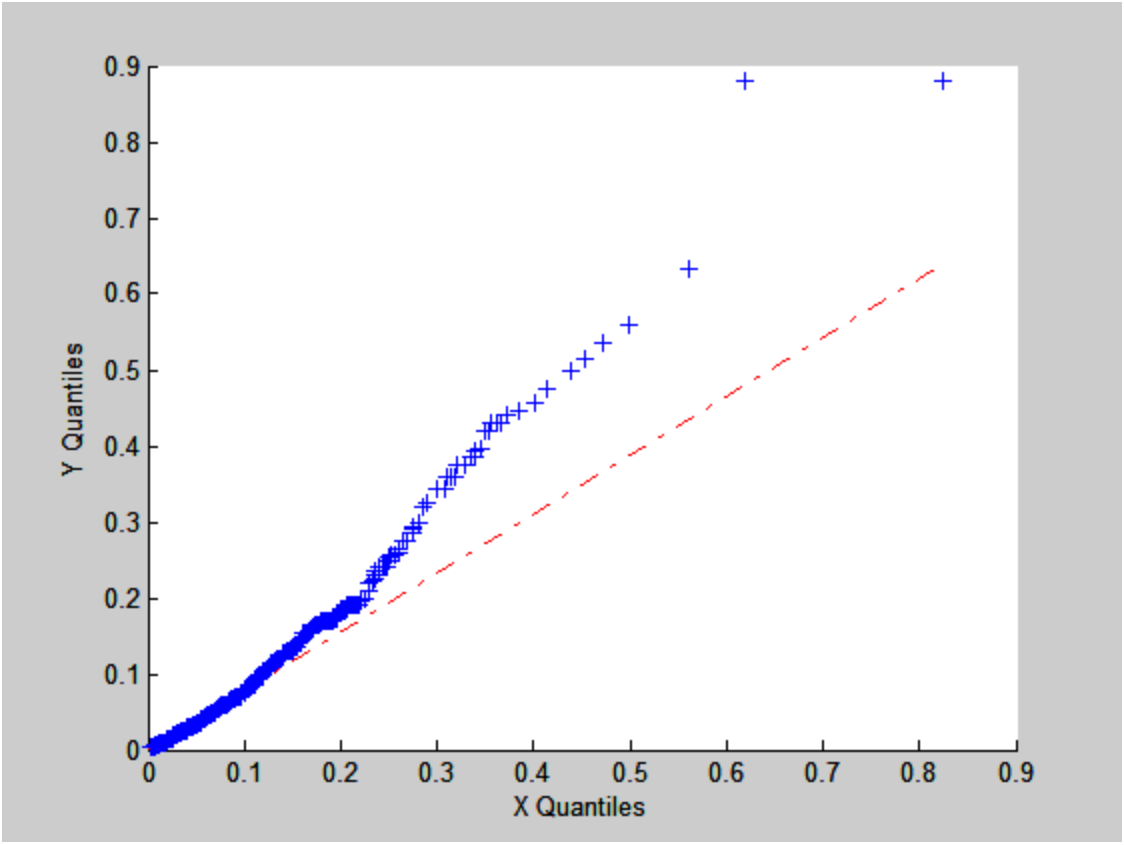
Stress Before vs After

- Mostly diff on the right tail??
  - Wilcoxon rank test → p=2.8364E-11



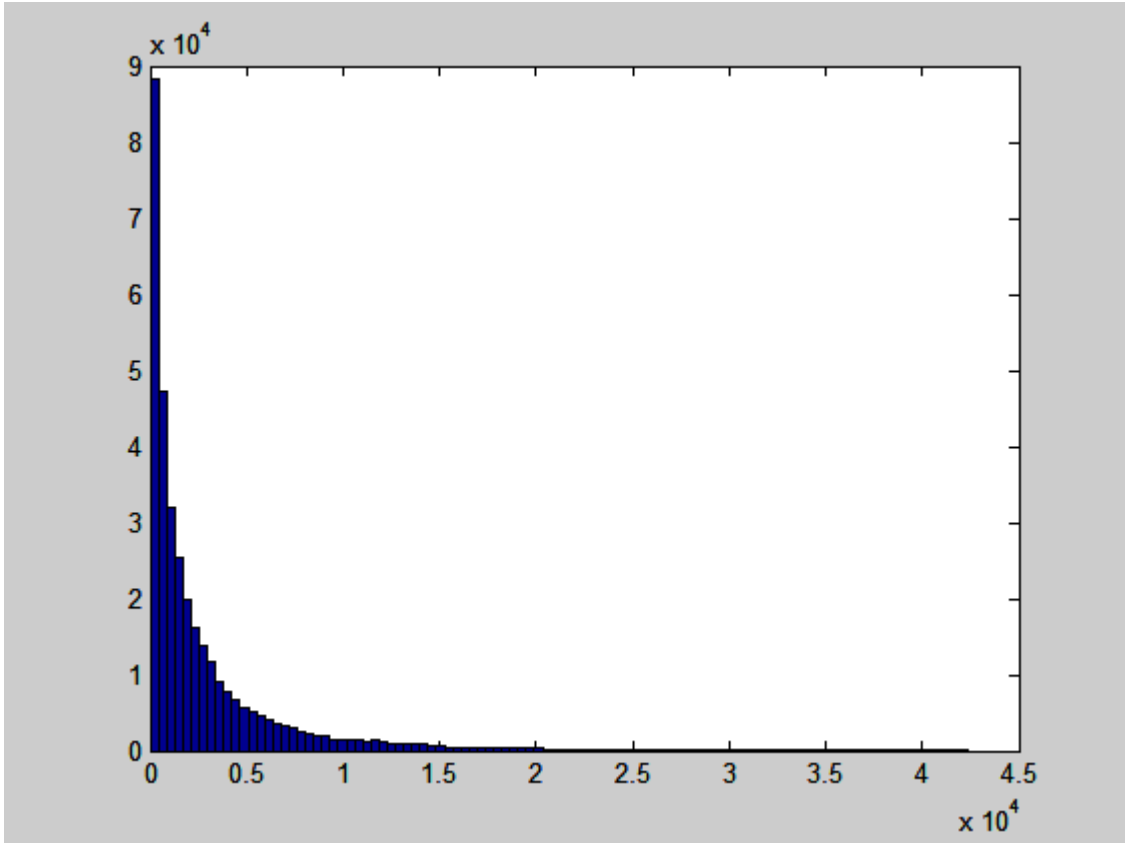
Stress Reduction vs. Increase

- Different distributions??



Back to Swipes – Duration

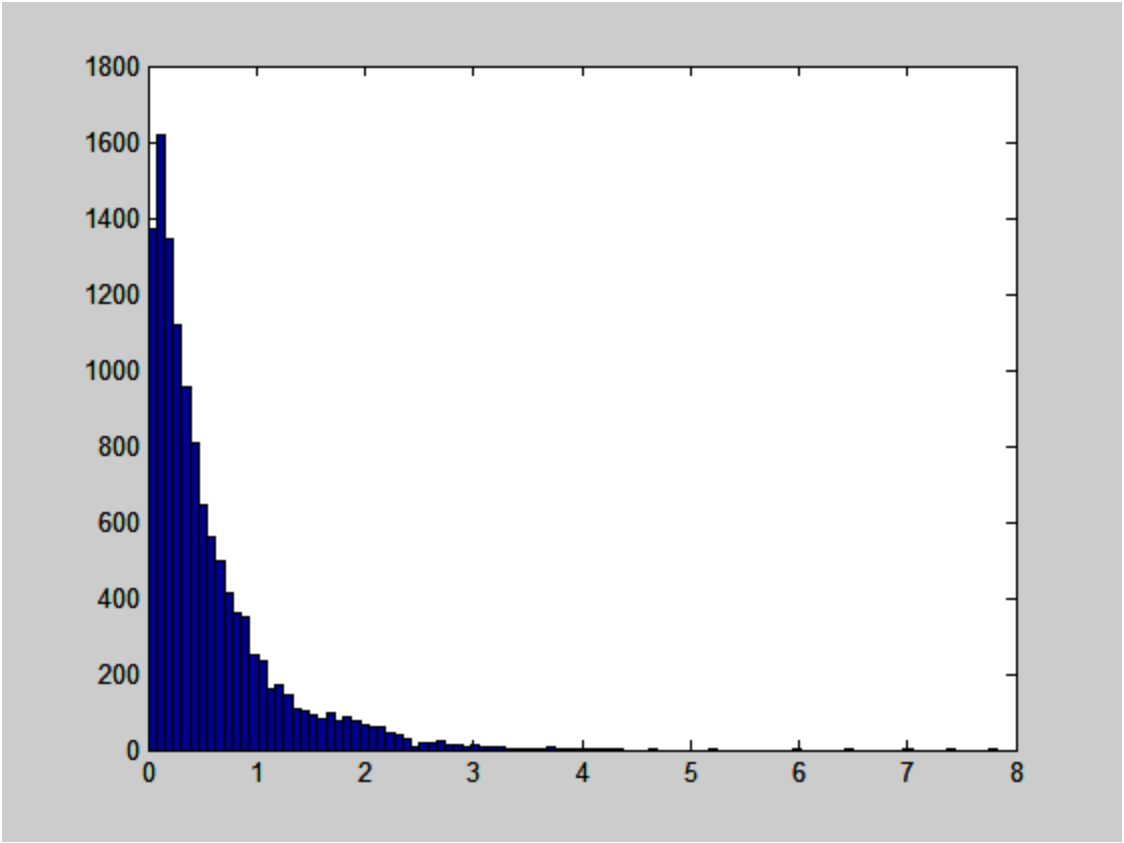
- Lost of tiny swipes…
  - but also huge duration ones?



X-axis = ms

Displacement X-axis

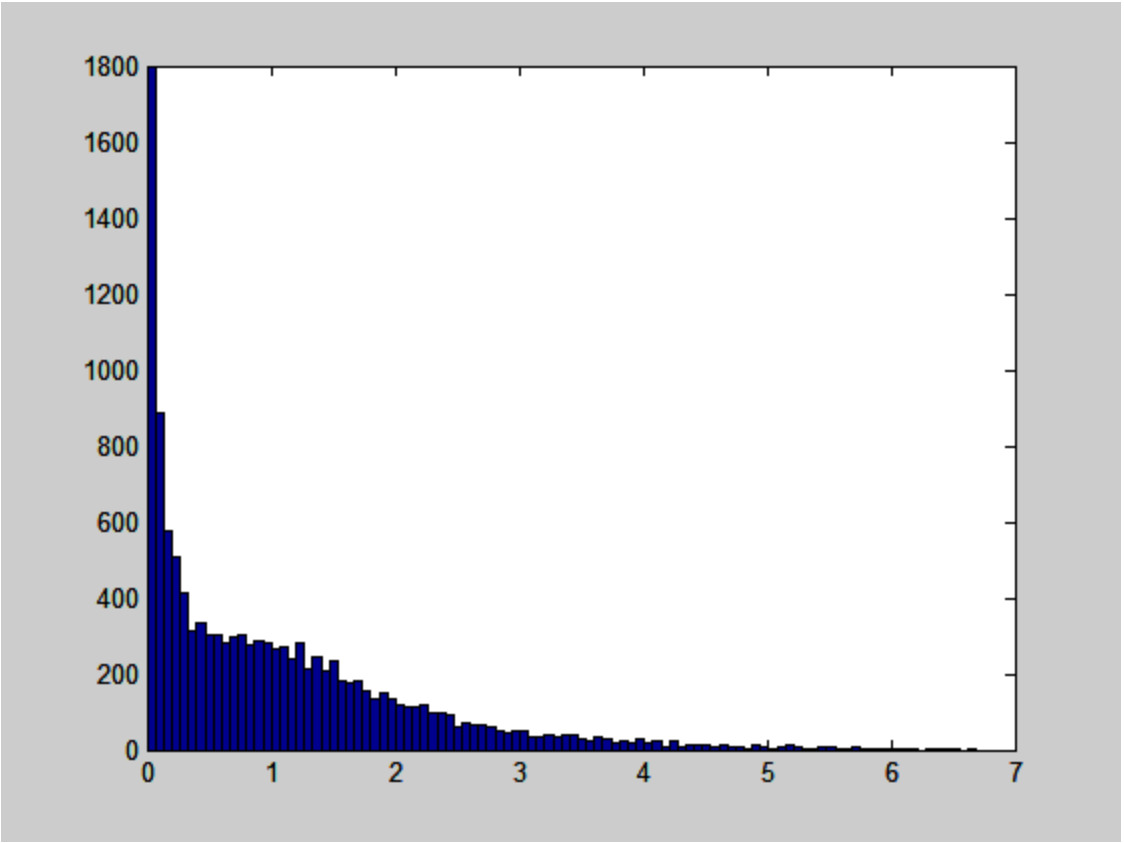
- More than 3 inches???



X-axis = in

Displacement Y-axis

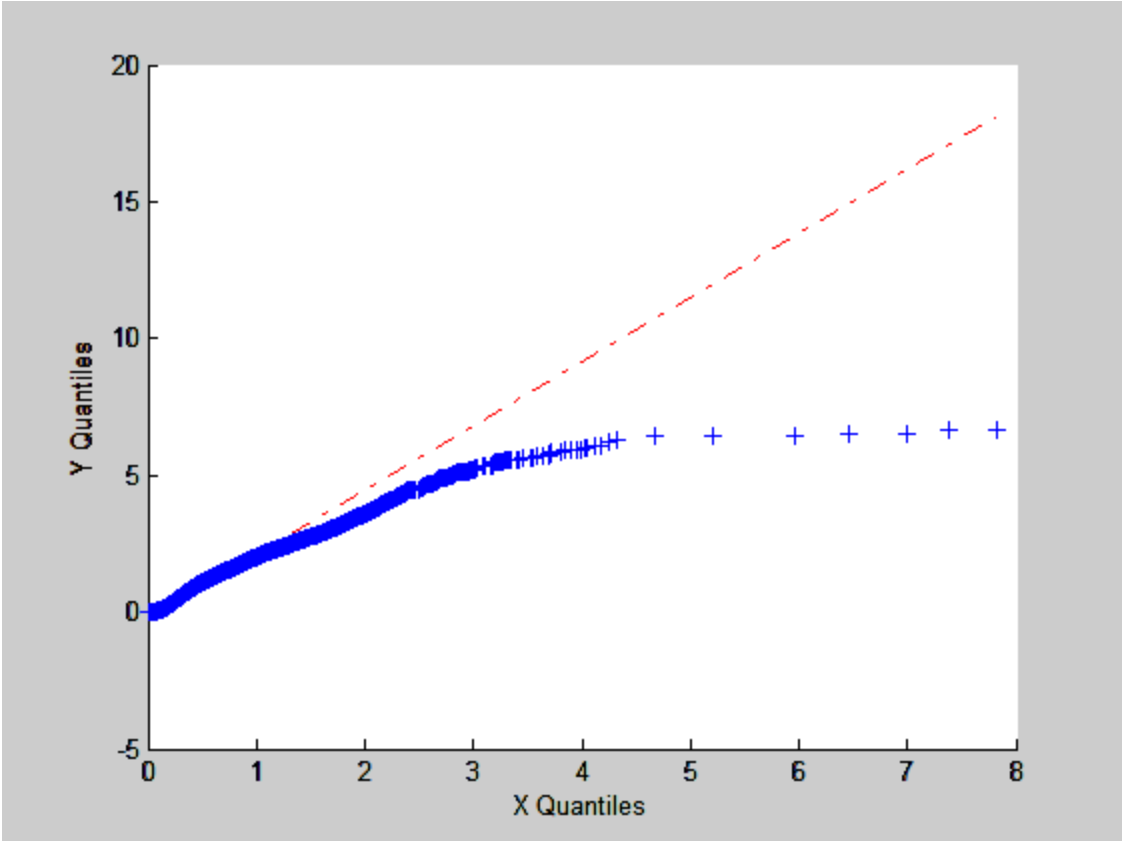
- More than 5 inches???



X-axis = in

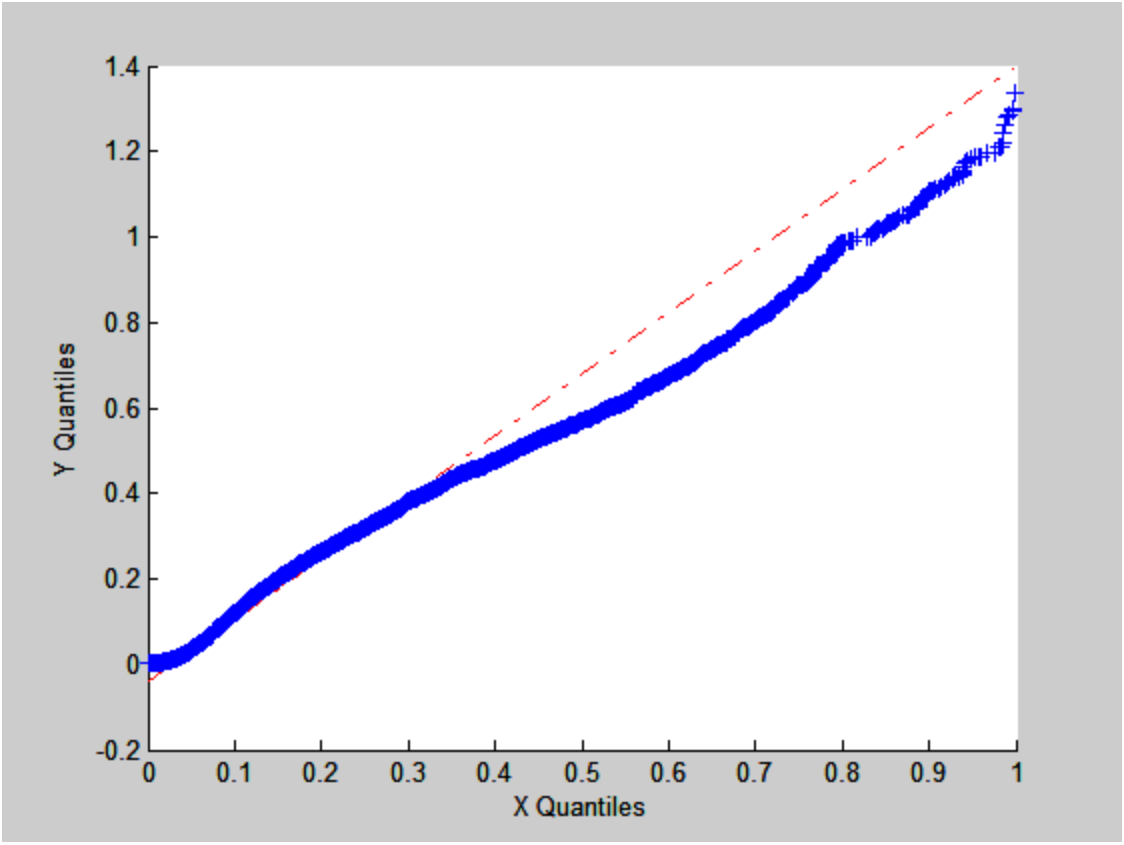
Displacement X vs Y

- ??



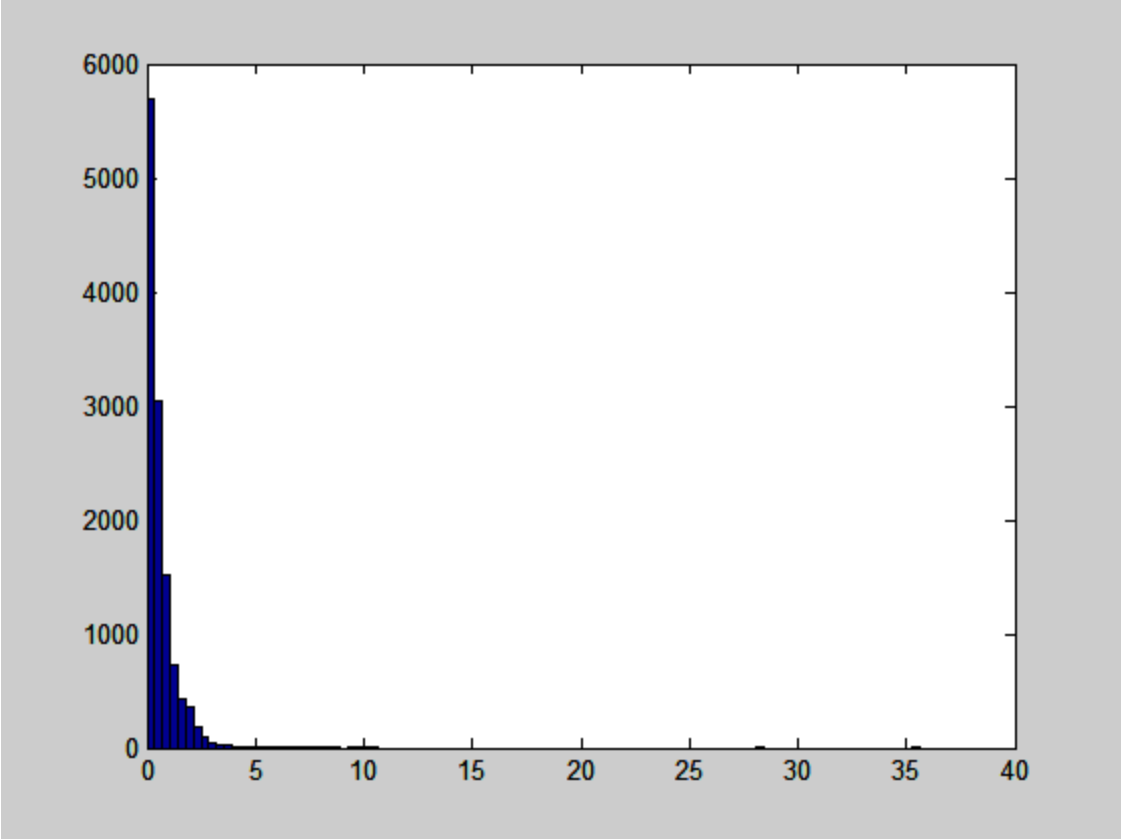
Displacement X vs Y

- No outliers, normalized (maxX=3, maxY=5)



Trajectory X-axis

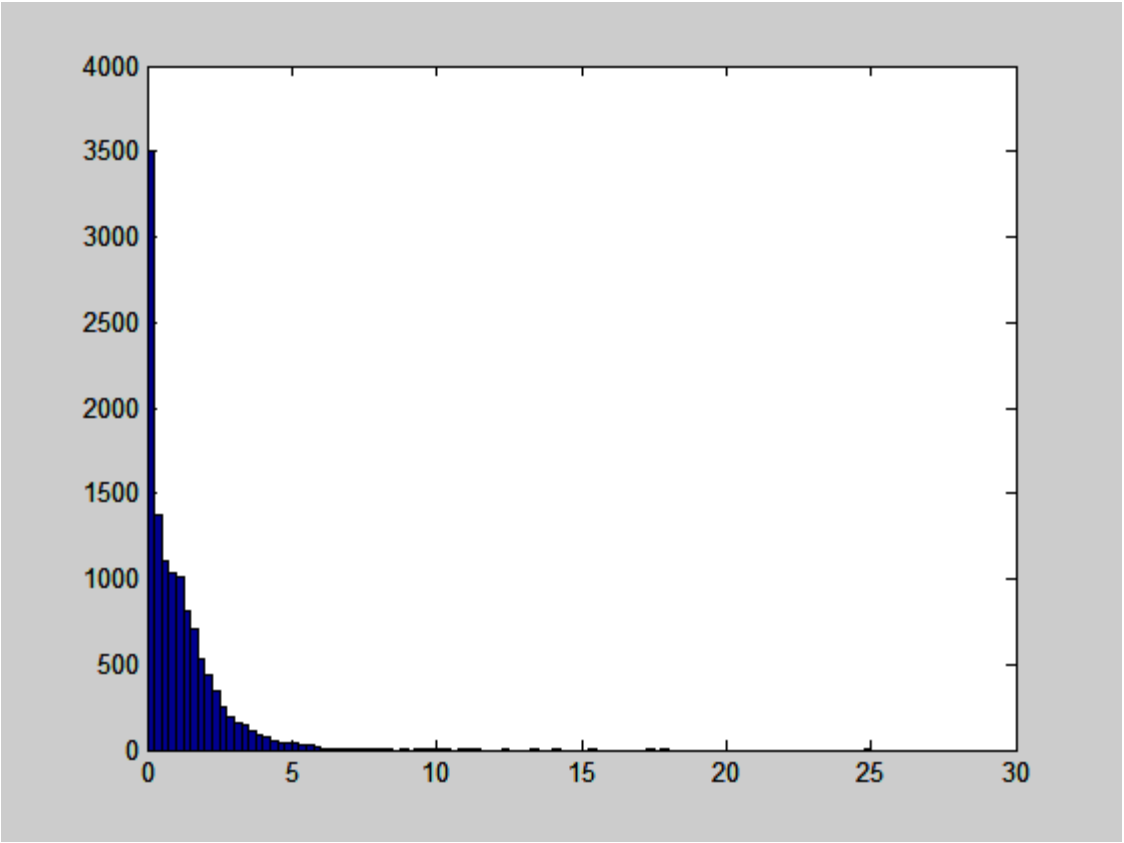
- Some very long trajectories!



X-axis = in

Trajectory Y-axis

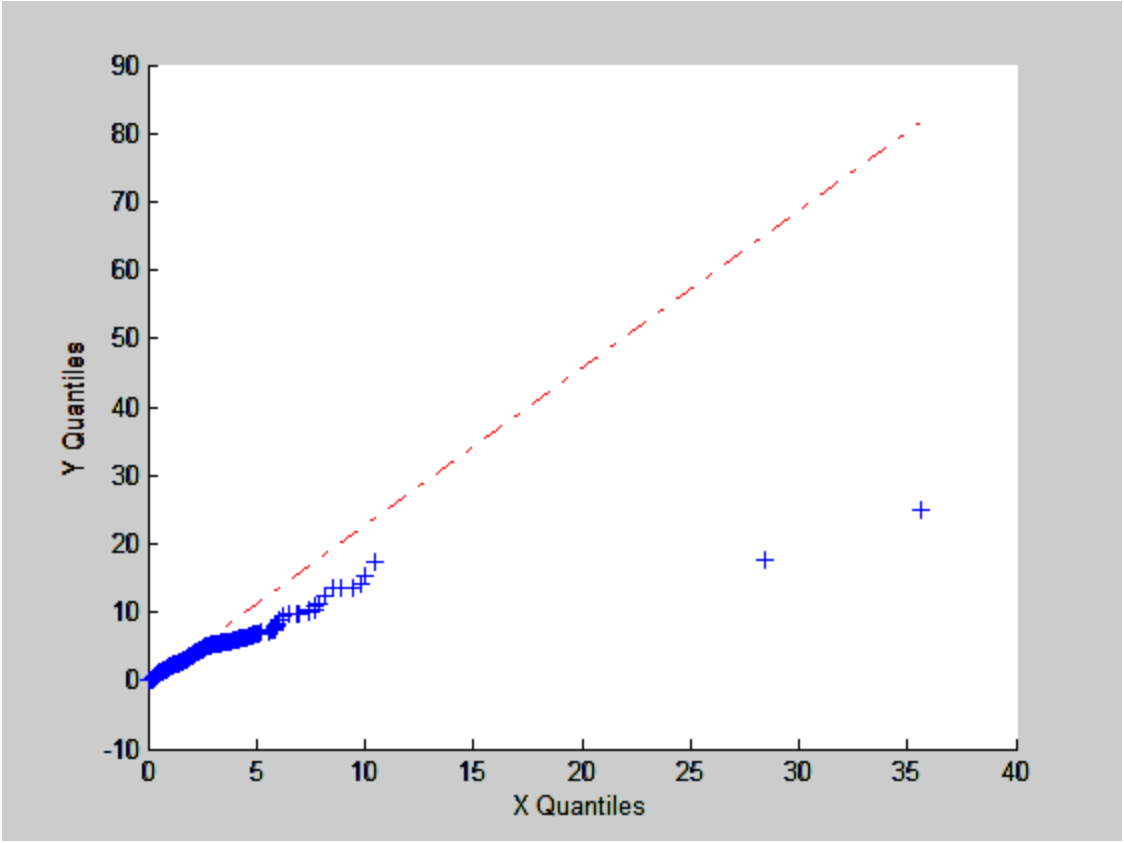
- Some very long trajectories!



X-axis = in

Trajectory X vs Y

- Some very long trajectories!



X-axis = in