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)

[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?
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].


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.

<table>
<thead>
<tr>
<th>Task</th>
<th>Distance (px)</th>
<th>Width (px)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pointing</td>
<td>64 128 256 512 1024</td>
<td>8 16 32 64</td>
</tr>
<tr>
<td>Dragging</td>
<td>64 128 256 512 1024</td>
<td>8 16 32 64</td>
</tr>
<tr>
<td>Steering</td>
<td>64 128 256 512 1024</td>
<td>16 32 64 128</td>
</tr>
</tbody>
</table>
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 can't 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:

\[ \omega_0 = \sqrt{\frac{k}{m}}, \quad \zeta = \frac{c}{\sqrt{mk}} \]

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:
Mouse dynamic tests in detail:

<table>
<thead>
<tr>
<th>Indicators</th>
<th>mCalm</th>
<th>mStress</th>
<th>t(48)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\omega_x$</td>
<td>0.126(0.001)</td>
<td>0.130 (0.001)</td>
<td>2.83</td>
<td>.003*</td>
</tr>
<tr>
<td>$\omega_y$</td>
<td>0.205(0.004)</td>
<td>0.215(0.004)</td>
<td>3.00</td>
<td>.002*</td>
</tr>
<tr>
<td>$\zeta_x$</td>
<td>0.532(0.0004)</td>
<td>0.534(0.0003)</td>
<td>3.11</td>
<td>.002*</td>
</tr>
<tr>
<td>$\zeta_y$</td>
<td>0.408(0.008)</td>
<td>0.414(0.008)</td>
<td>1.32</td>
<td>.097</td>
</tr>
<tr>
<td>$t$</td>
<td>1.03(0.05)</td>
<td>1.03(0.07)</td>
<td>-.02</td>
<td>.490</td>
</tr>
</tbody>
</table>
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

“First, please let me know, what is your current stress level?”

NOTE: Please remember, that your accurate responses are essential to allow us to come with methods to help people in stress.

1

“Ok, please let me know, what is your current stress level?”

NOTE: Please remember, that your accurate responses are essential to allow us to come with methods to help people in stress.

2

Food for the Soul

3
## Recommender System

### Context and Personal Features

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

### Data Type

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

## Maximize Stress Delta (Reduction)

![Stress Before Intervention](image1)

Stress Before Intervention - Stress After Intervention

![Stress After Intervention](image2)
Methodology

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

<table>
<thead>
<tr>
<th></th>
<th>Random recommendations</th>
<th>Machine Learning recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannot self-select</td>
<td>22 users 1307 interventions</td>
<td>21 users 1176 interventions</td>
</tr>
<tr>
<td>Can self-select</td>
<td>26 users 1444 interventions</td>
<td>26 users 1550 interventions</td>
</tr>
</tbody>
</table>
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)igin 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 $\Rightarrow$ 1 DIU = 1/96 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!

\[\begin{align*}
\text{X-axis} &= \text{in} \\
\text{Y-axis} &= \text{in}
\end{align*}\]
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 $\rightarrow$ p=2.8364E-11
Stress Reduction vs. Increase

- Different distributions??

![Graph showing stress reduction and increase with different distributions](image)
Back to Swipes – Duration

• Lost of tiny swipes...
  – but also huge duration ones?

X-axis = ms
Displacement X-axis

- More than 3 inches???
Displacement Y-axis

- More than 5 inches???
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!