



THE OHIO STATE UNIVERSITY

Autonomy for the Others

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Who are the “Others”?

- **Persons:**
 - Living in poverty
 - Living with mental illnesses
- **Ignored** by feedback control theorists, engineers



By Vincent
Van Gogh



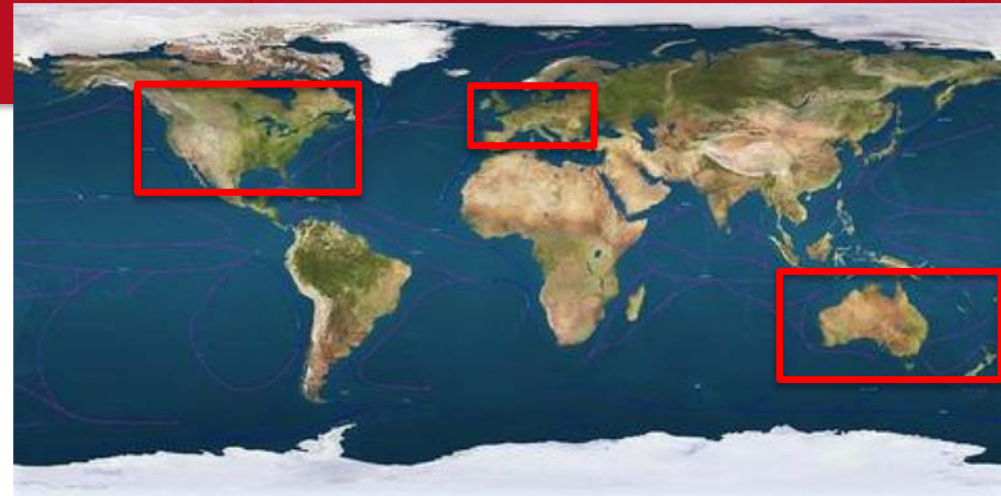
Poverty, prevalence:

World population:

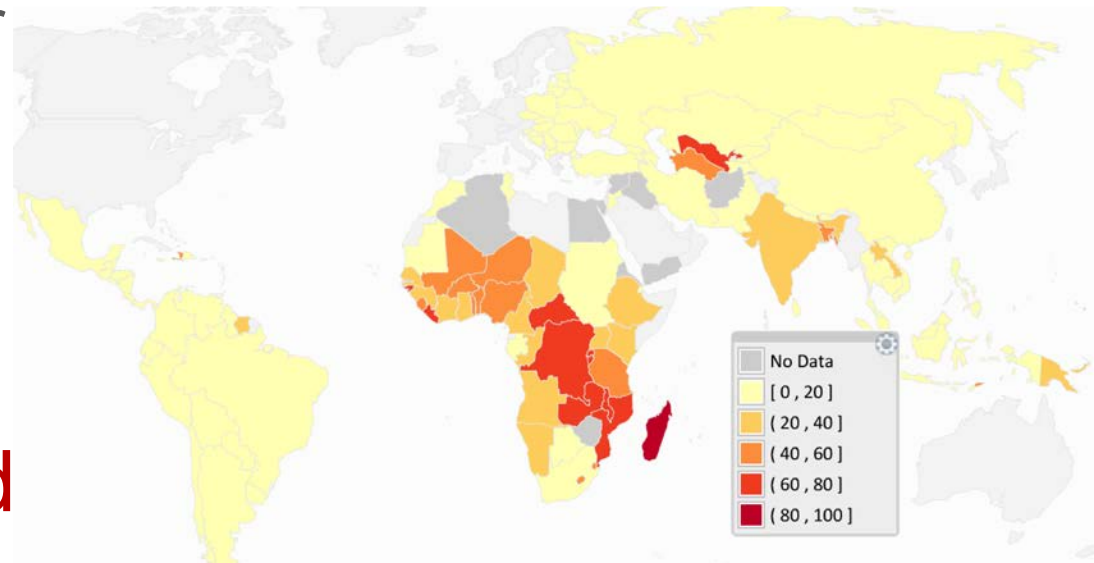
7.5 billion

- About 1 billion people living at below \$1/day (PPP)
- About 80% live on under \$10/day
- About 10% live in “developed world”

US population: 329 million, 4.4% of world



\$1.90/day poverty headcount ratio (2011 PPP)





Financial Advisor, Importance When Living in Poverty:

- A very complex financial setting
- Significant risk, one dollar matters
- Day-to-day income very uncertain
- Piggy-back on cell-phone for e-advice

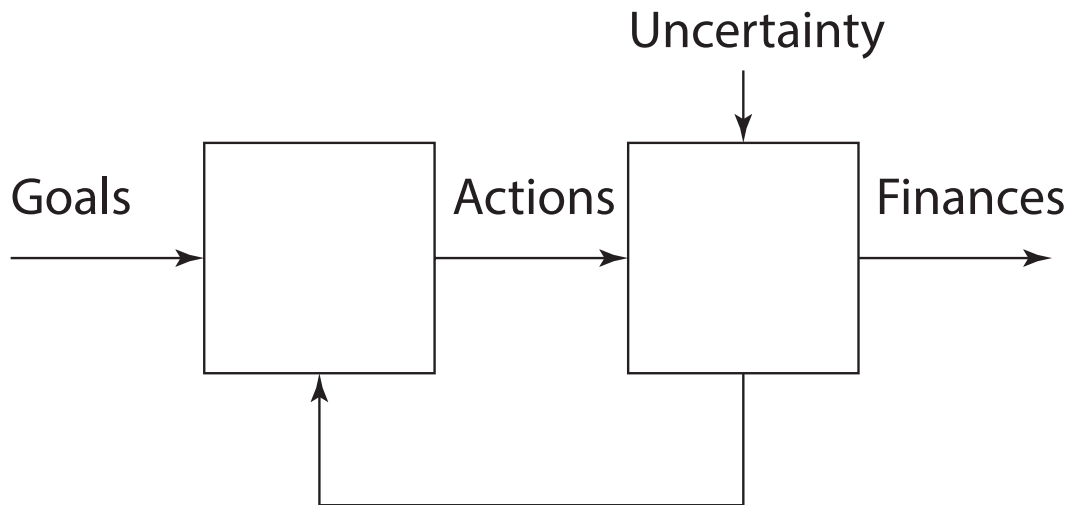




Feedback Controllers as Financial Advisors for Low-Income Individuals

Hugo Gonzalez Villasanti and Kevin M. Passino, *Fellow, IEEE*

Abstract—Feedback controllers are introduced to help manage individual’s or household’s financial life and build savings. The in [5], and some insights into households in developing economies can be found in [6]. Viewing economic system



Hugo Gonzalez Villasanti

Model-predictive control (MPC), PID, DP,...



Feedback Control Engineering for Cooperative Community Development

TOOLS FOR FINANCIAL MANAGEMENT ADVICE FOR LOW-INCOME INDIVIDUALS

HUGO GONZALEZ VILLASANTI, LUIS FELIPE GIRALDO, and KEVIN M. PASSINO



IEEE Control Systems Magazine, June 2018



Hugo Gonzalez Villasanti



Felipe Giraldo: **Google Latin America Award** to implement this

Distributed feedback control (cooperation) strategies for group finance management



Mental illness, prevalence:

“42.5 million American adults, or **18.2 percent** of the total adult population in the United States, suffers from some mental illness” (2015)

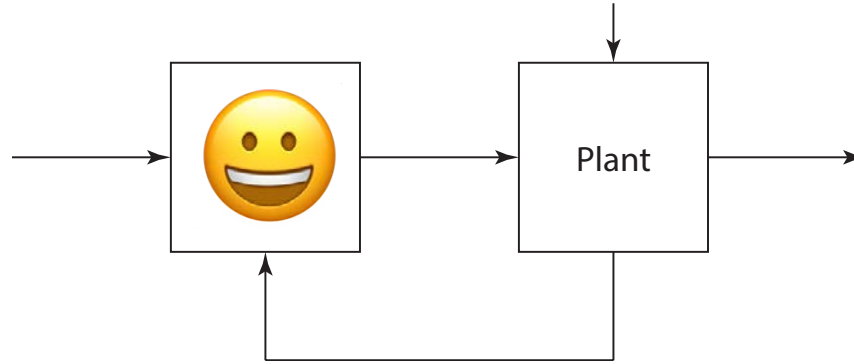
(US Substance Abuse and Mental Health Services Administration)

What can we do about this?

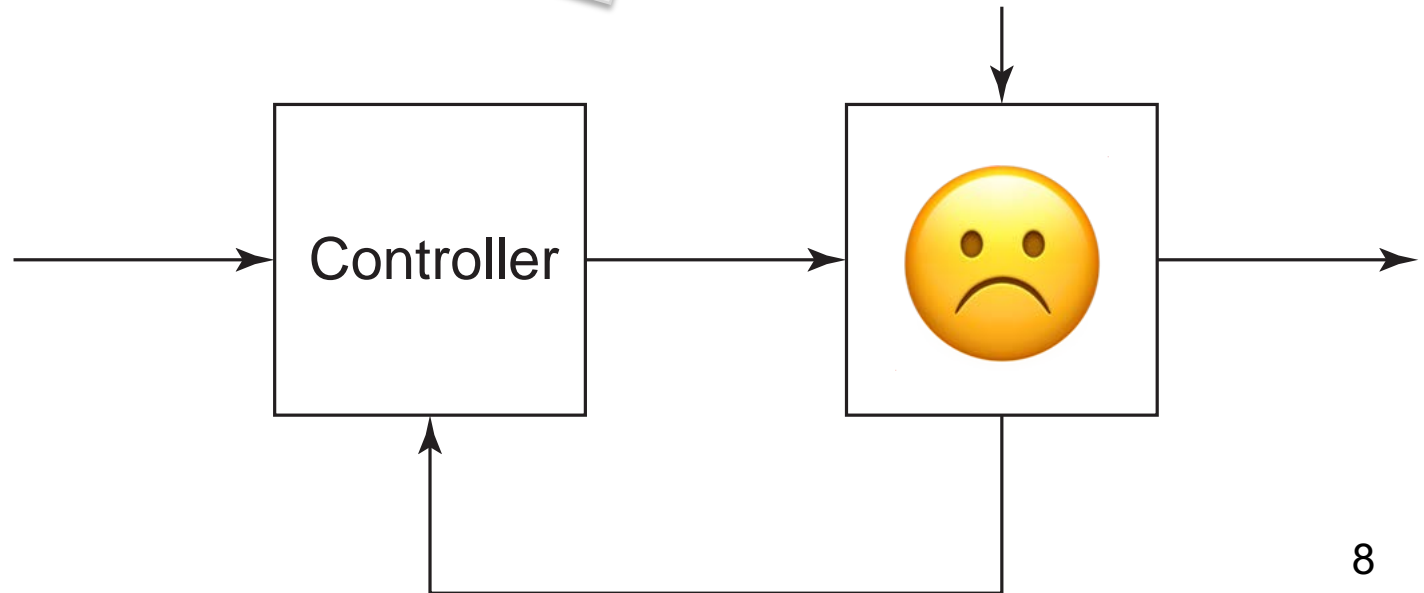


Feedback Control!

Intelligent control

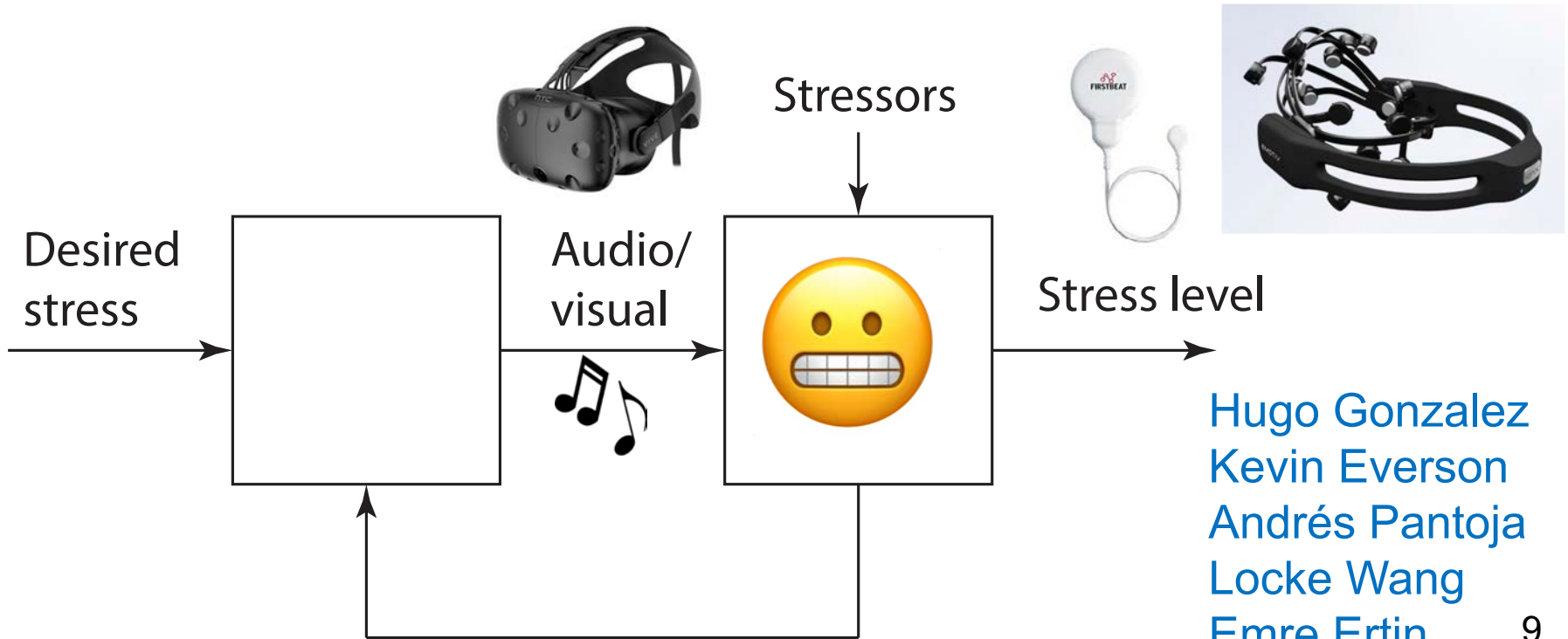


Feedback control for mental health





Stress Reduction (Stress Adversely Affects Other Illnesses)



Hugo Gonzalez
Kevin Everson
Andrés Pantoja
Locke Wang
Emre Ertin

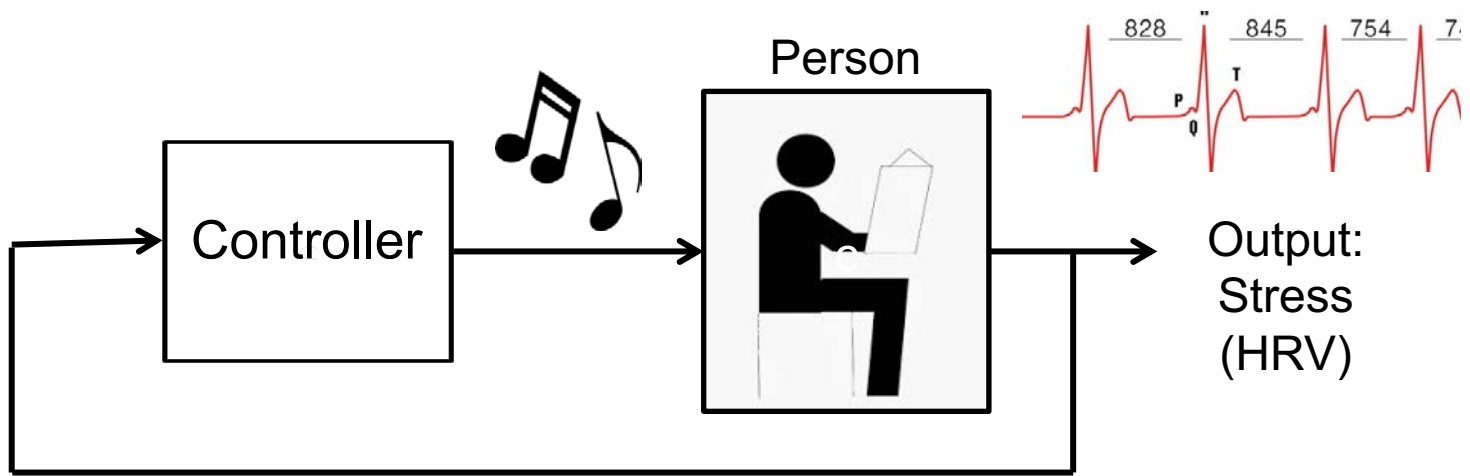
Feedback Control of Stress Using Music



Andrés Pantoja

Input: Music parameters

- Pitch
- Tempo
- Volume
- ...



Hugo Gonzalez Villasanti

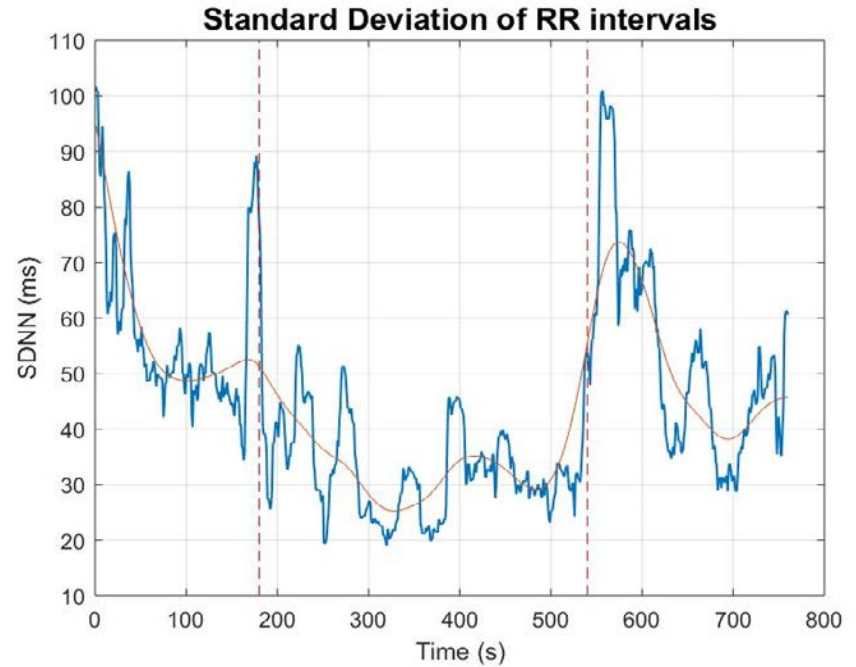
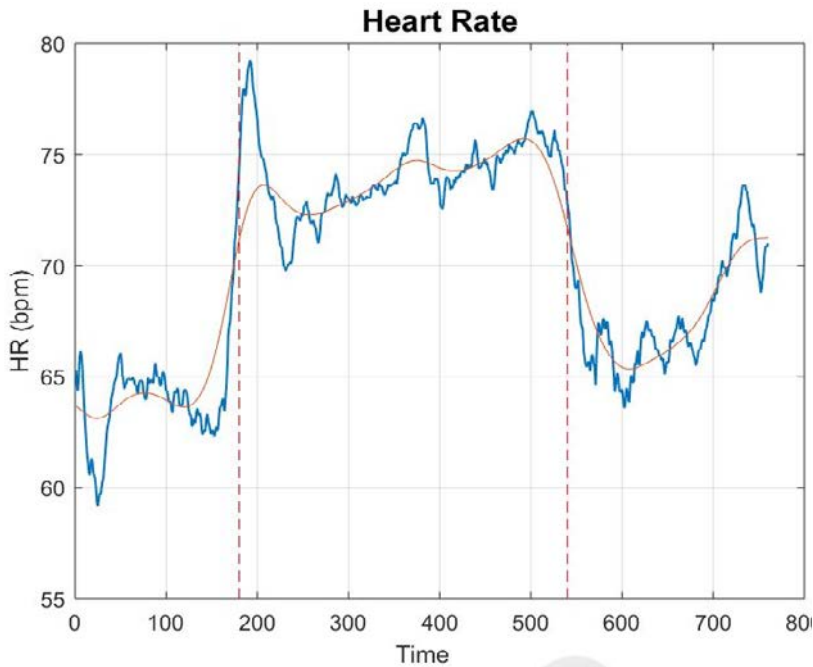


Stress (heart rate variability)

- RR intervals
- Frequency
- Nonlinear



Does stress affect physiological variables?



PURPLE **YELLOW** **RED**
BLACK **RED** **GREEN**

Rest

Stroop Test

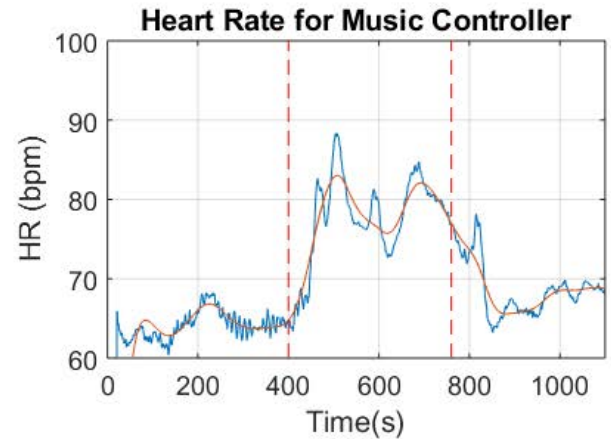
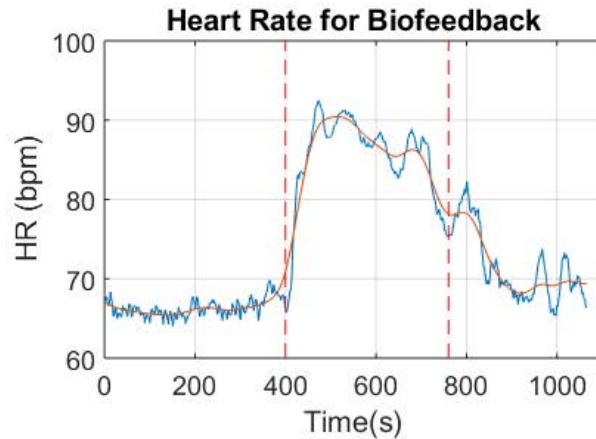
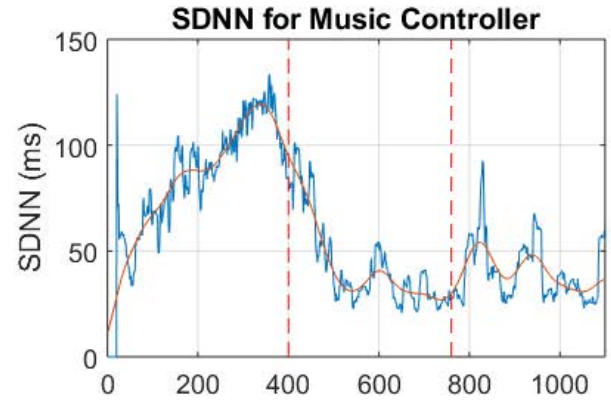
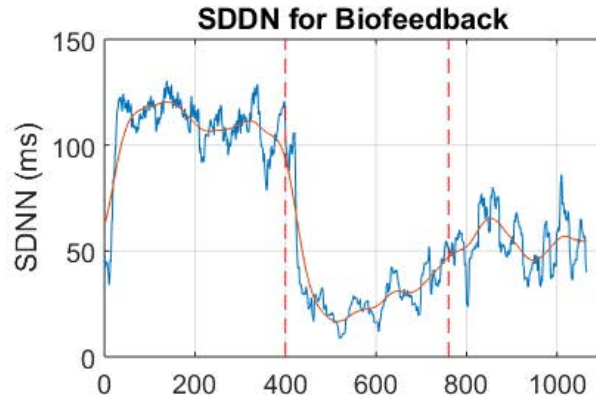
Rest



Some Results: PI Controller for Pitch

Errors in Stroop Test

Bio-feedback	Music Control
15.21%	7.69%



Feedback Control

vs.

Biofeedback

PURPLE YELLOW RED
BLACK RED GREEN

Stroop Test

Rest

Group Stress Reduction



Schoenbaum Family Center: A. Sophie Rogers School for Early Learning (OSU)

- Goal: Trauma-induced stress reduction in a preschool classroom
- Sensors: Watches, HRV, all children
- Actuators: Sound, light
- Algorithms for “adaptive ambience”

Abel Koury
Kelly Boone
Anneliese Johnson
Oliva Diaz Melgarejo
Hugo Gonzalez
Matt Lewis
Emre Ertin
Shelby Spare Werner

ADHD



10% of US
children have ADHD

Adults, also...



- EEG, sense focus
- Sustained attention task
- Goal: Learn to pay attention (ignore distractors/disturbances)

Agnibh Dey
Zhimin Chen
Morgan Ketchum
Hugo Gonzalez



Mood Disorders



Bipolar Disorder, NIMH:

- 2.8% adults last year (9.1 million people)
- 15 million, suicide after 15 years
- 1.1% of adult world (80 million people)

Depression, NIMH:

- 16 million adults had at least one major depressive episode in 2012.
- About 20K suicides/yr

World Health Organization (WHO):

- 350 million people worldwide suffer from depression.
- Leading cause of disability in world!





Mood disorders (BD, MDD):

1. Science well-studied, but few analytical studies of *dynamics*
2. Nonlinear dynamics, very complicated
3. Equilibria...

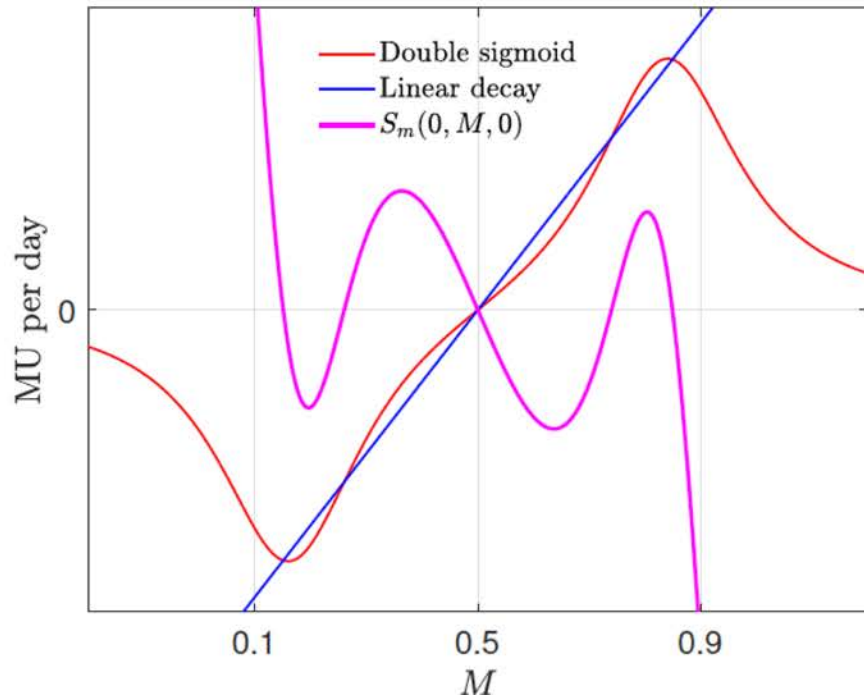


Hugo Gonzalez Villasanti

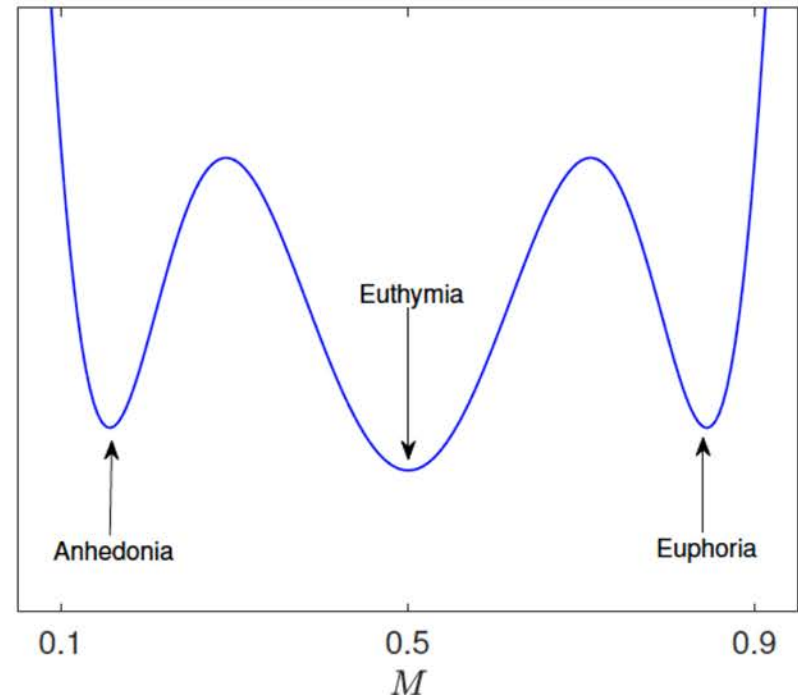
Mood disorders model:

$$\begin{aligned}\dot{D}(t) &= S_d(D, M, u_d) \\ \dot{M}(t) &= S_m(D, M, u_m)\end{aligned}$$

Mania map $S_m(0, M, 0)$



Integral of $S_m(0, M, 0)$





Lyapunov methods...

Theorem 1. Consider the one dimensional manic mood dynamics, given in Equation 4, and assume that

$$p_{m2}^2 < 4p_{m1}p_{m4}, \quad p_{m4} > 0. \tag{6}$$

If the bias parameter p_{m3} is such that

$$p_{m3}^2 < \frac{2}{27p_{m1}} \left(\sqrt{(12p_{m1}p_{m4} + p_{m2}^2)^3} - p_{m2} (36p_{m1}p_{m4} - p_{m2}^2) \right) \tag{7}$$

then the normal manic mood equilibrium point at $\bar{M} = n_m$ is globally exponentially stable.

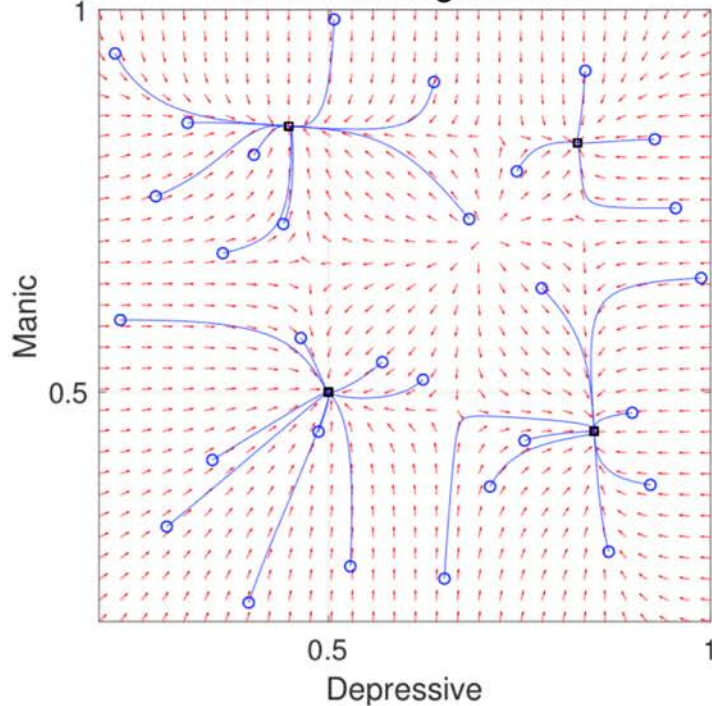
Psychological meaning:

(mood regulation rate) x (distress tolerance) >
(mood amplification)

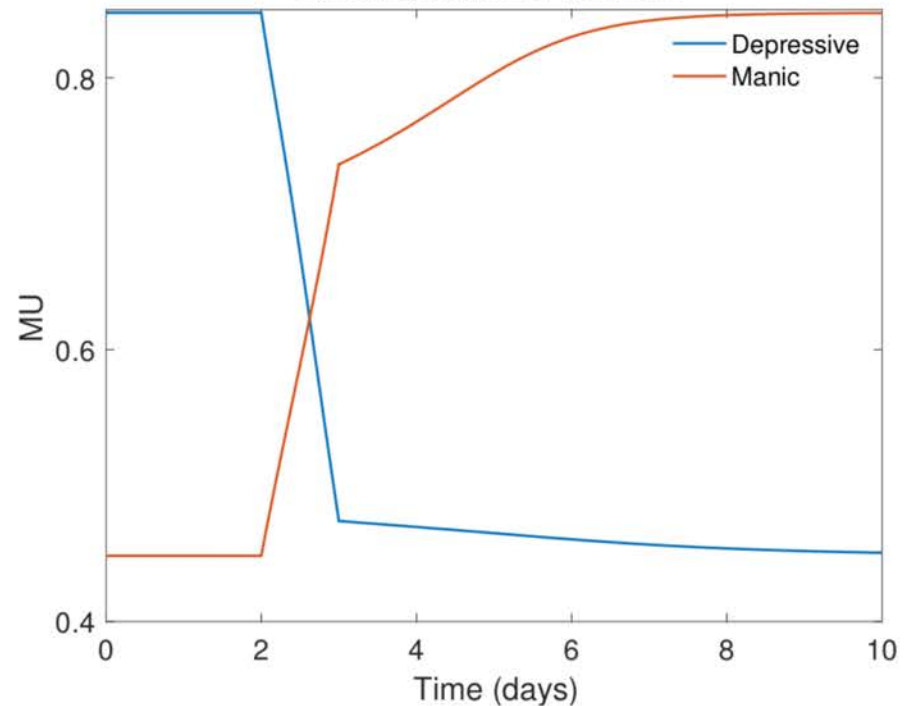
⇒ mood stabilizes to normal



Vector field diagram: BD-I



Mood shift in BD after AD



Current work:

- Expand, include other features
- Feedback controller development
- Technology implementation...



Evan Hamamoto
Eugene No
Sarah Matthiesen
Hugo Gonzalez



Summary:

Feedback control for:

- Alleviating poverty
- Improving mental health

Opportunities, challenges, impact?