STRESS

John Gabrieli
9.00
What stresses you?
STRESS

What stresses you?

exams, grades
deadlines
traffic
family relationships
life after college, etc., etc.
STRESS

What stresses you?

exams, grades
deadlines
traffic
family relationships
life after college, etc., etc.

What does not stress you?
STRESS

What stresses you?
- exams, grades
- deadlines
- traffic
- family relationships
- life after college, etc., etc.

What does not stress you?
- being eaten or eating another being
What stresses a zebra?

(Robert Saplosky, Why Zebras Don’t Get Ulcers)
What stresses a zebra?

- serious physical injury
- predators (lions)
- starvation
STRESS

- Psychological and physiological response to a stimulus (stressor) that alters the body's equilibrium
STRESS

Physical

Acute
injury

Psychological
deadline

Social

humiliation

Chronic
hunger, cancer

chronic work pressure

chronic isolation
STRESS

• for animals, stress is often acute, physical, responsive
• for people in industrial society, stress is often chronic, psychosocial, anticipatory
Neurobiological Substrates of Dread

- Berns 2006, Science
- fMRI and waiting for a cutaneous electrical shock to foot
- each trial starts with information about voltage level and amount of time
- at first 100% of trials had voltage
- choice phase, e.g., 90% voltage in 3 secs or 60% voltage in 27 secs
- some people prefer more voltage now than to wait for shock (extreme dreaders)
More Voltage (Pain) Associated with Greater Brain Activation

Source: Berns, G. S., et al. "Neurobiological Substrates of Dread." *Science*, 312, no. 5774 (2006): 754-58. © AAAS. All rights reserved. This content is excluded from our Creative Commons license. For more information, see [http://ocw.mit.edu/fairuse](http://ocw.mit.edu/fairuse).
Extreme Dreaders Had Earlier & More Sustained Activation Between Cue and Shock

Source: Berns, G. S., et al. "Neurobiological Substrates of Dread." *Science*, 312, no. 5774 (2006): 754-58. © AAAS. All rights reserved. This content is excluded from our Creative Commons license. For more information, see [http://ocw.mit.edu/fairuse](http://ocw.mit.edu/fairuse).
Mortality

• 1900?
Mortality

• 1900 - infectious diseases & childbirth
  pneumonia
  tuberculosis
  influenza (1918 - more than WWI)
  childbirth (young women)

• 2007?
Mortality

• 1900
  pneumonia
tuberculosis
influenza (1918 - more than WWI)
childbirth (young women)

• 2007 - cumulative damage
  heart disease
cancer
cerebrovascular disorders
STRESS

• Hans Selye - 1930s - insightful scientists, not so good at handling rats

Colleague extracted ovarian chemical - what does it do? - Selye injected rats daily - dropped them, ran around - several months later - peptic ulcers, enlarged adrenal glands, shrunken immune tissue - also in control rats - exposed rats to many stressors, all had the same result
STRESS

• The Stress Response is similar to a broad array of stressors

• if stressors go on for too long, they make you sick
STRESS & AUTONOMIC NERVOUS SYSTEM

• Sympathetic nervous system
  • brain to spine, organs, blood vessels, sweat glands, muscles and hairs (goosebumps)
  • emergency, arousal, activation
  • four Fs - flight, fright, fight, and sex
  • releases epinephrine/ norepinephrine (adrenaline/ noradrenaline)

• Parasympathetic nervous system
  sleep, eating, relaxation
<table>
<thead>
<tr>
<th></th>
<th>Sympathetic</th>
<th>Parasympathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>speeds up</td>
<td>slows down</td>
</tr>
<tr>
<td>Blood</td>
<td>to muscles</td>
<td>from muscles</td>
</tr>
</tbody>
</table>
STRESS & HORMONES

• hypothalamus
  releases CRH (corticotropin releasing hormone) to anterior pituitary
• anterior pituitary (15 sec)
  releases adrenocorticotropic hormone (ACTH) into blood
• adrenal glands (kidney) (few minutes)
  release glucocorticoids (steroids) (cortisol)
# The Stress Response and its Consequences

<table>
<thead>
<tr>
<th>Adaptive Stress-Response</th>
<th>Stress-Related Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mobilization of energy</td>
<td>• Myopathy, fatigue, diabetes</td>
</tr>
<tr>
<td>• Increased cardiovascular tone</td>
<td>• Stress-induced hypertension</td>
</tr>
<tr>
<td>• Suppression of digestion</td>
<td>• Ulceration, colitis</td>
</tr>
<tr>
<td>• Suppression of growth</td>
<td>• Psychogenic dwarfism</td>
</tr>
<tr>
<td>• Suppression of reproduction</td>
<td>• Amenorrhea, impotency, loss of libido</td>
</tr>
<tr>
<td>• Suppression of immune system</td>
<td>• Increased disease risk</td>
</tr>
<tr>
<td>• Sharpening of cognition</td>
<td>• Neuron death</td>
</tr>
</tbody>
</table>
# The Stress Response and its Consequences

<table>
<thead>
<tr>
<th>Adaptive Stress-Response</th>
<th>Stress-Related Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increased cardiovascular tone</td>
<td>• Stress-induced hypertension</td>
</tr>
<tr>
<td>• Increase heart rate</td>
<td>• Ventricular hypertrophy</td>
</tr>
<tr>
<td>• Increase blood pressure to muscle (and brain) away from digestive system</td>
<td>- (top predictor of cardiac arrest controlling for age)</td>
</tr>
<tr>
<td>• Decrease kidney function to keep water</td>
<td>• Damage to arteries</td>
</tr>
<tr>
<td>• Void the bladder</td>
<td>- Plaque formation</td>
</tr>
<tr>
<td></td>
<td>- Damaged inflamed blood vessels</td>
</tr>
</tbody>
</table>
## The Stress Response and its Consequences

<table>
<thead>
<tr>
<th>Adaptive Stress-Response</th>
<th>Stress-Related Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Suppression of digestion</td>
<td>• Ulceration, colitis</td>
</tr>
<tr>
<td></td>
<td>• Ulcer - hole in the wall of an organ</td>
</tr>
<tr>
<td></td>
<td>• Peptic (gastric, esophageal, duodenal)</td>
</tr>
<tr>
<td></td>
<td>- 1983</td>
</tr>
<tr>
<td></td>
<td>- Bacterium - heliobacter pylori swallowed/gastritis</td>
</tr>
<tr>
<td></td>
<td>- Antibiotic treatment</td>
</tr>
<tr>
<td></td>
<td>- But 15% of cases unrelated</td>
</tr>
<tr>
<td></td>
<td>- And only 10% with bacterium get ulcers</td>
</tr>
</tbody>
</table>
The Stress Response and its Consequences

Adaptive Stress-Response  Stress-related Disorder

• Suppression of growth          • Psychogenic dwarfism

• British Victorian family
• favorite son killed at 13
• Bereaved mother takes to bed
  - ignores 6 year-old son
• “David is that you? Oh, it is only you.”
• David was perfect
• 5ft as an adult
• J.M. Barrie writes Peter Pan
A child suffering from stress dwarfism: changes in appearance during hospitalization (left to right).

A Demonstration of the Sensitivity of Growth to Emotional State

<table>
<thead>
<tr>
<th>Condition</th>
<th>Growth hormone</th>
<th>Growth</th>
<th>Food intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Entry into hospital</td>
<td>5.9</td>
<td>0.5</td>
<td>1663</td>
</tr>
<tr>
<td>B. 100 days later</td>
<td>13.0</td>
<td>1.7</td>
<td>1514</td>
</tr>
<tr>
<td>C. Favorite nurse on vacation</td>
<td>6.9</td>
<td>0.6</td>
<td>1504</td>
</tr>
<tr>
<td>D. Nurse returns</td>
<td>15.0</td>
<td>1.5</td>
<td>1521</td>
</tr>
</tbody>
</table>

Source: From Saenger and colleagues, 1977. Growth hormone is measured in nanograms of the hormone per milliliter of blood following insulin stimulation; growth is expressed as centimeters per 20 days. Food intake is expressed in calories consumed per day.
mid 1950s
Meyer Friedman
Ray Rosenman
cardiology
practice

4/5 years later

TYPE A
PERSONALITY
STRESS

Type-A Personality

Friedman & Rosenman, 1960s
immensely competitive, over-achieving,
time-pressured, impatient, hostile
increased risk of cardiovascular disease
like smoking, or high cholesterol
STRESS

Type-A Personality

failures to replicate
applies to early age
key - hostility - many replications
suppressed expression
## The Stress Response and its Consequences

<table>
<thead>
<tr>
<th>Adaptive Stress-Response</th>
<th>Stress-related Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Mobilization of energy</td>
<td>• Myopathy, fatigue, diabetes</td>
</tr>
<tr>
<td>• Increased cardiovascular tone</td>
<td>• Stress-induced hypertension</td>
</tr>
<tr>
<td>• Suppression of digestion</td>
<td>• Ulceration, colitis</td>
</tr>
<tr>
<td>• Suppression of growth</td>
<td>• Psychogenic dwarfism</td>
</tr>
<tr>
<td>• Suppression of reproduction</td>
<td>• Amenorrhea, impotency, loss of libido</td>
</tr>
<tr>
<td>• Suppression of immune system</td>
<td>• Increased disease risk</td>
</tr>
<tr>
<td>• Sharpening of cognition</td>
<td>• Neuron death</td>
</tr>
</tbody>
</table>

(Sapolsky, 1992)
Neurons of the hippocampus of a rat. On the left: healthy neurons; on the right: neurons with their projections atrophied by sustained stress.
POST-TRAUMATIC STRESS DISORDER (PTSD)

- a severe anxiety disorder that can develop after exposure to any event which results in psychological trauma
- re-experience original trauma through flashbacks and dreams, increased arousal, hypervigilance
- assault/rape, combat
- sustained in about 20% of people
POST-TRAUMATIC STRESS DISORDER (PTSD)

- smaller hippocampal volumes in PTSD (some variability in results)
POST-TRAUMATIC STRESS DISORDER (PTSD)

• smaller hippocampal volumes in PTSD (some variability in results)

• cause or consequence?
POST-TRAUMATIC STRESS DISORDER (PTSD)

• smaller hippocampal volumes in PTSD (some variability in results)

• cause or consequence?

• twin study - correlation among monozygotic twins with and without combat exposure in hippocampal volume
Association between greater PTSD severity in combat-exposed twin and smaller hippocampal volume in both combat-exposed and non-combat exposed twin

POST-TRAUMATIC STRESS DISORDER (PTSD)

• prospective study
• Israeli military, 50 recruits before and after military service and stressful events
• increase in stress associated with greater amygdala and hippocampus response to stress-relate content
• amygdala reactivity before stress predicted increase in stress symptoms
• hippocampus change over time correlated with stress symptoms; content-specific
(A) Timeline (months) of the prospective imaging study.

Admon R et al. PNAS 2009;106:14120-14125

©2009 by National Academy of Sciences

Courtesy of Talma Hendler. Used with permission.
Psychological Modifiers of the Stress Response

- Outlets for frustration
- Sense of predictability and of control
- A perception of life improving
- Social support
Psychological Modifiers of the Stress Response

- Outlets for frustration (Jay Weiss)
  - rats receive mild shocks
  - prolonged stress response - heart rate up,
    glucocorticoid secretion up, ulcers
  - other rats can gnaw on wooden bar, or eat, or drink,
    or run on wheel - fewer ulcers
  - or run to another rat and bite it
  - baboons attack bystanders after losing a fight
Psychological Modifiers of the Stress Response

- Sense of predictability and of control
- Rats hear warning bell before shock - fewer ulcers - predictability (vs. unknown)
- Food delivered to rat at intermittent intervals vs. random delivery of equal food - glucocorticoid levels go up
- Rat given lever to avoid shocks - even if lever is disconnected to shocks, stress response is reduced
- People - noxious noises - one person has button to press to stop noise - less hypertensive whether button is pressed or not
- Occupational stress - high demand & low control
Psychological Modifiers of the Stress Response

- Sense of predictability and of control
  Rodin & Langer, 1977
- nursing home
  - group A - make decisions for yourself
    where to receive visitors
    when to watch movie
    what houseplant to take care of
  - group B - no instructions to make decisions
    got plant, but staff took care of plant

1.5 years later - group A more cheerful, active, and alert, healthier, half as many had died
Psychological Modifiers of the Stress Response

- Sense of predictability and of control

Cultural Influences

  Individualist - US/Europe
  Collectivist - East Asian (and rest of the world?)

Elementary school 7-9 year olds, Asian-American or Anglo-American - Ms. Smith - six markers (6 colors) - six piles of anagrams (family, animal, etc. RIBD)

Random assignment to 3 groups
  - you choose, teacher chooses, mother chooses
  - Anglo-Americans self = 4X Ms Smith, 2.5X mother
  - Asian-Americans - 30% more for mother than self, 2X than Ms Smith
Psychological Modifiers of the Stress Response

• Sense of predictability and of control

life and death struggle

Richter, 1957
Water temperature and endurance
Rats in a jar - how long does rat swim before drowning?
15 minutes-60 hours before giving up, much variation

Picked up rats, let them wriggle free, in and out of water,
Average of 60 hours of effort
Psychological Modifiers of the Stress Response

• Social support

• Primates - after stress response, among strangers - worse; among friends - better (measured by glucocorticoids)

• People - stressor (public speaking, math task, argument with strangers) - less cardio-vascular response with a supportive friend present

• Observations - people with spouses/close friends live longer; when spouse dies, risk of dying increases; parents of children killed in war have higher risk of disease/mortality only if divorced/widowed; patients with severe coronary disease had 3x death rate over 5 years if lacking social support
Psychological Modifiers of the Stress Response

- A perception of life improving (worsening)
- rats/shocks - rat #1 - 10/hr; rat #2 - 50/hr;
  Day 2 - all rats get 25/hr; 10-25 becomes hypertensive
Risk of Ulcer

- Shock alone
- + another rat
- + wood bar
- + warning signal
- + lever
- 50 → 25 shocks
- + friends
Embodied Cognition

• the nature of the human mind largely determined by the form of the human body
• ideas, thoughts, concepts, categories shaped by aspects of the body
• is emotional pain (social, romantic rejection) built out of physical pain?
Pain

sensory - objective

affective - subjective (suffering, unpleasantness)
Pain Processing

cingulate
somatosensory cortex

© source: unknown. All rights reserved. This content is excluded from our Creative Commons license. For more information, see http://ocw.mit.edu/fairuse.
Hypnotic Suggestion of High or Low Pain

Source: Rainville, P., et al. "Pain Affect Encoded in Human Anterior Cingulate but not Somatosensory Cortex." *Science* 277, no. 5328 (1997): 968-71. © AAAS. All rights reserved. This content is excluded from our Creative Commons license. For more information, see http://ocw.mit.edu/fairuse.
Methodology and results from an fMRI study of social exclusion. (a) Example of what participants viewed while in the scanner. Participants were included in the ball-tossing game during one round and excluded during another. (b) Participants showed increased dorsal anterior cingulate cortex (dACC) activity during the exclusion compared with the inclusion episode. (c) Participants’ levels of self-reported distress correlated highly with dACC activity during the exclusion episode compared with the inclusion episode.

Romantic Pain

• Physical pain (heat)
• Romantic pain/social rejection
• Participants “felt intensely rejected as a result of recently experiencing an unwanted romantic relationship break-up”
• Viewed pictures of ex-partners and thought about being rejected (vs. viewing pictures of friends and thinking about positive experiences)
Neural overlap between social rejection & physical pain

Copyright (2011) National Academy of Sciences, U.S.A. Used with permission.

Kross E et al. PNAS 2011;108:6270-6275
Pain of Social Rejection

- random assignment
  - 2000 mg acetaminophen (Tylenol, Excedrin) for 3 weeks
  - placebo
  - provide daily reports
  - by Day 15, less painful response to rejection
  - less brain response to social rejection
Stereotype Threat

threat that others' judgments or one's own actions will confirm negative stereotypes about one's group

stress from stereotype knowledge undermines performance

DEMO
<table>
<thead>
<tr>
<th>Unpleasant</th>
<th>Pleasant</th>
</tr>
</thead>
<tbody>
<tr>
<td>abuse</td>
<td>caress</td>
</tr>
<tr>
<td>crash</td>
<td>freedom</td>
</tr>
<tr>
<td>filth</td>
<td>health</td>
</tr>
<tr>
<td>murder</td>
<td>love</td>
</tr>
<tr>
<td>sickness</td>
<td>peace</td>
</tr>
<tr>
<td>accident</td>
<td>cheer</td>
</tr>
<tr>
<td>death</td>
<td>friend</td>
</tr>
<tr>
<td>grief</td>
<td>heaven</td>
</tr>
<tr>
<td>poison</td>
<td>loyal</td>
</tr>
<tr>
<td>stink</td>
<td>pleasure</td>
</tr>
<tr>
<td>assault</td>
<td>diamond</td>
</tr>
<tr>
<td>disaster</td>
<td>gentle</td>
</tr>
<tr>
<td>Black Americans</td>
<td>White Americans</td>
</tr>
<tr>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>ALONZO</td>
<td>ADAM</td>
</tr>
<tr>
<td>JAMEL</td>
<td>CHIP</td>
</tr>
<tr>
<td>LERONE</td>
<td>HARRY</td>
</tr>
<tr>
<td>THEO</td>
<td>ALAN</td>
</tr>
<tr>
<td>JEROME</td>
<td>FRANK</td>
</tr>
<tr>
<td>LEROY</td>
<td>IAN</td>
</tr>
<tr>
<td>DARNELL</td>
<td>JUSTIN</td>
</tr>
<tr>
<td>LAMAR</td>
<td>FRED</td>
</tr>
<tr>
<td>RASHAUN</td>
<td>JED</td>
</tr>
<tr>
<td>DEION</td>
<td>TODD</td>
</tr>
<tr>
<td>LAMONT</td>
<td>HANK</td>
</tr>
<tr>
<td>MALIK</td>
<td>WILBUR</td>
</tr>
</tbody>
</table>
LEFT for Unpleasant

cancer
health
corpse
diamond
truth
death
assault
triumph
glory

RIGHT for Pleasant

brutal
talent
agony
kindness
family
divorce
stink
peace
torture
LEFT for BLACK

ALONZO
JAMEL
ADAM
LERONE
HARRY
CHIP
MALIK
TODD
LEROY
DARNELL
JUSTIN
FRED
LAMAR
HANK
DEION
FRANK
JED
RASHAUN

RIGHT for WHITE
LEFT
for Unpleasant or BLACK

FRANK
devil
ANDREW
diamond
MALIK
health
TYRONE
triumph
BRAD
brutal
RASHAUN
agony
HARRY
family
JACK
beauty
LAMAR
stink

RIGHT
for Pleasant or WHITE
LEFT for WHITE

RASHAUN
DARNELL
JUSTIN
FRED
LAMAR
HANK
DEION
FRANK
JED
ALONZO
JAMEL
ADAM
LERONE
HARRY
CHIP
MALIK
TODD
LEROY

RIGHT for BLACK
cancer
LAMAR
corpse
MATTHEW
truth
JED
assault
DEION
glory
JONATHAN
talent
LAMONT
kindness
JAMEL
divorce
TERRYL
peace
JUSTIN

LEFT
for
Unpleasant
or
WHITE

RIGHT
for
Pleasant
or
BLACK
• faster for “unpleasant or black” than “unpleasant or white”?
IMPLICIT ASSOCIATION TEST (IAT)

- faster for white + pleasant than black + pleasant? 75% of whites; 50% of blacks

- automatic stereotypes?
  - attitudes vs. associations?

- many domains - aging, techies vs. fuzzies/in-group vs. outgroup

- https://implicit.harvard.edu/implicit/
IMPACT OF INTERRACIAL CONTACT ON EXECUTIVE FUNCTION

• Richeson et al., 2003
• White individuals completed IAT
• Go to a different room, interact with either black or white experimenter, videotaped comments on college fraternity system and racial profiling after 9/11
• Go back and perform Stroop task
• Measure interference (incompatible (BLUE) minus control (BLUE) trials)
Fig. 1. Predicted Stroop interference as a function of Implicit Association Test (IAT) bias, after interaction with a White or Black partner.

Source: Richeson, J., and J. Shelton. "When Prejudice Does Not Pay: Effects of Interracial Contact on Executive Function." *Psychological Science* 14, no. 3 (2003): 287-90. © Sage publications. All rights reserved. This content is excluded from our Creative Commons license. For more information, see [http://ocw.mit.edu/fairuse](http://ocw.mit.edu/fairuse).
The Yerkes-Dodson Law
