

STRESS

John Gabrieli

9.00

STRESS

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

STRESS

What stresses a zebra?

(Robert Saplosky, *Why Zebras Don't Get Ulcers*)

STRESS

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

	<u>Acute</u>	<u>Chronic</u>
<u>Physical</u>	injury	hunger, cancer
<u>Psychological</u>	deadline	chronic work pressure
<u>Social</u>	humiliation	chronic isolation

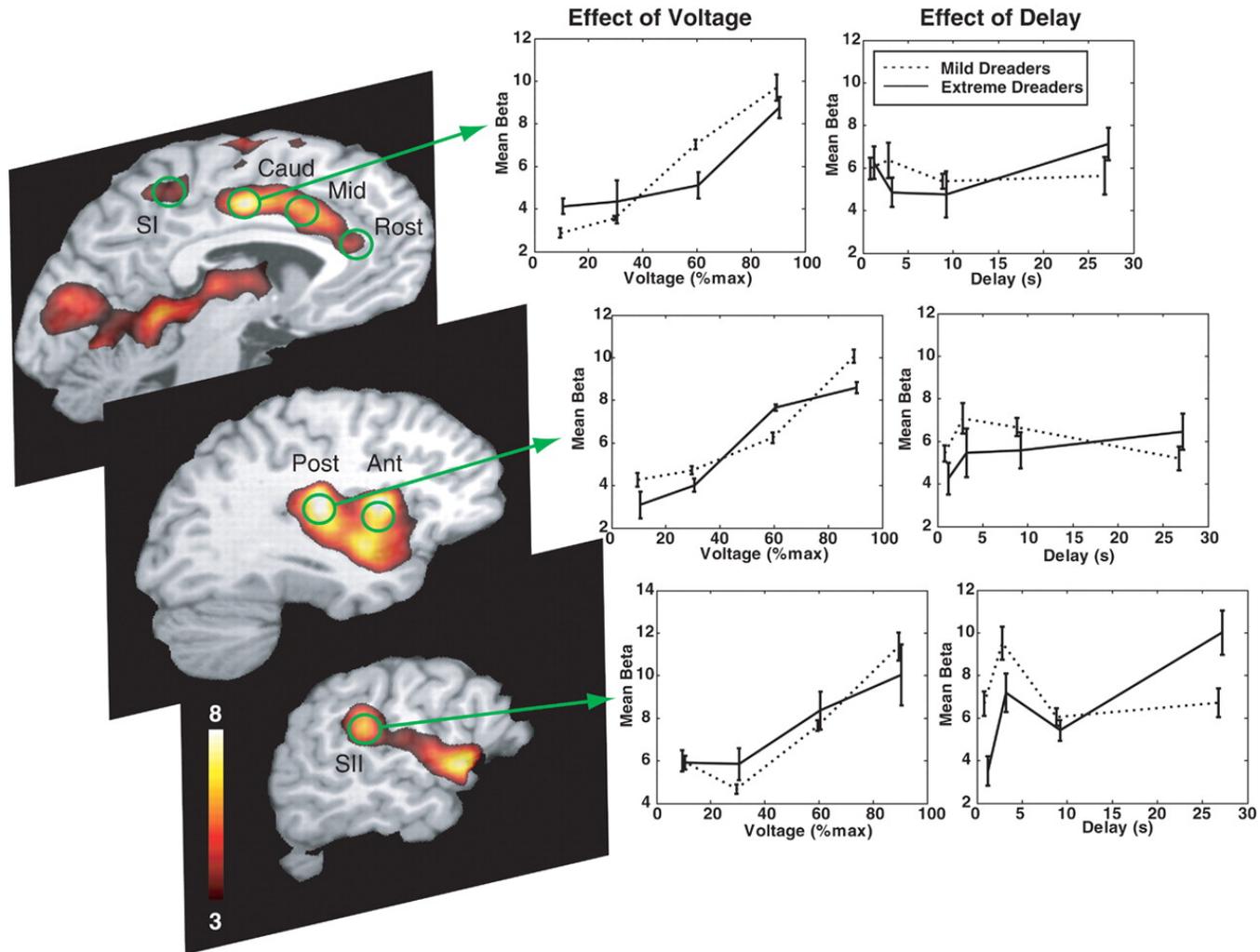
STRESS

- for animals, stress is often acute, physical, responsive
- for people in industrial society, stress is often chronic, psychosocial, anticipatory

Neurobiological Substrates of Dread

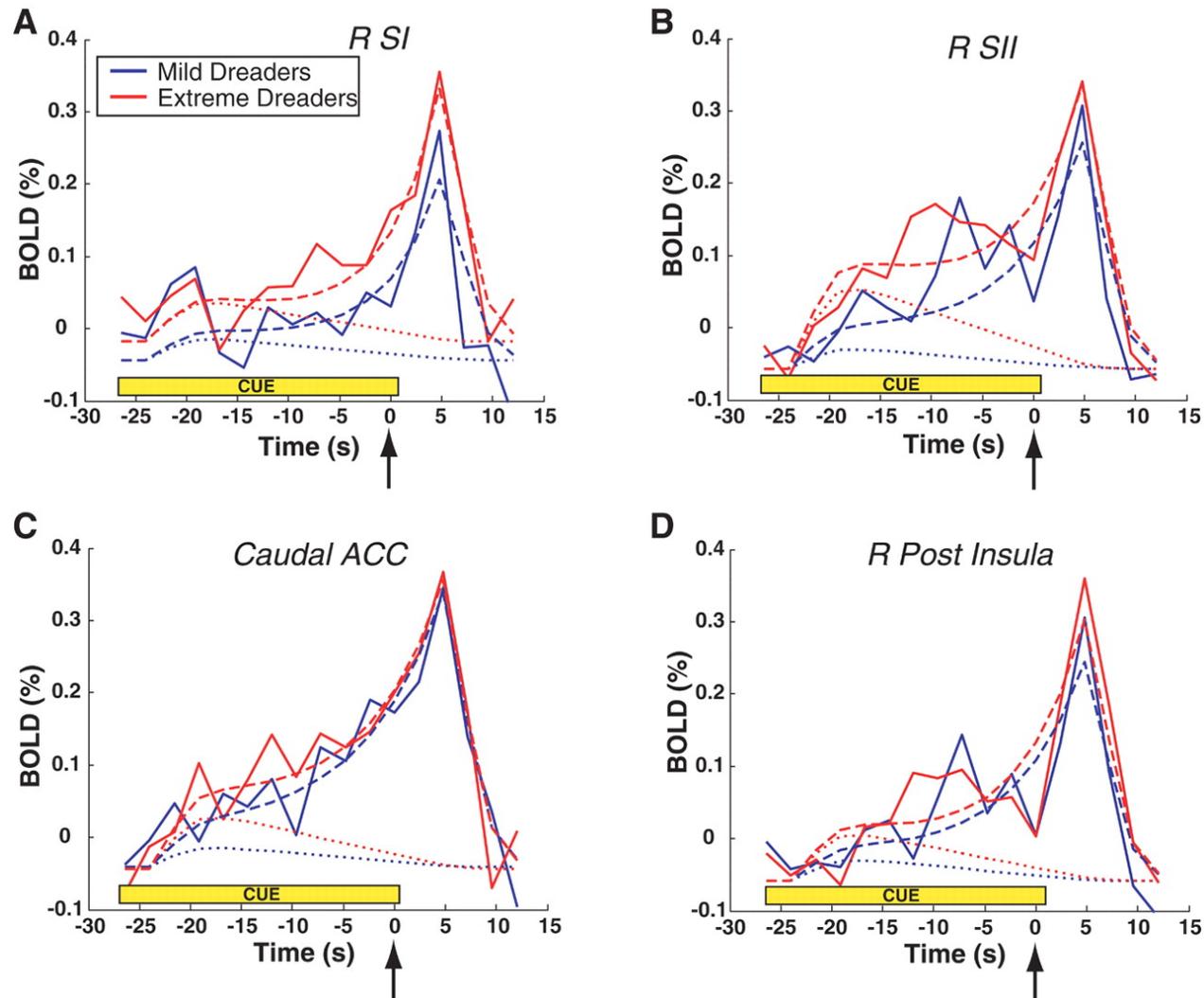
- Berns 2006, *Science*
- fMRI and waiting for a cutaneous electrical shock to foot
- each trial starts with information about voltage level and amount of time
- at first 100% of trials had voltage
- choice phase, e.g., 90% voltage in 3 secs or 60% voltage in 27 secs
- some people prefer more voltage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

More Voltage (Pain) Associated with Greater Brain Activation



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Extreme Dreaders Had Earlier & More Sustained Activation Between Cue and Shock



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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

STRESS & AUTONOMIC NERVOUS SYSTEM

	<u><i>Sympathetic</i></u>	<u><i>Parasympathetic</i></u>
<i>Heart</i>	speeds up	slows down
<i>Blood</i>	to muscles	from muscles

STRESS & HORMONES

- hypothalamus
 - releases CRH (corticotropin releasing hormone) to anterior pituitary
- anterior pituitary (15 sec)
 - releases adrenocorticotrophic hormone (ACTH) into blood
- adrenal glands (kidney) (few minutes)
 - release glucocorticoids (steroids) (cortisol)

The Stress Response and its Consequences

Adaptive Stress-Response

- Mobilization of energy
- Increased cardiovascular tone
- Suppression of digestion
- Suppression of growth
- Suppression of reproduction
- Suppression of immune system
- Sharpening of cognition

Stress-Related Disorder

- Myopathy, fatigue, diabetes
- Stress-induced hypertension
- Ulceration, colitis
- Psychogenic dwarfism
- Amenorrhea, impotency, loss of libido
- Increased disease risk
- Neuron death

The Stress Response and its Consequences

Adaptive Stress-Response

- Increased cardiovascular tone
- Increase heart rate
- Increase blood pressure to muscle (and brain) away from digestive system
- Decrease kidney function to keep water
- Void the bladder

Stress-Related Disorder

- Stress-induced hypertension
- Ventricular hypertrophy
 - (top predictor of cardiac arrest controlling for age)
- Damage to arteries
 - Plaque formation
 - Damaged inflamed blood vessels



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The Stress Response and its Consequences

Adaptive Stress-Response

- Suppression of digestion

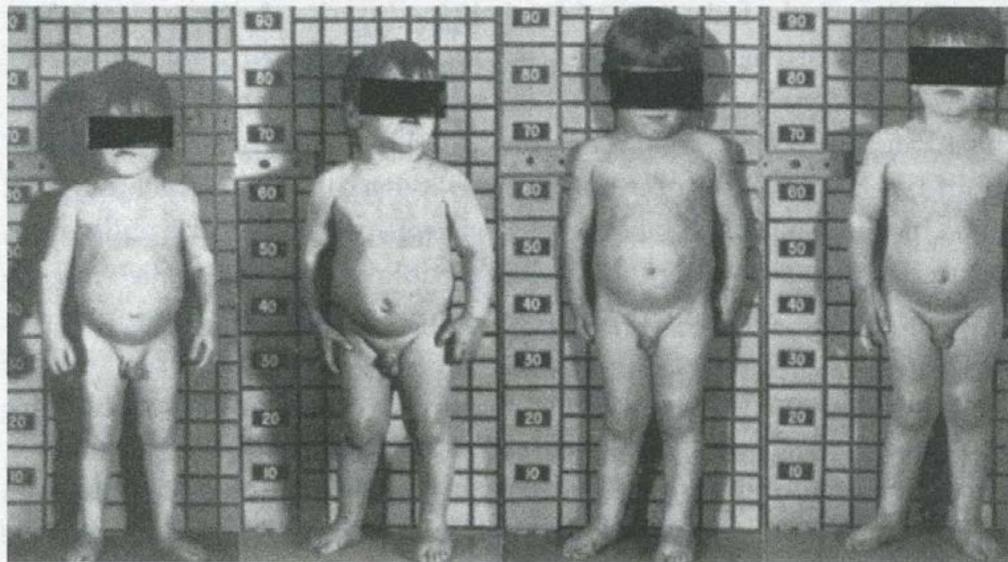
Stress-Related Disorder

- Ulceration, colitis
- Ulcer – hole in the wall of an organ
- Peptic (gastric, esophageal, duodenal)
 - Robert Warren/Barry Marshall/2005 Nobel
- – 1983
 - Bacterium – *heliobacter pylori* swallowed/gastritis
 - Antibiotic treatment
 - But 15% of cases unrelated
 - And only 10% with bacterium get ulcers

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

Condition	Growth hormone	Growth	Food intake
A. Entry into hospital	5.9	0.5	1663
B. 100 days later	13.0	1.7	1514
C. Favorite nurse on vacation	6.9	0.6	1504
D. Nurse returns	15.0	1.5	1521

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

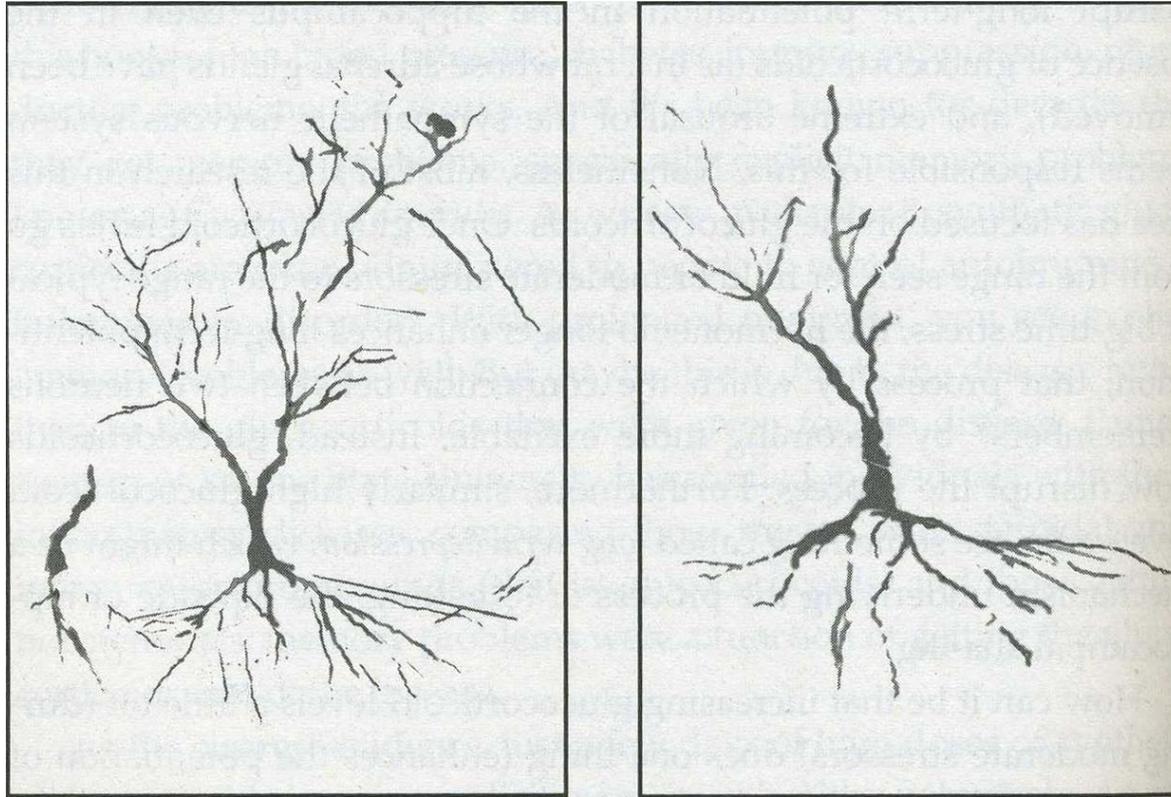
The Stress Response and its Consequences

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- Neuron death



Neurons of the hippocampus of a rat. On the left: healthy neurons; on the right: neurons with their projections atrophied by sustained stress.

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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)

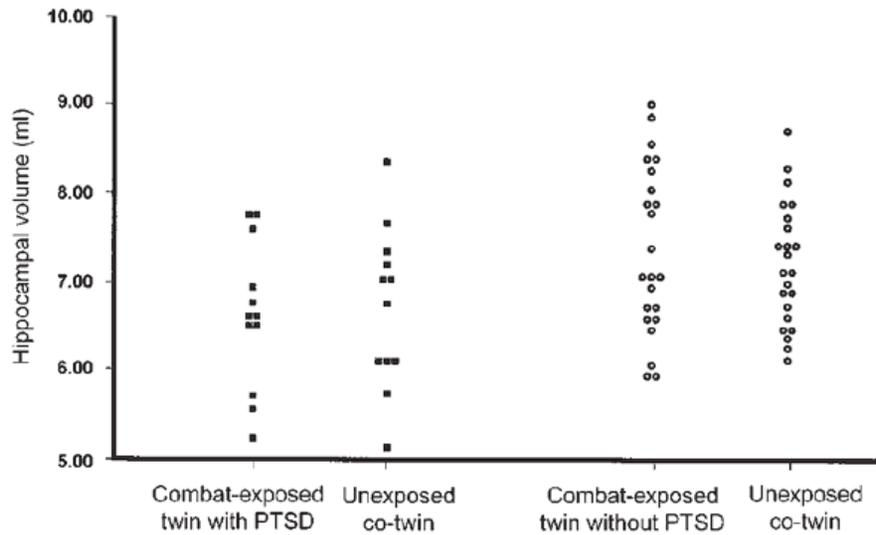
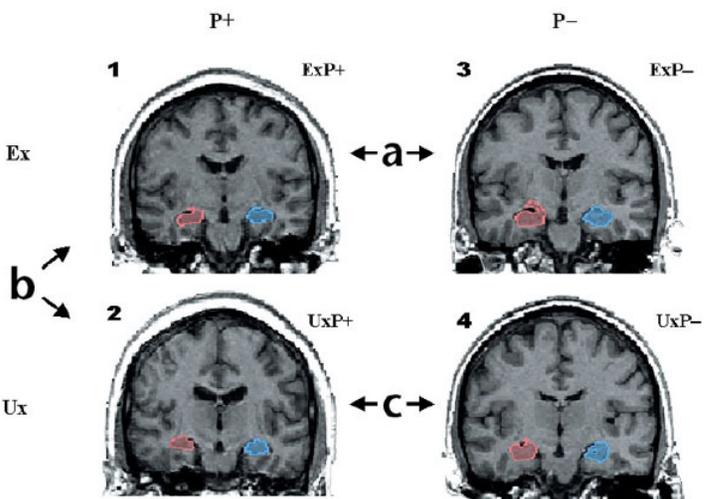
- smaller hippocampal volumes in PTSD (some variability in results)

POST-TRAUMATIC STRESS DISORDER (PTSD)

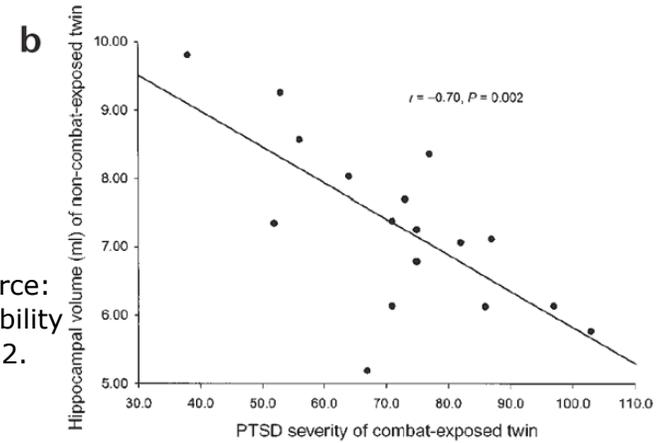
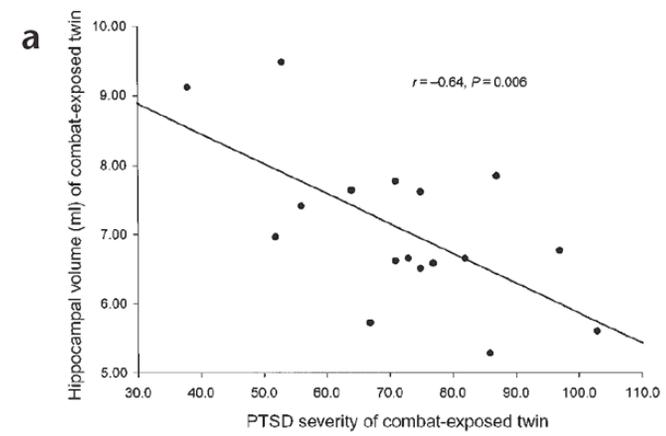
- smaller hippocampal volumes in PTSD (some variability in results)
- cause or consequence?

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

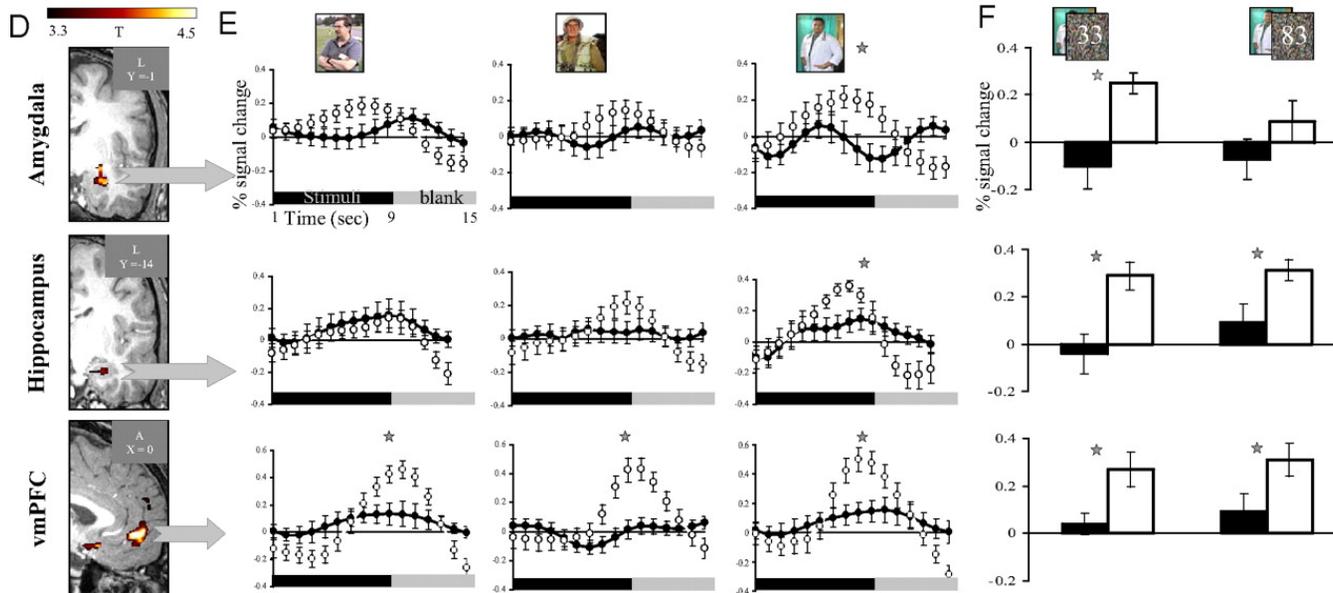
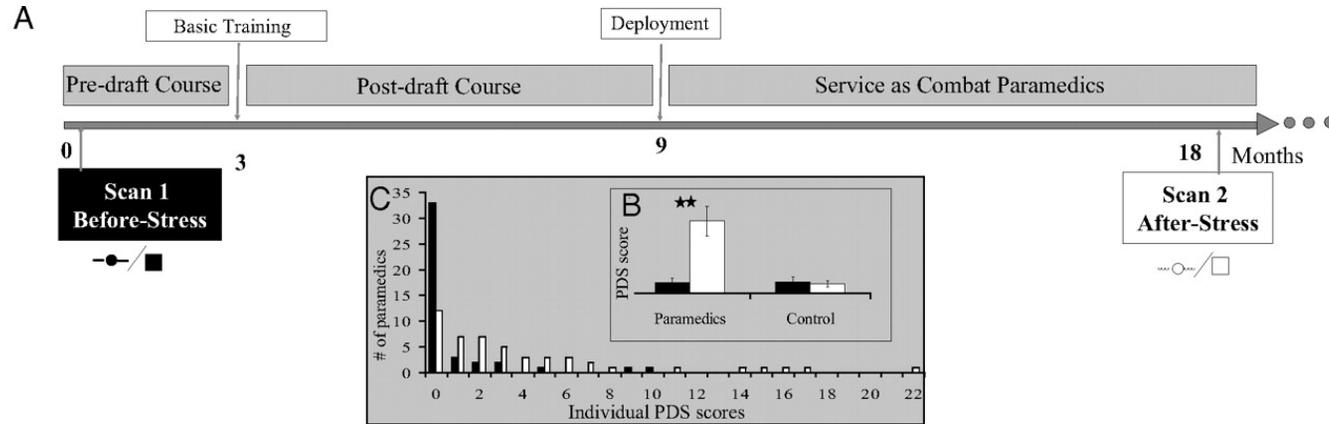


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POST-TRAUMATIC STRESS DISORDER (PTSD)

- 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-related 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

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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

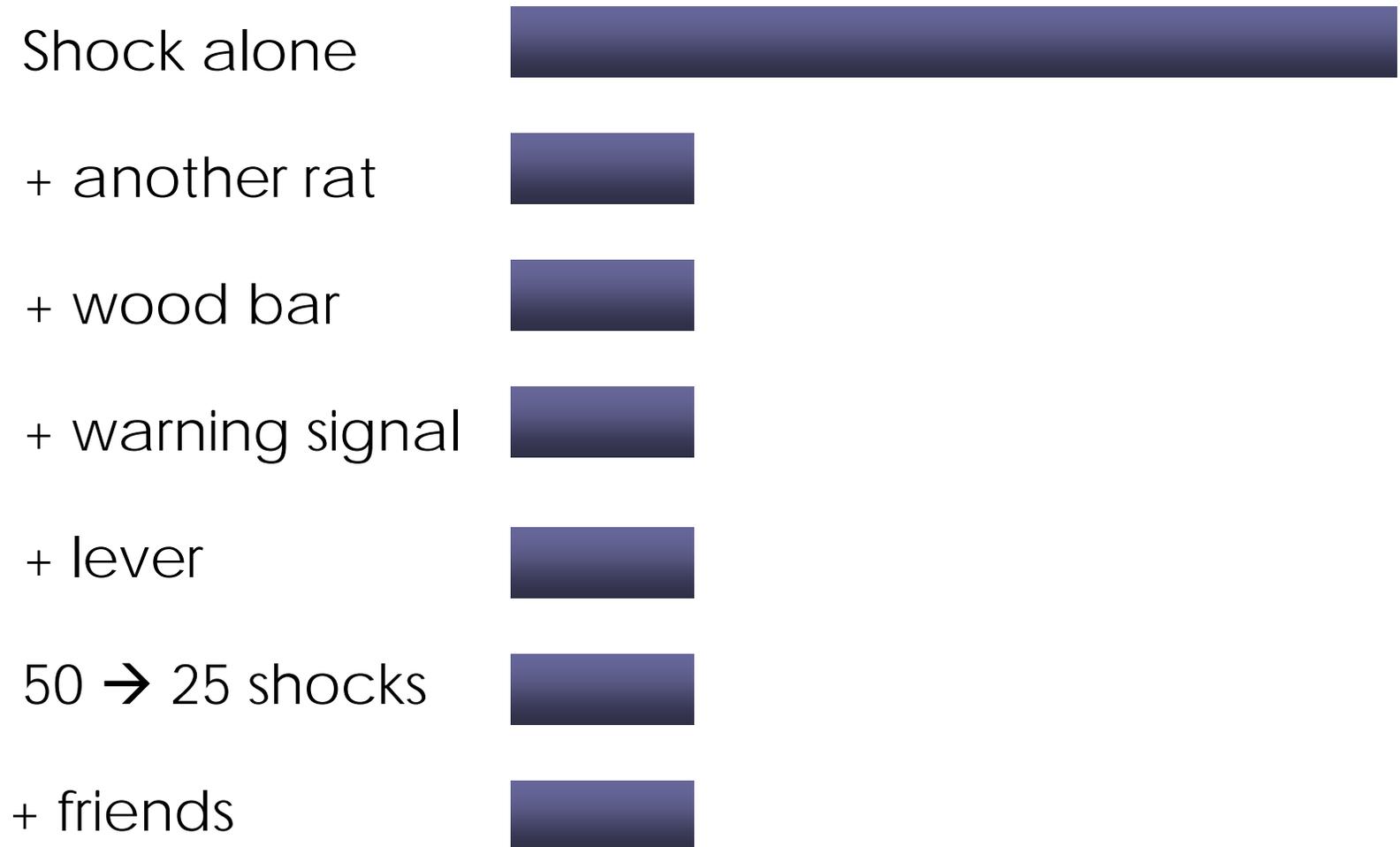
- *Social support*
- Primates - after stress response, among strangers - worse; among friends - better (measured by glucocorticoids)
- People - stressor (public speaking, math task, argument with strangers) - less cardio-vascular response with a supportive friend present
- Observations - people with 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



Embodied Cognition

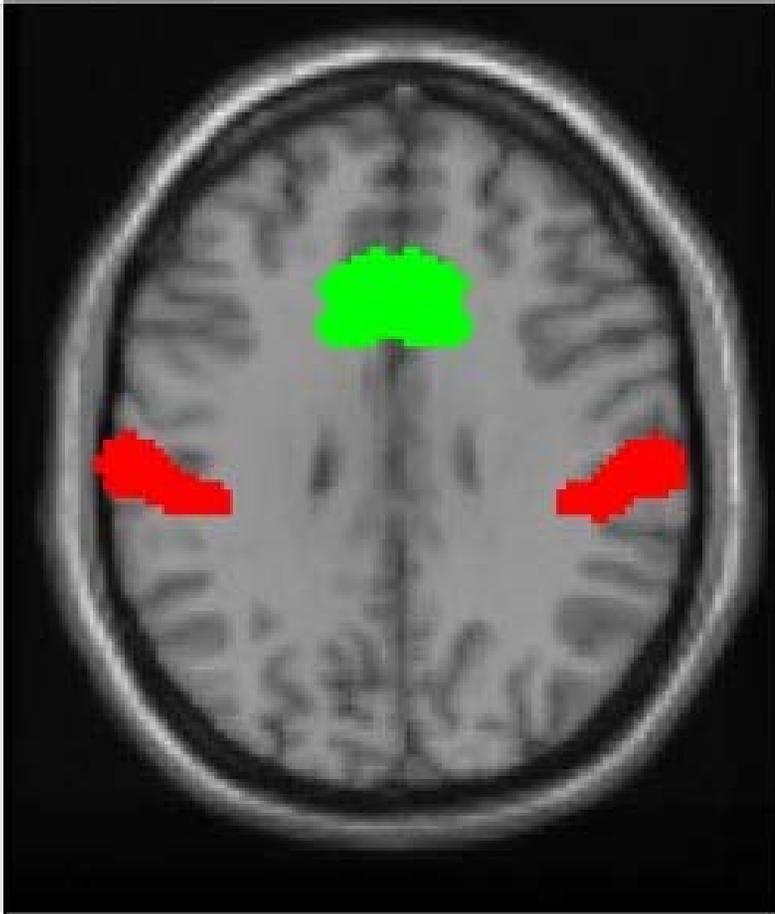
- the nature of the human *mind* largely determined by the *form* of the human body
- ideas, thoughts, concepts, categories shaped by aspects of the body
- is *emotional pain* (social, romantic rejection) built out of *physical pain*?

Pain

sensory - objective

affective - subjective (suffering,
unpleasantness)

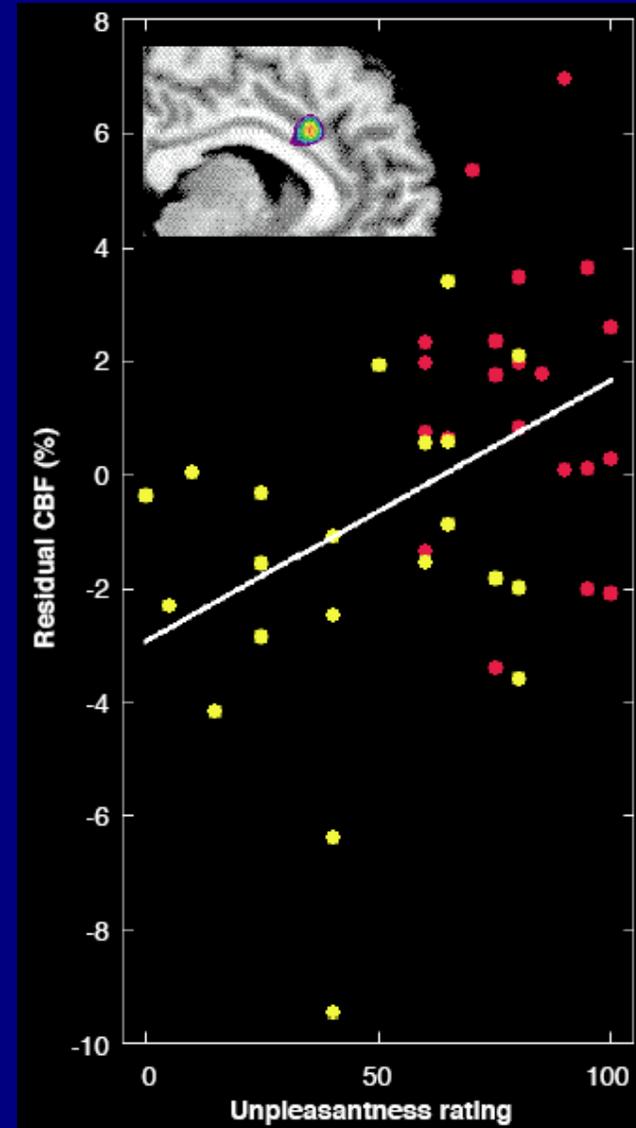
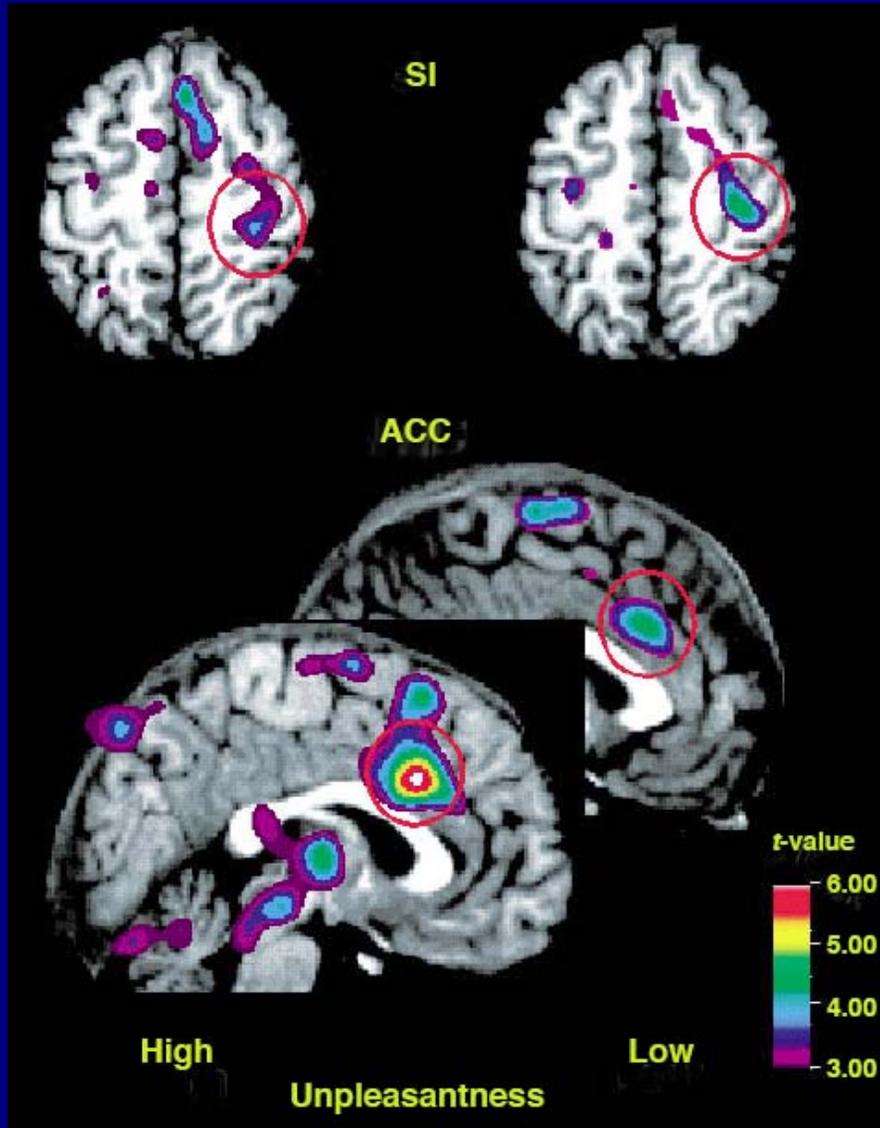
Pain Processing



- cingulate
- somatosensory cortex

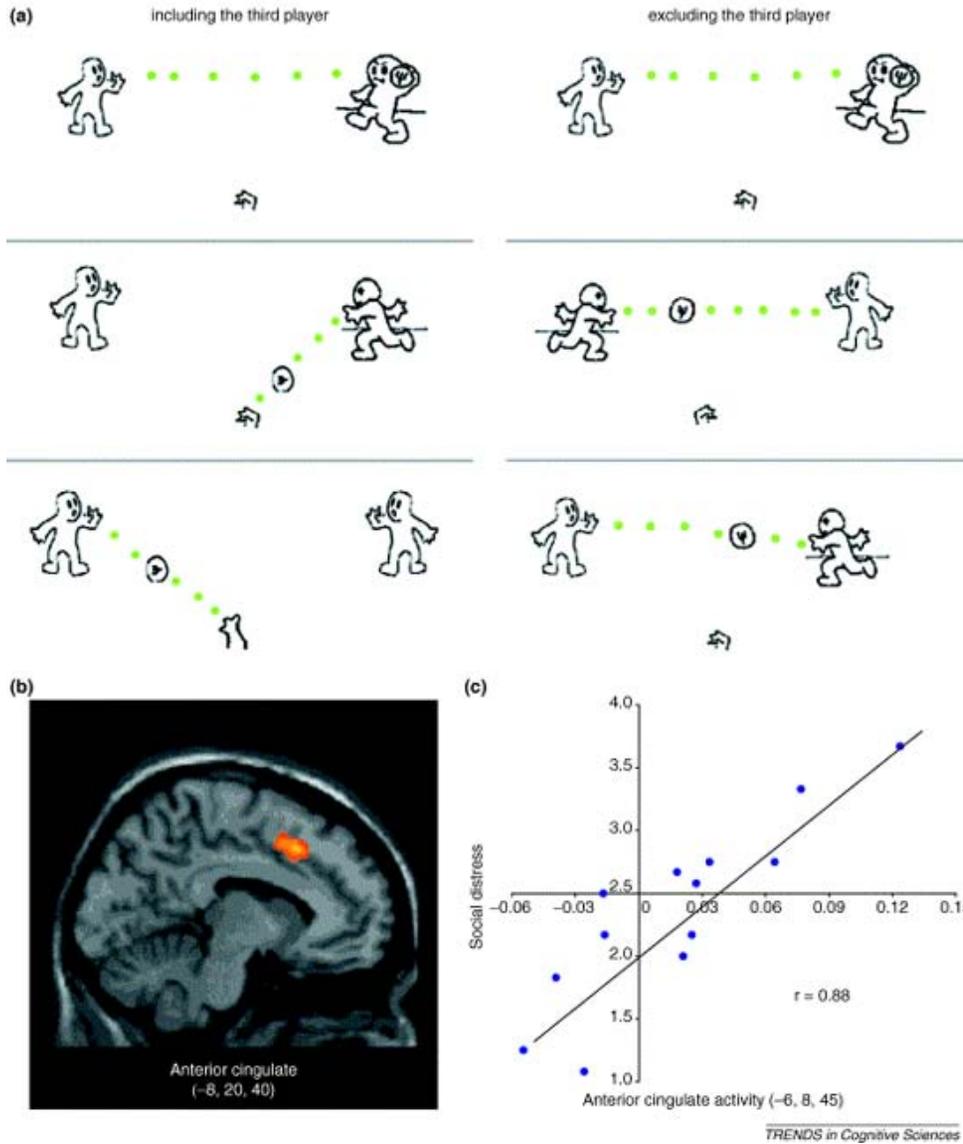
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Hypnotic Suggestion of High or Low Pain



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>.

Social Pain



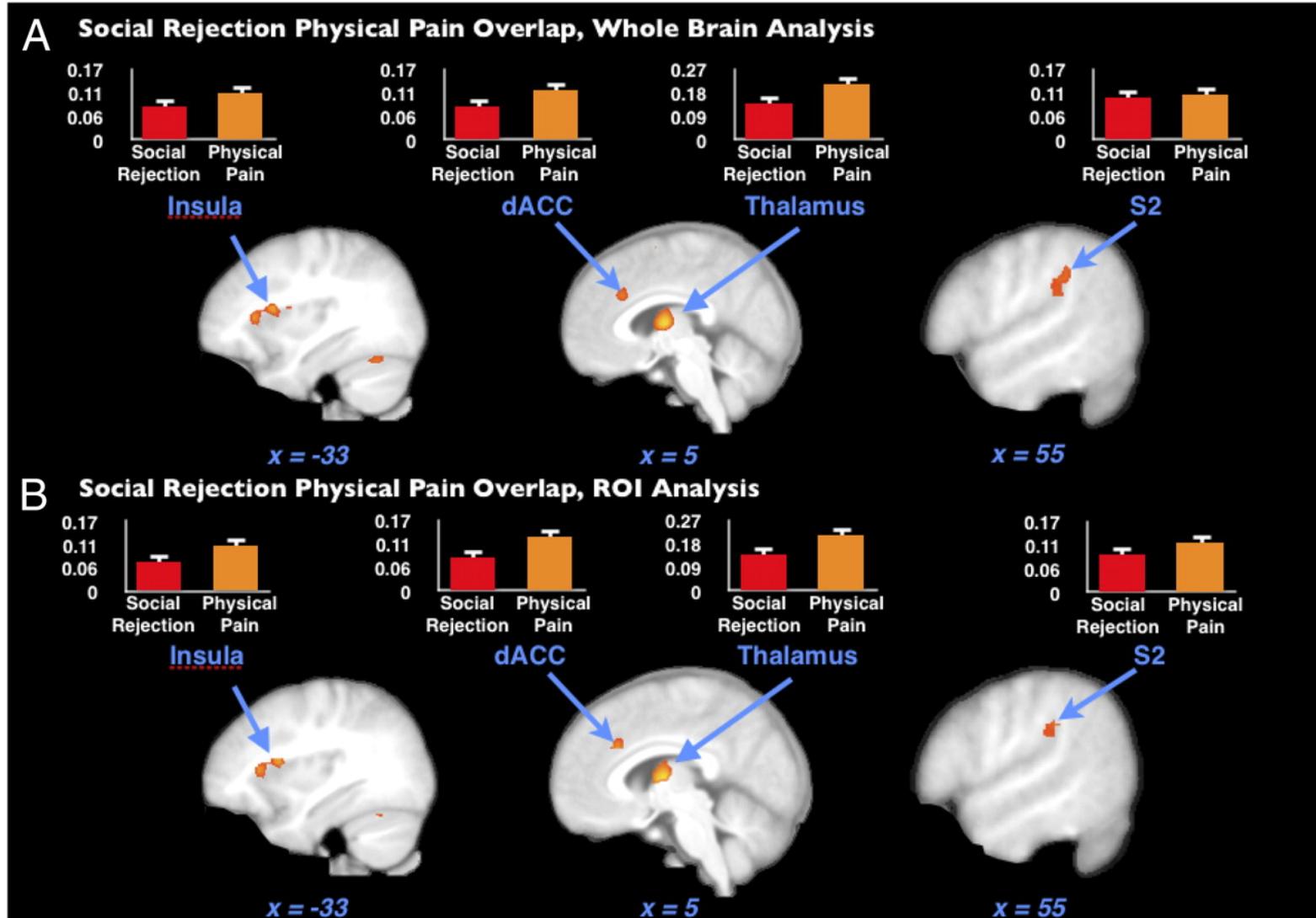
Methodology and results from an fMRI study of social exclusion. **(a)** Example of what participants viewed while in the scanner. Participants were included in the ball-tossing game during one round and excluded during another. **(b)** Participants showed increased dorsal anterior cingulate cortex (dACC) 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.

Source: Eisenberger, N. I., and M. D. Lieberman. "Why Rejection Hurts: A Common Neural Alarm System for Physical and Social Pain." *Trends in Cognitive Sciences* 8, no. 7 (2004): 294-300. Courtesy of Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

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



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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

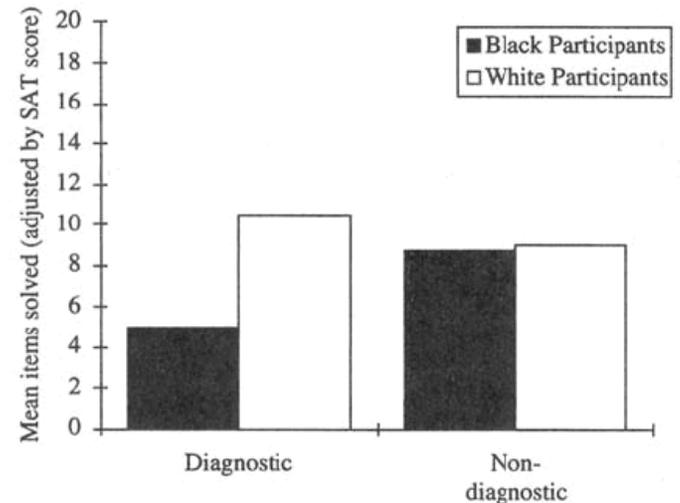
Stereotype Threat

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

stress from stereotype knowledge undermines performance

Figure 2

Mean Performance on a Difficult Verbal Test as a Function of Race and Test Characterization



Note. SAT = Scholastic Assessment Test.

Source: Steele, Claude M. "A Threat in the Air: How Stereotypes Shape Intellectual Identity and Performance." *American Psychologist* 52, no. 6 (1997): 613-29. Courtesy of American Psychological Association. Used with permission.

DEMO

Unpleasant

abuse
crash
filth
murder
sickness
accident
death
grief
poison
stink
assault
disaster

Pleasant

caress
freedom
health
love
peace
cheer
friend
heaven
loyal
pleasure
diamond
gentle

Black Americans

ALONZO
JAMEL
LERONE
THEO
JEROME
LEROY
DARNELL
LAMAR
RASHAUN
DEION
LAMONT
MALIK

White Americans

ADAM
CHIP
HARRY
ALAN
FRANK
IAN
JUSTIN
FRED
JED
TODD
HANK
WILBUR

**LEFT
for
Unpleasant**

**cancer
health
corpse
diamond
truth
devil
assault
triumph
glory
brutal
talent
agony
kindness
family
divorce
stink
peace
torture**

**RIGHT
for
Pleasant**

**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
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CHIP
MALIK
TODD
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**RIGHT
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**cancer
LAMAR
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MATTHEW
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assault
DEION
glory
JONATHAN
talent
LAMONT
kindness
JAMEL
divorce
TERRYL
peace
JUSTIN**

**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))

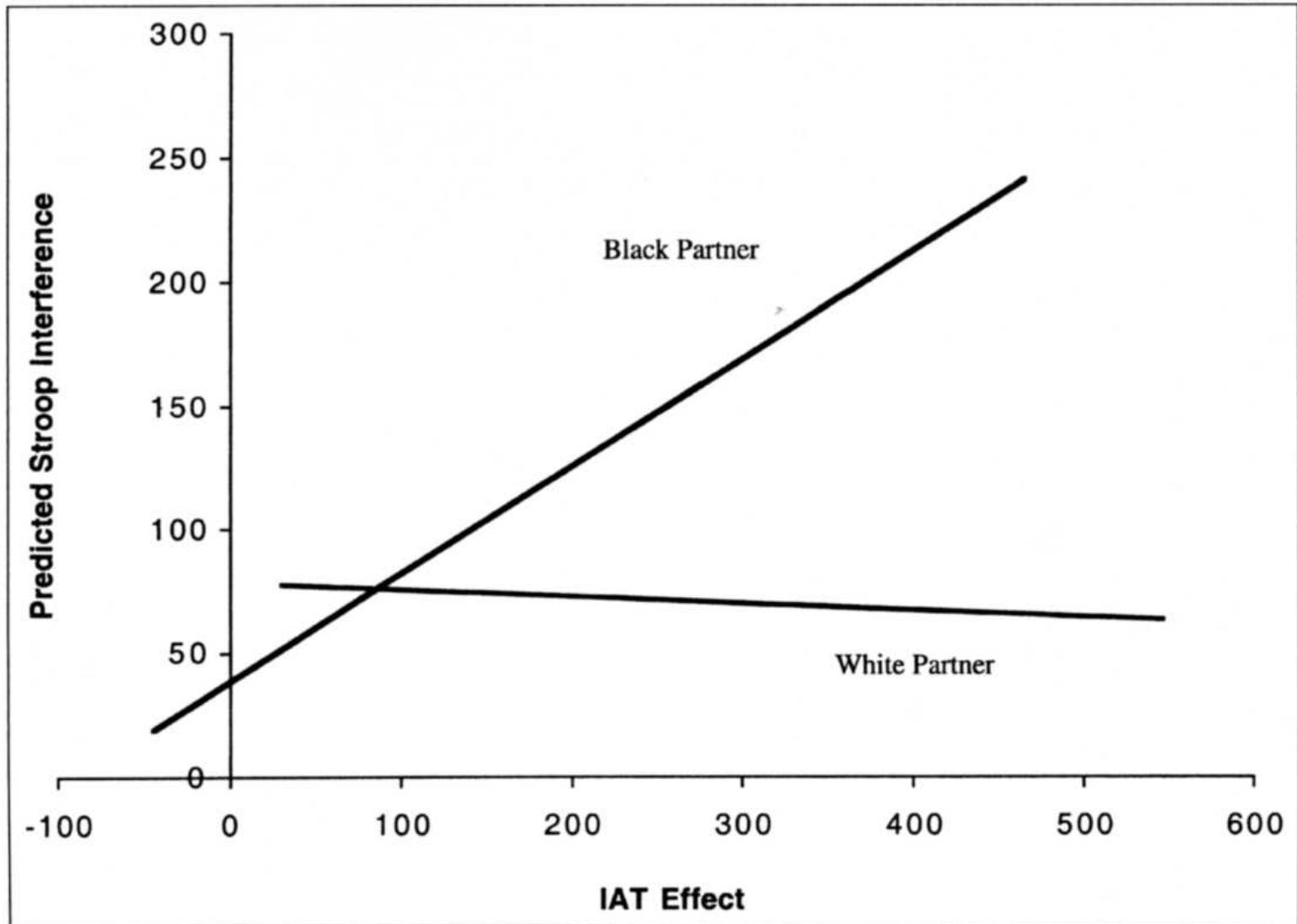


Fig. 1. Predicted Stroop interference as a function of Implicit Association Test (IAT) bias, after interaction with a White or Black partner.

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>.

The Yerkes-Dodson Law

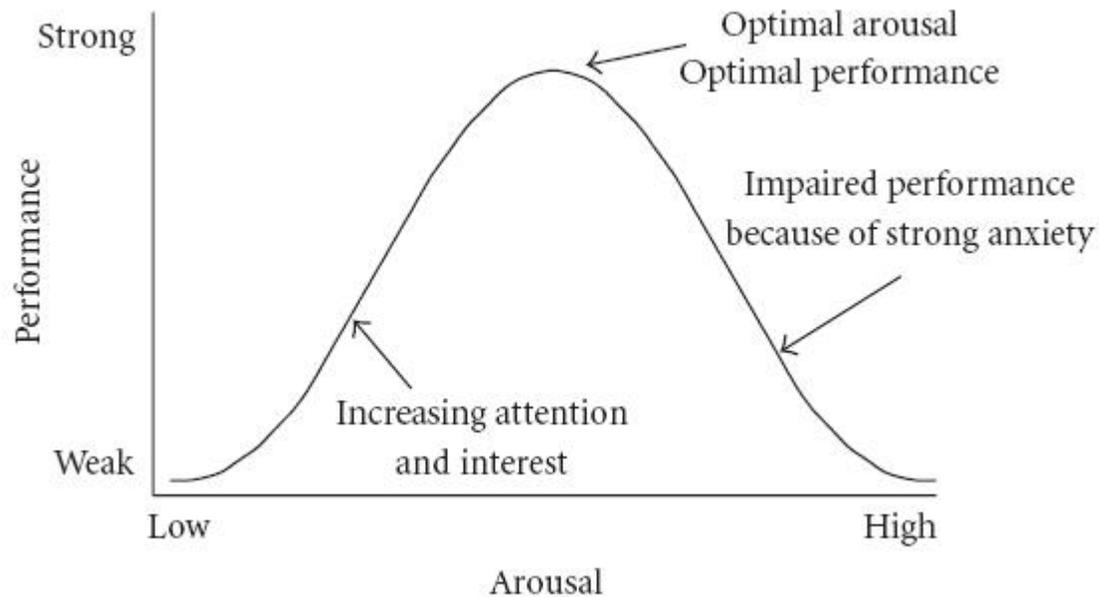


Image is Figure 3 from Diamond D. M., et al. "The Temporal Dynamics Model of Emotional Memory Processing: A Synthesis on the Neurobiological Basis of Stress-Induced Amnesia, Flashbulb and Traumatic Memories, and the Yerkes-Dodson Law." *Neural Plasticity* 33 (2007) [dx.doi.org/10.1155/2007/60803](https://doi.org/10.1155/2007/60803).

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