Building Resistance to Stress and Aging: The Toughness Model

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An Introduction:

Toughening activities Lead to Physiological toughness in body & brain

Physiological Toughness Leads to Mental/Psychological Toughness

Elements of mental/psychological toughness
- Stress tolerance & emotional stability
- Fluid intelligence & executive functions
- Episodic memory formation and retrieval
- Capacity for nurturance and affection
- Self control and mental energy

Thanks!

And a sound check
Elements of physiological toughness

- Balanced neurochemistry
- Enhanced neural structures
- Balanced and well-controlled endocrine function

Activities that toughen

- Mental enrichment
- Physical exercise training
- Receiving & providing nurturance
- Meditation and related activities
- Challenges and manageable stressors
- Practicing self-control

Why toughening activities toughen

- Genes as more than templates
- **But** our activities, our environments, even our mental activities impact our development by activating and deactivating genes.

Genes

- Activated or “transcribed” genes produce (indirectly) proteins that change our body.
- Sometimes for a brief time
- **BUT**: Activation and deactivation can last a lifetime:
### Your gain from this conversation

- Understanding **how much** toughening activities boost mental/psychological toughness.

- Understanding **how** toughening activities boost mental/psychological toughness by leading to physiological toughness.

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### The brain divided at midline

- Anterior cingulate cortex
- Hypothalamus
- Pituitary
- Amygdala
- Hippocampus

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### Challenge & Stress

- **Challenges** require coping & energy. Positive outcomes. SAM arousal with adrenaline & blood glucose.

- **Stressors** are threats and harm/loss. Bad outcomes. PAC arousal with CHR and cortisol.

- **Stress** is inside us.

  (Definitions after Lazarus & Folkman)

### SAM versus PAC

- **SAM (adrenaline)**
  - Immediate onset
  - Energizes by cardio and blood glucose
  - Exacerbates ongoing emotion
  - Quick offset.

- **PAC (cortisol & CRH)**
  - Delayed onset
  - Energizes brain and body depleting muscles
  - Suppresses other systems
  - Feelings of tension
  - Very slow offset
**Mental control of arousal**

- We have some control of our appraisals and thus over the nature of the arousal we experience.

**Down-regulating PAC arousal**

- A classic negative feedback system.
- Cortisol crosses blood-brain barrier.
- Receptors in hippocampi and elsewhere instruct hypothalamus to stop the CRH.

**Chronic stress**

- Cortisol’s activation of hippocampi and cortex
  - Dendritic branches pruned back
  - Synapses diminish in quantity
  - Neurons are killed
  - Damaged hippocampi fail to down-regulate PAC arousal to future stressors.
  - Damaged cortical structures lose cognitive efficiency and cannot control impulsivity.
  - (Robert Sapolsky & Bruce McEwen)

**Aging: Not for Sissies**

- Slowing.
- Shrinking gray: hippocampi and prefrontal cortex.
- Poor control of PAC arousal.
- Shrinking white: Myelin after 40.
- Shrinking telomeres (from stress too).
And Now Toughness

- References will be few.
- Email address later.

Opponent Process theory and Toughness

- The body “opposes” any depletion of energy or neurochemistry.
- With repetition and rest, the opposition processes strengthen.
- A training effect that is not just for muscles, but for neural and endocrine systems as well.

Cognitive Enrichment

- Use it or lose it?
- Cognitive reserves?

Cognitive Enrichment

- Correlational/longitudinal research is always strongly positive.
- Dementia is delayed
  - Language learning
  - Playing an instrument
    - (Hertzog, et al., 2008)
Cognitive Enrichment Experiments

- Early: training for the test.
- But we want: Fluid Intelligence; executive processes; and working memory.
- Latest:
  - Digital photo for 180 hrs.
  - Memory measures ($d = .54$; Park et al. 2014)
  - Video games with strategies for 24 hrs
  - Raven’s fluid intelligence ($d = .55$; Basak et al., 2008) (70th percentile)

Cognitive enrichment: How? (the neural level)

- **Neurotransmitters:** Noradrenaline, Dopamine, Serotonin, Acetylcholine, Glutamate & GABA.
- **Neurotropins:** heroic & blessed.
  
  - BDNF neurogenesis, synaptogenesis, overall health and well being of neurons.
  - VEGF & IgF-1 for both neurogenesis & vascular expansion.

Cognitive Enrichment: How? (the structural level)

- **ANIMAL RESEARCH**

  In prefrontal cortex, hippocampi, entorhinal
  - Dendritic branches & spines & synapses
  - Vascular networks

Cognitive Enrichment: How? (the structural level)

- **Humans:**
  - Cabbies??
  - German Med students (MRI’s)
    - Prefrontal & Hippocampi until exam
    - Hippocampi after too. (Draganski)
  - Swedish language students
    - Pre-post 3 months. Hippocampi & language-related gray areas (Martensson)
Exercise toughens too

- But Use it or lose it????

Exercise leads to Mental/Psychological Toughening

- Colcombe and Kramer (2003); Hertzog et al. (2008).
  - Meta analyses of all random-assignment studies: Impacts on cognitive skills was $d = .48$. Better for executives. (68%)
  - (Heyn et al., 2004): For dementia, $d = .57$; (72%)

Physiological toughening from Exercise programs

- Cardiovascular connection.
- Inflammation connection: cytokines.
- PAC control
- Brain glycogen & mitochondria
- Neurotropins
- Neurotransmitters: Noradrenaline & Serotonin

Exercise and brain toughening

- fMRIs during mental processing: Circulatory enhancement in hippocampi, prefrontal & parietal cortex.
- MRIs: hippocampus, prefrontal cortex & temporal cortex, both white & gray.
- E.g. Erickson et al. 2011. 120 elderly. One year: aerobic vs stretch & tone: hippocampi (-1.4% vs +2%) fitness & spatial memory.
Toughening via Meditation

- Psychological/mental toughness
- Physiological toughness
- Genetic transcription
- Wait for Cynthia Stonnington.

Nurturance causes mental/psychological toughness

Longitudinal research: control of negative emotions, stress tolerance, and social competence (e.g., Hostinar et al., 2014).

And the flip side: (e.g., Harlow; Romanian orphanages).

Nurturance causes physiological toughness

(neurochemical & receptor levels)

- Genes for oxytocin & estrogen receptors—lasting a lifetime (Champagne et al., 2006)
- Genes for BDNF.
- Increased cortisol receptors (Champagne, 2010)
- Increased acetylcholine
- Increased synaptic proteins.
- Reduced sensitivity to CRH and increased sensitivity to GABA (e.g., Heinrichs et al., 2003)

Nurturance causes physiological toughness

(brain structures)

- Enhance hippocampal and prefrontal functions that control PAC-system arousal.
- Enhance capacity and responsiveness of the oxytocin affection system (e.g., Daskalakis et al., 2013; and Hostinar et al., 2014)
So hug somebody already!
T-shirt slogans

- Hugs for synapses
- Hugs for brain health
- Hugs for Cognitive preservation
- Hugs for control of PAC-system arousal

Modest stressors toughen people

- Seery (2011).
- 2000 Ss
- Lifetime serious stress assessed: illnesses, injuries, assaults, deaths, divorce, natural disasters.
  - Most lifetime stress had least tolerance.
  - Low-to-moderate levels of lifetime stressors were most tolerant.

- Seery (2013): Cold pressor
  Moderate levels of background stressors had least pain & negative affect.

AND a “test of intelligence”
Challenge cardiovascular response (e.g., Blascovich)

- Aschbacher et al., (2013):
  - PAC arousal causes oxidative damage.
  - Lab stressor: Moderate prior life stress Ss had least oxidative damage.
Physiological toughening monkeys from Manageable stressors

- Physiological toughness
  - New hippocampal neurons (44%; Lyons)
  - Prefrontal cortex gray & white (Katz).
  - Reduced PAC arousal (Parker)

- Mental/Psychological toughness
  - Cognitive abilities, stress tolerance (Parker)

Self Control

- Choosing the harder thing (Mischel)
- Controlling impulsiveness and emotions
- Controlling working memory.

Toughening self control

Self control consumes mental energy.
(the ego depletion studies; Baumeister)

Practicing self control toughens:
  - exercise; studying; saving (Oaten); handgrip; sweets; non-dominant hand.

Structural origins of self control

fMRIs while making choices for smaller immediate or larger delayed rewards:
With Self Control: prefrontal cortex and the anterior cingulate cortex activated.
With smaller-but-immediate choices: activated limbic structures: ventral tegmental area & nucleus accumbens (e.g., Wagner et al., 2013).
Physiological origins of self control

Glucose and glycogen (Galliot).
But the controlling brain structures require: blood circulation; effective PAC control; neurotropins. Low serotonin leads to impulsiveness. Neurotransmitters maintain self control (Sripada et al., 2014).
Even brain mitochondria by physical exercise.
All the physiological elements that contribute to self control are strengthened and maintained by all of the toughening activities described above.

Toughness and therapy

Are we tough yet?

- Depression lifetime: 20% W & 10% M diagnosable
  Elderly: 5% in communities & up to 40% in hospitals or nursing facilities.
- Anxiety disorders lifetime experience: 30% W & 19% M

Eliminating fearful thoughts

- They remain.
- Perhaps with storage of “safety” memories
- Re-emergence with age- or stress-associated prefrontal cortical weakening or by prefrontal disruption. (McEwen & Morrison, 2013)

Suppression by prefrontal cortex

Common to depression and anxiety:

Failure to keep working memory or consciousness free from disturbing cognitive & affective material.
Toughness and therapy

(Harvey et al., 2014, titled their paper "Improving outcome of psychosocial treatments by enhancing memory and learning")

Any procedures that toughen the prefrontal cortex with its executive-functions and memory-consolidation processes ultimately benefit therapy outcomes. All the procedures reviewed here do that!!

Downward cascades with stress versus upward spirals of toughness

**Stress**-cortisol-hippocampal and prefrontal cortical deterioration-disregulated PAC arousal-stress intolerance and more damage

**Challenging activities**-hippocampal and prefrontal cortical toughness-PAC system control and fluid intelligence-approach to new toughening challenges.

A Summary Model of Toughness

- Opponent processes depend on
- Rhythms of tolerable use/depletion and recovery.

Final issues

- Can toughening activities be substituted?
  - Do they lead to the same elements of physiological toughness?
- Is physiological toughness a unified concept?
  - PAC control, Neurotropin generation, Neurotransmitter-receptor balance, Hippocampal and prefrontal cortex preservation
- Is mental/psychological toughness unified?
  - How much do emotional control and mental efficiency and self control correspond?
A visual model of toughening activity and outcomes

Thanks

- For References
- Email Dick at: RDIEN@NEB.RR.COM

Or check out: “Building Resistance to Stress and Aging: The toughness Model.”