Harnessing the Beneficial Effects of Acute Stress on Response Inhibition

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Overview

- The body's stress response is adaptive
- Response inhibition is critical for survival
  - Enables rapid suppression of actions in changing environments
  - Acute Stress enhances response inhibition
- Beneficial effects of stress depend on physiological stress-reactivity
- Value in understanding the integration of Stress, Reactivity, and Inhibition
- Integration can be leveraged in two ways to improve military and personal readiness:
  - Enhance behavioral control during acute stress
  - Reduce risk for substance abuse

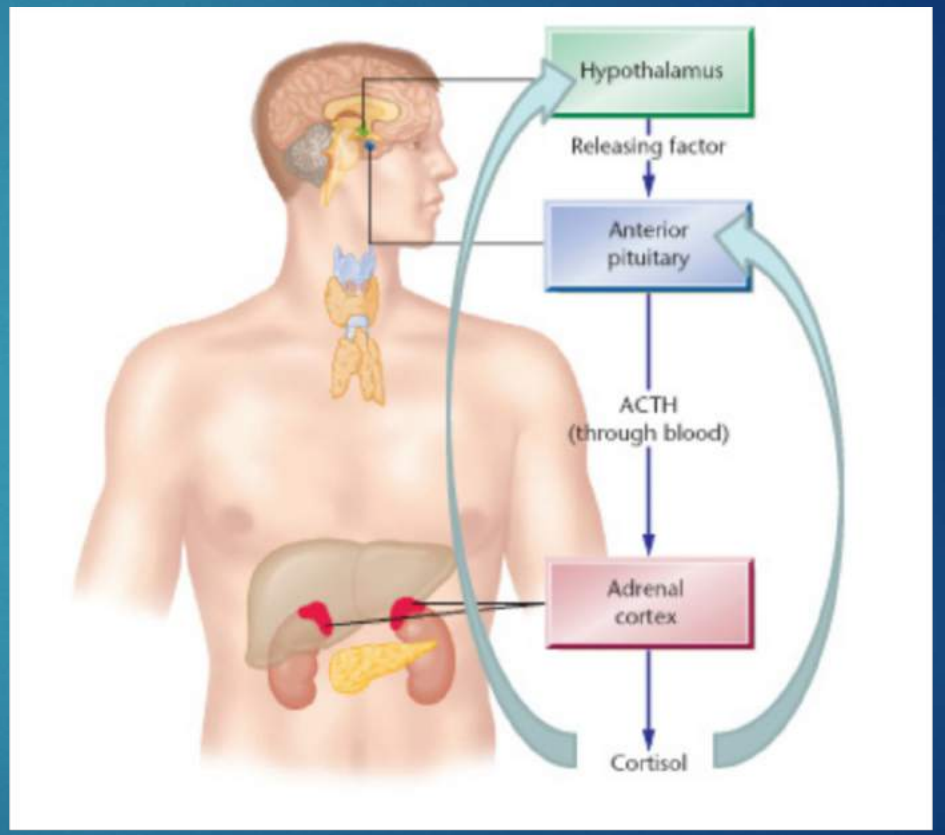
Importance of Response Inhibition

- Refers to the suppression of actions that are inappropriate in a given context and that interfere with goal-driven behavior
- Response Inhibition is critical for survival:
  - Allows us to rapidly respond to environmental changes by suppressing actions that are unsafe, inappropriate, or no longer needed
  - Dynamic and flexible behavioral control
- Stop Signal Response Inhibition
  - Ability to stop an ongoing action (i.e., action cancellation)
  - Very relevant to rapidly changing environments

Mostofsky et al. (2008); Aron and Poldrack (2006); Hamilton et al. (2015)

The Importance of Stress

- Stress: the perception, appraisal, and response to harmful, threatening, or challenging events or stimuli
- The Acute Stress Response
  - 2 pathways: autonomic and HPA-axis
  - Increases Heart-Rate, respiration
  - Increases cortisol to mobilize energy
- Stress impacts executive functions
  - Stress response forces attention toward highly salient (i.e., threat-related) stimuli



Goldstein and McEwen (2002); Sinha (2008)

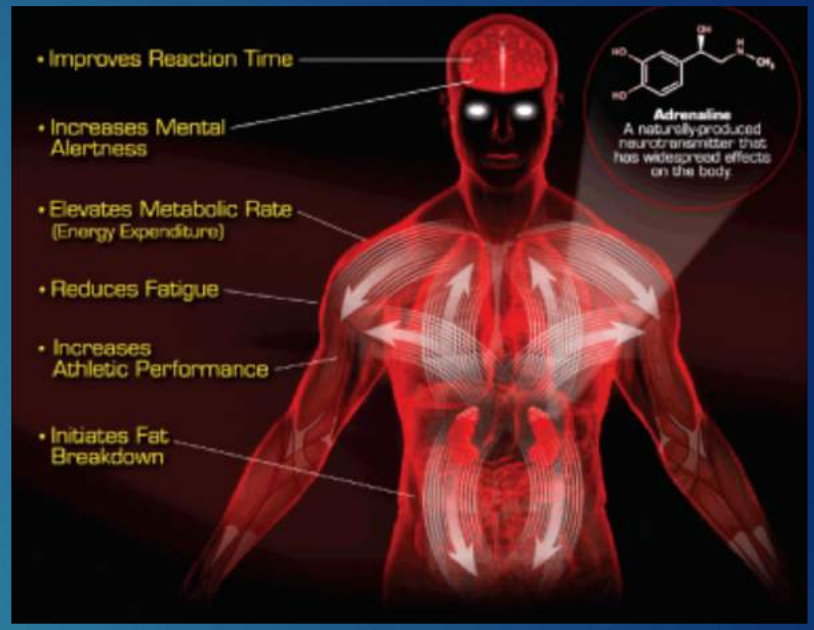
The Body's Stress Response is Adaptive

- Fight or Flight Response
  - Increased attention to salient stimuli, increased response inhibition
    - Tiger
    - Escape Route
    - Rapidly change behavior
  - Increased Heart-Rate, Respiration
  - Increased Cortisol to mobilize energy

Cannon, 1929; 1939

The Importance of Stress-Reactivity

- Beneficial effects of acute stress on response inhibition depend on the stress response (e.g., cardiovascular, cortisol)
  - Individual differences in stress-reactivity could moderate effects of stress on response inhibition
- Low stress-reactivity is unrelated to the subjective experience of stress
  - unconscious physiological disengagement in the face of acute stressors
  - Stress-reactivity is coordinated in brain regions that are central to motivation and autonomic functioning (i.e., insula)



Carroll et al., 2017; Gianaros et al., 2012; Ginty et al., 2013

Integration of Stress, Stress-Reactivity, and Response Inhibition

- Between-groups studies comparing response inhibition between stress groups and neutral control groups reported that response inhibition was greater (i.e., faster SSRTs) in the stress group compared to the control group.
- One study reported that enhanced response inhibition was associated with larger increases in cortisol from baseline
- In addition, stress did not enhance response inhibition in a group in which receptors that mediate neuroendocrine-related cognitive effects of stress on the brain were pharmacologically blocked

Dierolf et al. (2018); Scholz et al. (2009); Schwabe et al. (2013)

Our preliminary research:

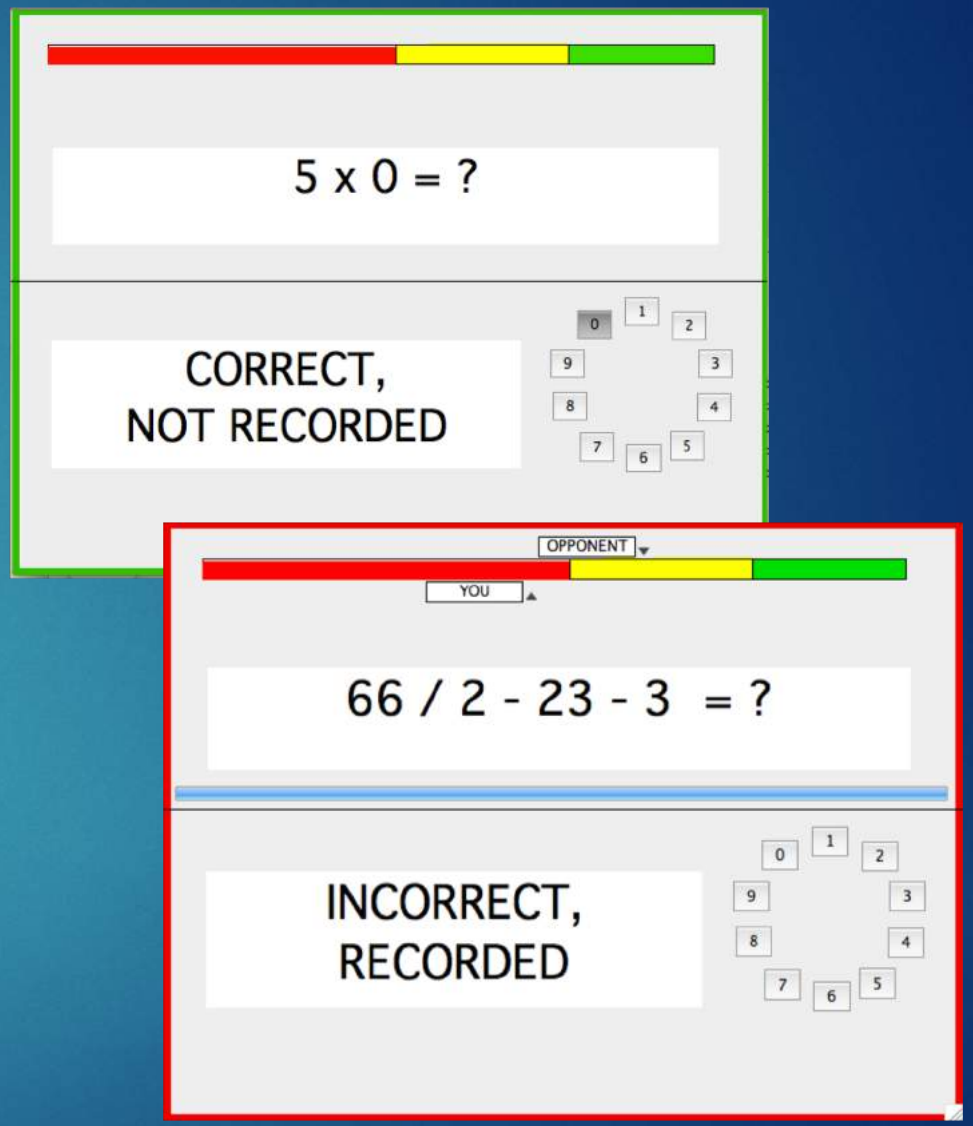
Purpose:

- To replicate the beneficial effects of acute stress on response inhibition using a sensitive within-subjects design
  - Counterbalanced
  - Carefully controlled
- To determine whether degree of cortisol stress-reactivity is associated with stress-related changes in response inhibition

Study Design

Acute Stress Induction:

- The MIST psychosocial stress task (Pruessner et al., 2008)
  - Neutral Condition:
    - No time limit with easy math problems
    - No comparison to average
    - Neutral feedback
  - Stress condition:
    - Timed with difficult math problems
    - Comparison to "average" at the top of the screen
    - Negative evaluative feedback from experimenter



Pruessner et al., 2008

Study Design

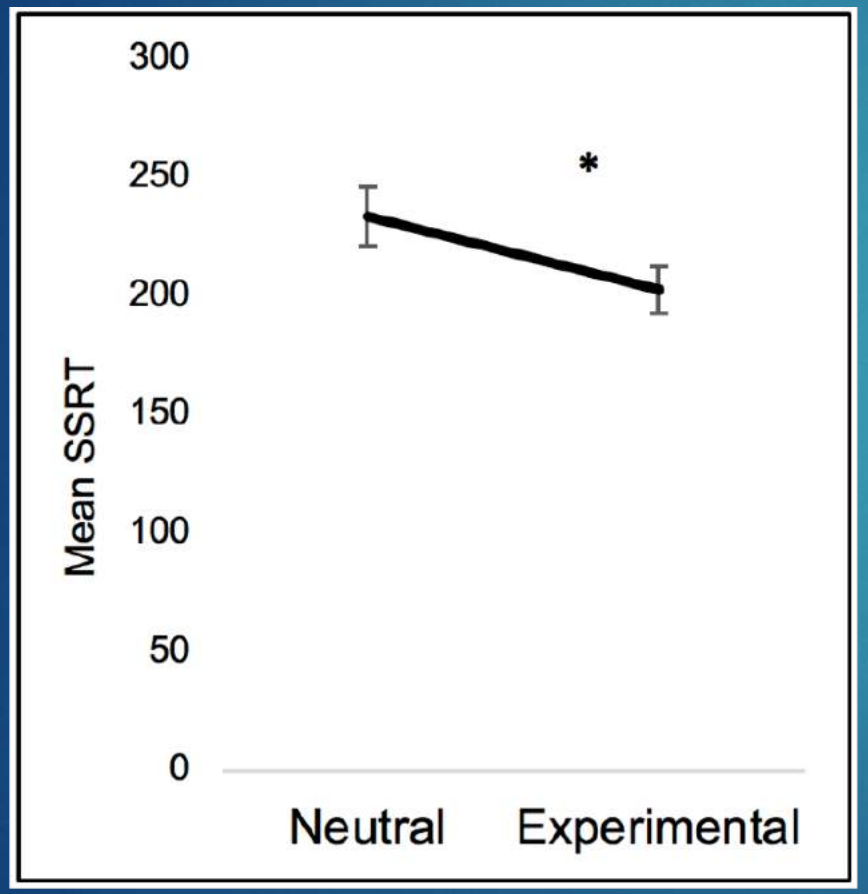
Response Inhibition Assessment:

- Stop Signal Task
  - Subjects are required to respond to a "Go" cue with a button press (~75% of trials), but to inhibit their response when a "Stop Signal" appears after the Go Cue (~25% of trials)
  - Requires stopping an ongoing action (i.e., action cancellation)

Salivary Cortisol Assessment:

  - 1 baseline sample
  - 3 samples during stress (at 10 minute intervals)
    - 20 minutes after beginning of stress phase
    - 30 minutes after beginning of stress phase
    - 40 minutes after beginning of stress phase
- Order of Stress and Neutral Conditions is counterbalanced across subjects (orders A,B)
- Stop Signal Response Inhibition is assessed immediately following each MIST phase

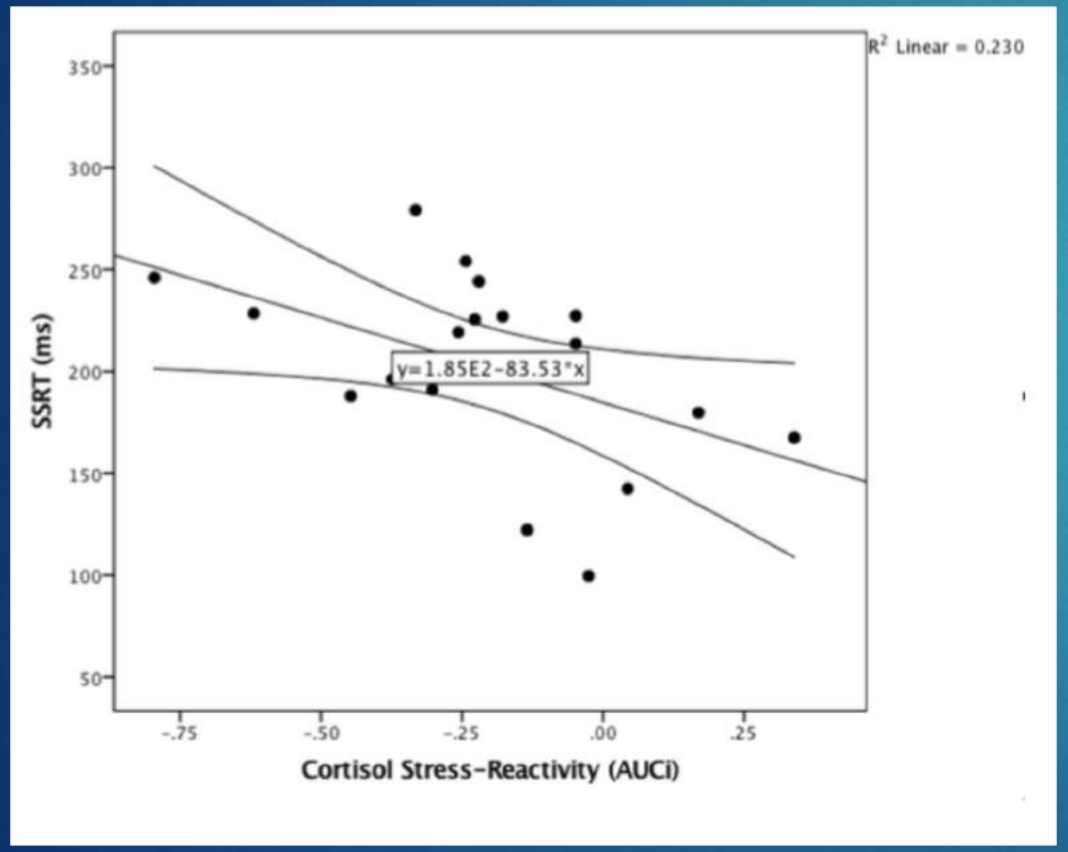
Preliminary Results: Acute Stress enhanced response inhibition.



- Acute psychosocial stress induction enhanced response inhibition, as indicated by faster Stop Signal Reaction Times (SSRTs) [$F(1,29) = 4.92$, $p = .035$*]

Hamilton and Dougherty, unpublished data

Preliminary Results: Enhanced response inhibition during stress was associated with greater cortisol stress-reactivity.



- In cortisol responders, faster SSRT during stress was associated with greater cortisol stress-reactivity, as indexed by greater Area Under the Curve with respect to Increase (AUC_i) [r = -.48, p = .038*]

Hamilton and Dougherty, unpublished data

Value of understanding the Integration of Stress, Reactivity, and Inhibition: Relevance to the Military

- **Optimal Stress-Reactivity**
  - Beneficial Effects on Behavioral Control during Stress
- **Low Stress-Reactivity**
  - Increased Risk of Substance Abuse

Integrating Stress, Reactivity, and Inhibition: Implications

- Harness the beneficial effects of acute stress on response inhibition
  - Improve the ability to screen and assign well-suited personnel (i.e., those with optimal stress-reactivity) to highly stressful and dynamic situations
  - Inform the development of strategies and interventions (i.e., pharmacology, technology, training) to augment beneficial effects of stress on response inhibition

Missile Defense Project, "GMD Fire Control and Communication," *Missile Threat*, Center for Strategic and International Studies, published August 11, 2016, last modified June 15, 2018, https://missilethreat.csis.org/defsys/gmd-fire-control/.

Integrating Stress, Reactivity, and Inhibition: Implications (continued)

- Leverage this understanding to reduce substance abuse risk in military personnel

Norman et al. (2018); Schmid et al. (2017)

Proposed Studies

- Characterize the integration of Stress-Reactivity-Inhibition in military personnel using our behavioral paradigm, and determine whether this behavioral profile prospectively predicts performance during military training operations

- Examine the efficacy of pharmacologically enhancing stress reactivity to improve response inhibition and performance during military training operations (e.g., with fludrocortisone [a mineralocorticoid receptor agonist])

Conclusions

- Considerable value in understanding the integration of Stress, Reactivity, and Inhibition
- Integration can be leveraged in two ways to improve military and personal readiness
- My proposed research would:
  - establish the relevance of the integration of Stress, Reactivity, and Inhibition to behavioral control and success during military operations
  - and lay the groundwork for interventions (e.g. pharmacology, technology, training).

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Questions?