Self-Control Gone Awry: The Cognitive Neuroscience Behind Bulimia Nervosa

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Outline

• What is bulimia nervosa?
• What is self-regulatory control?
• How does it go awry in bulimia nervosa, and how could these disturbances promote bulimic symptoms?
• How might disruptions in self-control circuits help us predict clinical outcome and develop new treatments?
• Where do we go next?
Behavioral Features for Diagnosis

• Recurrent episodes of binge eating
  • Eating a large amount of food in a discrete time period
  • Experiencing a sense of loss of control during the episode

• Recurrent compensatory behaviors
  • Self-induced vomiting
  • Laxative/diuretic/medication misuse
  • Excessive exercise
  • Fasting

• 46-72% heritable

American Psychiatric Association, 2013; Sullivan et al., 1998
History of Bulimic Behaviors

780-1037 AD
Avicenna’s Canon of Medicine

1200 AD
Saint Veronica

1979
“ominous variant of anorexia nervosa”

Nasser, 1993; Bell, 1985; Russell, 1979
Who are affected?

- **Sex**: 4-10 times more prevalent in females
- **Age**: median age of onset at 18
- **Lifetime prevalence**: 1-3%
  - US incidence has increased with COVID-19
  - One in 5 women have had episodes of binge eating, one in 3 have made themselves vomit or taken pills to lose weight
- **Associated disability**: 78% moderate
- **Course**: typically persists for several years, can be chronic or intermittent

Qian et al., 2021; Solmi et al., 2021; Perkins & Brausch, 2018; Taquet et al., 2021; Reba-Harrelson et al., 2009; Tith et al., 2020; Hudson & Pope, 2018
Typical Treatments

• Cognitive-Behavioral Interventions
  • First: Normalize eating, eliminate restriction
  • Second: Address difficulties regulating emotions

• Pharmacotherapy
  • Fluoxetine FDA approved

Over 60% of patients who receive first-line treatments for bulimia nervosa remain symptomatic.

Fairburn, 2008; Linardon & Wade, 2018; Quadflieg & Fichter, 2019
How and why do these individuals get stuck in these out-of-control behaviors?
Self-Control

- Action inhibition
- Response selection
- Conflict monitoring
- Error monitoring
- Emotion regulation
- Attention regulation

Eagle et al., 2008; Mischel et al., 1989
How does self-control go awry in bulimia nervosa, and how could these disturbances promote bulimic symptoms?
Altered structure of control circuits?
Altered Cortical Thickness in BN

Berner et al. (2018), *Journal of Psychiatry & Neuroscience*
Altered Cortical Thickness in BN

Frontoparietal cortical thickness reductions in BN across all ages
Reduced Cortical Thickness Associated with Symptom Severity

Log transformed OBE frequency, past 3 months
Reduced Cortical Thickness Associated with Symptom Severity

Log transformed LOC episodes, past month
Reduced Cortical Thickness Associated with Symptom Severity

Greater illness severity, more pronounced frontoparietal cortical thickness reductions

Log transformed LOC episodes, past month
Prefrontal Thinning Appears Early and Persists

Right vlPFC (opercularis)

Right vmPFC (orbitalis)

BN < HC

Cyr...Berner et al., 2018, JAACAP
Prefrontal Thinning Appears Early and Persists

Prefrontal cortical thickness reductions may be a trait marker of BN

Cyr…Berner et al., 2018, JAACAP
Subcortical Shape Inversions

Berner, Wang et al., 2019, *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*
Shape Inversions Linked to Symptom Severity

Berner, Wang et al., 2019, *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*
Shape Inversions Linked to Symptom Severity

Berner, Wang et al., 2019, Biological Psychiatry: Cognitive Neuroscience and Neuroimaging
Shape Inversions Linked to Symptom Severity

Dorsal striatal and pallidal alterations may relate to impaired control over eating and urges to induce vomiting

Berner, Wang et al., 2019, Biological Psychiatry: Cognitive Neuroscience and Neuroimaging
Altered function of control circuits?
Control in Context of Conflict

Simon Task

congruent

incongruent
Reduced Activation in Adolescents and Adults when Engaging Control to Override Conflict

Simon Task

Marsh et al., 2009, *Biol Psychiatry*; Marsh...Berner et al., 2011; *Am J Psychiatry*
Extremes of Body State and Under and Over-Control in BN

Under-controlled

- Loss-of-control (binge) eating
- Compensatory purging

Over-controlled

- Dietary restriction

Holderness et al., 1994; Kaltiala-Heino et al., 2003; Paul et al., 2002; Brockmeyer et al., 2014; Harrison et al., 2010; Lavender et al., 2015; Svaldi et al., 2012; Crow et al., 2009
Changes in Internal States and Control

• Dramatic body state changes in bulimia nervosa also involve unpleasant internal experiences.

• Tendency to act with little control in response to unpleasant internal experience is highly predictive of bulimic symptoms.

• Training inhibitory control reduces brain reactivity to aversive stimuli

Corstorphine et al 2006; Cohen et al., 2015, 2016; Cohen and Mor, 2018
Adjustment to Aversive Change

Aversive Interoception: Inspiratory Breathing Load Paradigm

Increased Activation during Anticipation in RBN

Berner et al., 2019, Neuropsychopharmacology
Increased activation when anticipating an aversive internal state

- Consistent: MDD, anxiety, low resilience
- Opposite: women with a history of AN
Altered Neural Adjustment Over Time in RBN

Left Posterior Insula

Berner et al., 2019, *Neuropsychopharmacology*
Altered Neural Adjustment Over Time in RBN

Berner et al., 2019, Neuropsychopharmacology
An abnormal decline in activation when experiencing an aversive state change

- Consistent: PTSD
- Opposite: women with a history of AN
Anticipatory Hyperactivation is Linked to More Frequent Purging

Berner et al., 2019, *Neuropsychopharmacology*
Summary

• Self-control circuits are structurally altered in teens and adults with bulimia nervosa, particularly those with the most severe symptoms.

• Teens and adults with bulimia nervosa insufficiently engage self-control circuits to control their non-food-specific behavior.

• Bulimia nervosa is linked to brain hyperactivation when anticipating an unpleasant body-state change, and an abnormal decline in activation, particularly in control-related regions, when experiencing it.
What might this mean for treatment?
Potential Treatment Implications

Berkman et al., 2014; Houbon & Jansen, 2011; Turton et al., 2018; Veling et al., 2013

Inhibitory control training
Changing Neurobiology

SELF-CONTROL

- DBT + mood stabilizer (lamotrigine)

Berner, Reilly et al., under review
Changing Neurobiology

**SELF-CONTROL**

- DBT + mood stabilizer (lamotrigine)

Berner, Reilly et al., under review
Changing Neurobiology

SELF-CONTROL

- DBT + mood stabilizer (lamotrigine)
  - Increases self-control circuit connectivity

Berner, Reilly et al., under review
What’s next for research?
The Control of Eating

Plassman et al., 2021
Loss of control over eating:

Is brain activation associated with eating-specific control altered in bulimia nervosa?
General Inhibitory Control

*Standard Go/No-Go Task*

**NO-GO**

**NO-GO**

**NO-GO**

Animation Credit: Shana Adise, Penn State University
Eating-Specific Inhibitory Control

Eating-specific Go/No-Go Task

Berner et al., under review
Portable Imaging

Functional Near-infrared Spectroscopy (fNIRS)

- Changes in oxygenated and deoxygenated hemoglobin concentration in the PFC

- Cross-validated with fMRI using go/no-go tasks

Rubia et al., 2006; Irani et al., 2007; Herrmann et al., 2005; Medvedev et al., 2011; Rodrigo et al., 2014; Cui et al., 2007; Tsujii et al., 2011
Women with BN were less able to control their eating responses.

Women with more severely dysregulated eating did not effectively recruit medial or lateral PFC to inhibit eating.

Berner et al., under review
Group Differences in Activation: Effect Size Maps

Berner et al., under review, Journal of Abnormal Psychology

Standard Task

Eating Task

Berner et al., under review
Other Outstanding Questions

• How do eating and associated signals from the gut to the brain influence self-control in bulimia nervosa?

• Which precise aspects of the self-control process go awry in bulimia nervosa?
  – Belief updating about whether inhibition is needed in the next moment?
  – Tracking of control-related surprises?
  – Deciding whether engaging control is worth it?
Please describe your experience of “loss of control”

• “I didn't want to stop. I already blew it, I’ll go for the whole thing"

• “I already started, I’ll just go all the way. I feel like if I tried hard, I could stop, but I just don't care."

• "I know I can stop, but once I start I'm not going to stop"
Persistently High Ghrelin After Eating in Bulimia Nervosa

Monteleone et al., 2003
Hypothesized Mechanism of Action

Eating, via the prolonged and elevated ghrelin response that follows, abnormally affects how people with bulimia nervosa calculate the estimated costs vs. benefits of exerting control.
Parting Points

• Difficulty effectively engaging self-control circuitry may make eating, and other behaviors, feel out of control to people with bulimia nervosa.

• Treatment may be able to directly target this dysfunction.

• Interdisciplinary research aimed at understanding the precise processes that drive under- and over-controlled eating behavior will help us understand symptoms of bulimia nervosa as well as other eating disorders.

• Longitudinal studies with large sample sizes are needed to disentangle brain-based causes from symptom effects on the brain.
Research and Treatment

Interested in participating in our research or learning more about it?
If you are female, right-handed, 18-35 years-old, and able to attend three study visits in Manhattan please call (212)-659-8799, e-mail thalia.viranda@mssm.edu, or scan the QR code below to let us know how and when to contact you.

Have structural scans of individuals with bulimia nervosa?
Join the ENIGMA Eating Disorders Working group http://enigma.ini.usc.edu/ongoing/enigma-eating-disorders/
Contact: laura.berner@mssm.edu

Looking for helpful resources?
National Eating Disorders Association Help Line: (800) 931-2237
Academy for Eating Disorders www.aedweb.org
Acknowledgments

Columbia University/NYSPI
• Rachel Marsh, Ph.D.
• Seonjoo Lee, Ph.D.
• Mihaela Stefan, M.S.
• Zhishun Wang, Ph.D.
• Marilyn Cyr, Ph.D.
• Evelyn Attia, M.D.
• Joanna Steinglass, M.D.

Drexel University
• Michael Lowe, Ph.D.
• Samantha Winter, Ph.D.
• Alyssa Matteucci, B.S.
• Allison Tipton, B.S.
• Jennifer Gilbert, B.S.
• Hasan Ayaz, Ph.D.
• Patricia Shewokis, Ph.D.
• Meltem Izzetoglu, Ph.D.

University of California, San Diego
• Alan Simmons, Ph.D.
• Amanda Bischoff-Grethe, Ph.D.
• Christina Wierenga, Ph.D.
• Ursula Bailer, M.D.
• Martin Paulus, M.D.
• Walter Kaye, M.D.

Icahn School of Medicine at Mount Sinai
• Tom Hildebrandt, Psy.D.
• Xiaosi Gu, Ph.D.
• Daniela Schiller, Ph.D.
• Kurt Schulz, Ph.D.
• Robyn Sysko, Ph.D.
• Center for Computational Psychiatry
• Center of Excellence in Eating and Weight Disorders

NIH National Institute of Mental Health  American Psychological Association  AED  Davis Foundation  BRAIN & BEHAVIOR RESEARCH FOUNDATION
Awarding NARSAD Grants
Thank you for your attention!

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What about emotional control?

- Is emotional control circuitry altered in bulimia nervosa?
Testing a State-Specific Model in Bulimia Nervosa

FASTED STATE
- Neural signal tracking control-related prediction errors
- Prolonged dietary restriction (fasting)

FED STATE
- Neural signal tracking control-related prediction errors
- Loss-of-control over eating

Compensatory behavior

Eating
A

- Errors

- Go Trials
- Rare Go Trials
- No-Go Trials

B

- Mean Correct Response Time (ms)

- Go Trials
- Rare Go Trials

- Mean Error Reaction Time (ms)

- Go Trials
- Rare Go Trials

T0

T1
Summary

• Self-control circuits are structurally altered in teens and adults with bulimia nervosa, particularly those with the most severe symptoms.

• Teens and adults with bulimia nervosa insufficiently engage self-control circuits to control their non-food-specific behavior.

• Eating-specific inhibitory control deficits and associated prefrontal dysfunction may contribute to eating that feels out of control.

• Bulimia nervosa, particularly more purging, is linked to brain hyperactivation when anticipating an unpleasant body-state change.

• Self-control circuitry may represent a useful treatment target.
Tracking Demands for Control

- Start eating
- Keep restricting
- Stop eating
- Purge
- Wait to see if urge to purge comes down

Will I need to engage control? Is it worth it to try?

Time

FASTED

FED STATE
Ghrelin-Control Connection?

Extra-hypothalamic
- Inhibitory control
- Learning and memory
- Reward and motivation
- Mood and anxiety regulation
- Stress responsivity

Hypothalamic
- Appetite regulation
- Energy metabolism
- Glucose homeostasis

Brain and Behavior Research Foundation Young Investigator Award