Mindsets, Motivation, and Rebounding from Failure

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Funded by IES (Institute for Educational Sciences)
Presented at the Learning & The Brain Conference, May 5, 2011
High-stakes Testing
Test-Enhanced Learning
(Roediger, McDermott, and colleagues)

Practice Test  Feedback  Test

"Congratulations, Phillip. You've managed to score somehow lower than chance."
Feedback and Rebound from Failure

First Test

Feedback

Performance Feedback

Learning Opportunity

Unexpected Retest

↑

Intrinsic Interest

“Epistemic Curiosity”
Epistemic curiosity

• an emotional or motivational condition creating the *drive* for knowledge-seeking behavior
  
  – The “wick in the candle of learning”
  
High epistemic curiosity can overcome a high anxiety level

- Improves likelihood one will pursue learning in challenging and effortful situations.
- Curiosity activates reward circuitry (Kang et al., 2009)
Neuro-Monitoring Responses to Feedback

Feedback

Negative Feedback: Conflict with Desired Outcome

Performance Feedback

Learning Opportunity

Shallow (perceptual)

Deep (conceptual)
Neuro-monitoring with EEG/ERP

- Covertly monitor cascade of stimulus evaluation processes
- Larger amplitudes reflect increased synchrony within populations of cortical neurons...
  - Scalp maps show topography of electrical changes across scalp
  - Both positive and negative deflections may reflect excitatory inputs from other regions
  - Interpretations of locus of activity supported by converging evidence from other methods
Modulating Responses to Feedback

- **Environmental Emphasis**
  (is this about performance or learning?)

- **Environmental Expectations**
  (how do others expect me to do?)

- **Individual’s Achievement Motivation**
  (why do I want to learn and do well?)

- **Individual’s Expectations**
  (will I be able to do well if I put in the effort?)

- **Attention to Negative Feedback**

- **Quality and Quantity of Engagement with Learning**

- **Likelihood of Subsequent Error Correction**
Rebound from Failure: The Basics

Attention to Negative Feedback → Quality and Quantity of Engagement with Learning → Likelihood of Subsequent Error Correction
What is the body’s largest organ?

INTESTINE

200-250 Questions: Titrated to 30-40% correct overall

Butterfield & Mangels, 2003
Negative Feedback

Detection (good/bad)

Orienting (to unexpected/undesired outcome)

FRN 250 ms

P3a 350 ms

Butterfield & Mangels, 2003
Learning Opportunity

SKIN
What is the body’s largest organ?
SKIN
Learning Success:
Relating Neural Activity During Learning to Success at Retrieval

SKIN
Later Recalled “SKIN” — Later Forgotten “INTESTINE” “LIVER” = Neural Activity Predicting Later Memory
Correlates of Successful Learning

Sequence of activity when student is shown correct answer at study that predicts later correction (cued recall) on surprise retest

Butterfield & Mangels, 2003
Modulating Responses to Feedback

- Attention to Negative Feedback
- Quality and Quantity of Engagement with Learning
- Likelihood of Subsequent Error Correction

Individual’s Achievement Motivation
(why do I want to learn and do well?)

Individual’s Expectations
(will I be able to do well if I put in the effort?)
Mindset

- **Entity Theorists**
  - **Intelligence is fixed**
    - Trait largely determined by nature
  - **Performance goals**
    - “In school I’m focused on demonstrating that I am smarter than other students”

- **Incremental Theorists**
  - **Intelligence is malleable**
    - Quality that can be increased through nurture
  - **Learning goals**
    - “In school, I’m always seeking new opportunities to develop new skills and acquire new knowledge”

Desire similar outcome
- achieving good scores, doing “well”

Different goals motivating pursuit of this outcome

(Dweck, 1999, 2007)
Mindset

Entity Theorists

- **Intelligence is fixed**
  - Trait largely determined by nature

- **Performance goals**
  - seeking to validate ability as good relative to others

Incremental Theorists

- **Intelligence is malleable**
  - Quality that can be increased through nurture

- **Learning/Challenge goals**
  - seeking to develop ability

In the face of negative feedback or failure

- **Helpless-Oriented**
  - Low effort
  - Threat/Withdrawal

- **Mastery-Oriented**
  - Effortful processing
  - Challenge/Engagement

(Dweck, 1999, 2007)
Self-Theories of Intelligence (TOI)

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<td>strongly agree</td>
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<td>strongly disagree</td>
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Ex. You have a certain amount of intelligence and you really can’t do very much to change it _______

**Entity Theorists** (trait determined by nature, N=22)

**Incremental Theorists** (quality developed by nurture, N=25)

**Entity Theorists:** Performance Goals > Learning Goals

**Incremental Theorists:** Learning Goals > Performance Goals
Negative Feedback
Rebound from Failure

Entity Theorists Oriented more to negative feedback

NEGATIVELY (r = -.47) correlated with learning goals (incrementals only)

Mangels, Butterfield, Lamb, Good & Dweck, 2006
Rebound from Failure

Incremental Theorists: Encode Learning Opportunity more Deeply

Mean amplitude 500-1000 ms
Rebound from Failure

Entity Theorists Orient more to negative feedback

Incremental Theorists Encode Learning Opportunity more Deeply

Incremental Theorists Rebound Better from Failure

Mangels et al., 2006
Modulating Responses to Feedback

Environmental Emphasis
(is this about performance or learning?)

Environmental Expectations
(how do others expect me to do?)

Individual’s Achievement Motivation
(why do I want to learn and do well?)

Individual’s Expectations
(will I be able to do well if I put in the effort?)

Attention to Negative Feedback

Quality and Quantity of Engagement with Learning

Likelihood of Subsequent Error Correction
Manipulating Environment

Teacher A: Performance Focus

Teacher B: Mastery Focus

Biology long term goal:
To master all the material tested on the regents exam in June of 2011
Manipulating Environment

Performance Focus Block (100 Questions)

“…we will assess your accuracy on these questions… will directly compare your individual performance to that of other university students…”

Mastery Focus Block (100 Questions)

“…interested in how people learn to solve different kinds of questions over time, rather than in their accuracy … interested in determining the types of questions that people find useful and learn the most from…”

N=24

Rodriguez, Guerra-Carrillo, Higgins, & Mangels, in prep
Processing Learning Opportunities

Performance Focus Block (100 Questions)

Mastery Focus Block (100 Questions)

Remembered - Forgotten

“skin”

posterior perceptual areas

anteror conceptual areas
Teaching Neuroplasticity as Path to an Incremental, Learning-Oriented View

Joshua Aronson, Jennifer Mangels, Matt McGlone
Funded by IES CASL Grant
Can the brain change and recover after injury?

The brain is responsible for all that we think, say and do, and we usually can rely upon it to do this work for us, day in and day out. But what happens when a part of it is severely damaged by a major accident, a brain tumor or a stroke? Can our brains recover and regain the function that was lost? Studies of stroke victims with damage to the part of the brain that controls talking (speech production) suggest that, at least under certain circumstances, the undamaged parts of the brain can change enough to at least compensate for the damage.

The speech production area is in a part of brain called Broca’s area, which is in the frontal lobe (it’s called that because it is the part of brain that is in the front). When this area is damaged, it causes something called Broca’s aphasia. Broca’s aphasia produces slow speech and an inability to form complete sentences. People with Broca’s aphasia usually find this struggle to communicate very frustrating! Speaking is something they were usually able to do without much effort before their brain damage.

Stroke: During a stroke, the brain’s cells don’t get enough oxygen, either because a blood vessel (blood carries oxygen) breaks open or because it is blocked, usually by a mass of cells (a clot) that has traveled from another part of the body. If a stroke is not detected and treated immediately, these oxygen-starved cells will die. Below is a picture of the brain with the whole frontal lobe (in light blue), and Broca’s area — the speech production area (in purple).
Teaching Through Engaging Fiction

Gray Matter

The only reason I signed up was to get out of Band. It was a couple weeks before school started. I found the notice on the High School Bulletin Board at the local library. It was next to the sign up sheet for the Vampire Book Club and underneath the reminder for The Back to School Book Sale.

ATTENTION: LOCAL NEUROSCIENTISTS SEEK STUDENTS TO PARTICIPATE IN RESEARCH ON TEENAGE BRAINS AND NEUROPLASTICITY. STUDENTS WILL MEET FOR WEEKLY DISCUSSIONS AND CONTRIBUTE TO A GROUP BLOG RELATING TO PROJECT. WE OFFER FREE BREAKFAST, ONE ELECTIVE CREDIT, AND THE CHANCE TO LEARN ABOUT THE BRAIN AND YOURSELF. IF INTERESTED, PLEASE SIGN UP BELOW.

Gray Matter Wednesdays is what we called our weekly morning meetings. Then it became what we called ourselves - Mackenzie Monroe, Kevin Foreman, Gavin Charles, and Cara Calmer, 4 high school students turned lab rats. We’re all pretty
Encouraging Results

Can change beliefs, but can it result in real differences under challenge (rebound from failure)?
Mathematics Problem Solving

\[ \frac{\partial}{\partial \theta} MT(\xi) = \frac{\partial}{\partial \theta} \int T(x)f(x, \theta)dx = \int \frac{\partial}{\partial \theta} T(x)f(x, \theta)dx = \int \frac{\partial}{\partial \theta} T(x)dx \]

\[ \frac{\partial}{\partial a} \ln f_{a,\sigma^2}(\xi_1) = \frac{(\xi_1 - a)}{\sigma^2} f_{a,\sigma^2}(\xi_1) = \frac{1}{\sqrt{2\pi}\sigma} \]

\[ \int T(x) \frac{\partial}{\partial \theta} f(x, \theta)dx = M(\xi) \frac{\partial}{\partial \theta} \ln L(x, \theta) \]

\[ \int T(x) \left( \frac{\partial}{\partial \theta} \ln L(x, \theta) \right) f(x, \theta)dx = \int T(x) \frac{\partial}{\partial \theta} f(x, \theta)dx = \int T(x) \frac{\partial}{\partial \theta} f(x, \theta)dx \]

\[ \frac{\partial}{\partial \theta} MT(\xi) = \frac{\partial}{\partial \theta} \int T(x)f(x, \theta)dx = \int \frac{\partial}{\partial \theta} T(x)f(x, \theta)dx \]

I have no special talents. I am only passionately curious.

-Albert Einstein
Rebound from Failures in Math

If the figure above is a rectangular solid composed of cubes, each with edge of length 4 centimeters, what is the volume of the rectangular solid in cubic centimeters?

(A) 100
(B) 256
(C) 400
(D) 5120
(E) 6400
Performance feedback
Correct Answer

(E) 6,400
Math Tutor

Answer: (E) 6,400

Step 1:

Step 2:

Step 3:
Math Tutor

Answer: (E) 6,400

Step 1: Label figure with edge length of each cube and length, width, and height. (more)

Step 2:

Step 3:
Math Tutor

Answer: (E) 6,400

**Step 1:** Label figure with edge length of each cube and length, width, and height.

**Step 2:**

**Step 3:**
Step 1: Label figure with edge length of each cube and length, width, and height.

Step 2: Find the values of the length, height, and width of the solid.

Step 3:
Answer: (E) 6,400

**Step 1:** Label figure with edge length of each cube and length, width, and height.

**Step 2:** Find the values of the length, height, and width of the solid.

**Step 3:**

Length = \(4 + 4 + 4 + 4 = 16\)

Width = \(4 + 4 + 4 + 4 + 4 = 20\)

Height = \(4 + 4 + 4 + 4 + 4 = 20\)
Math Tutor

Answer: (E) 6,400

**Step 1:** Label figure with edge length of each cube and length, width, and height.

**Step 2:** Find the values of the length, height, and width of the solid.

**Step 3:** Find the volume of the solid.

Length = $4 + 4 + 4 + 4 = 16$

Width = $4 + 4 + 4 + 4 + 4 = 20$

Height = $4 + 4 + 4 + 4 + 4 = 20$
Math Tutor

Answer: (E) 6,400

**Step 1:** Label figure with edge length of each cube and length, width, and height.

**Step 2:** Find the values of the length, height, and width of the solid.

**Step 3:** Find the volume of the solid.

**Volume of a Rectangular Solid:**

\[ V = l \times w \times h \]

Volume = \( 20 \times 16 \times 20 \)

\[ = 6,400 \]
Tutor helps Rebound

- Surprise retest on isomorphic problems
  - Test concept transfer
  - 48-hour delay

- Deeper investigation of tutor yields better rebound
Modulating Responses to Feedback

- **Environmental Emphasis**
  (is this about performance or learning?)

- **Environmental Expectations**
  (how do others expect me to do?)

- **Individual’s Achievement Motivation**
  (why do I want to learn and do well?)

- **Individual’s Expectations**
  (will I be able to do well if I put in the effort?)

- **Attention to Negative Feedback**

- **Quality and Quantity of Engagement with Learning**

- **Likelihood of Subsequent Error Correction**

- **Stereotypes**
  Fixed views
Social Stereotypes Undermine Females in Math

Nimrod & Heine, Science, 2006
Stereotype Threat

activation of the stereotype

activates fixed (entity) theory and performance-focus

worry that performance will demonstrate lack of ability

resources available for solving math problems

errors, negative feedback

appraisal of negative feedback as threat to ability

poorer utilization of opportunities to learn from error

true gaps in knowledge
Stereotype Threat

activation of the stereotype
↓
activates fixed (entity) theory and performance-focus
↓
↑ worry that performance will demonstrate lack of ability
↓
↓ resources available for solving math problems
↓
↑ errors, ↑ negative feedback
↓
appraisal of negative feedback as threat to ability
↓
poorer utilization of opportunities to learn from error
↓
true gaps in knowledge
Time Course of Emotions

Koole, 2009 (after Kuhl, 2008)
When Emotion Blocks Learning

• Two ways that emotion can interfere:
  – Vigilance-avoidance
    • Respond to failure by avoiding investigation of tutor
  – Rumination-interference
    • Respond to failure by drawing thoughts internally, interfering with processing of external information

Mangels, Good, Maniscalco, Whiteman & Dweck, 2011
Manipulating Threat

**Stereotype Threat**

- “…aim to understand what makes *some people better at math than others*”
- “…comparing your score to other students for the purpose of studying gender differences in math”
- *Indicate gender* before starting
- N=32

**Non-Threat**

- “…unlike typical math tests, our purpose here is *NOT to see how smart you are*…rather, we want to examine psychological processes associated with effortful problem solving”
- “…analysis of thousands of students' results has shown that *males and females perform equally well on this problem set*”
- N=36
Response to Error Feedback

Tutor Use

Error Correction

Math Tutor

Answer: (E) 6,400

Step 1: Label figure with edge length of each cube and length, width, and height.

Step 2: Find the values of the length, height, and width of the solid.

Step 3: Find the volume of the solid.

Volume of a Rectangular Solid:

\[ V = l \times w \times h \]

\[ V = 20 \times 16 \times 20 \]

\[ V = 6,400 \]

Sensitivity/ Vigilance

Rumination/ Sustained Arousal

FRN 250 ms

P3a 350 ms

LPP 500-750 ms
When Emotion Blocks Learning

- Two ways that emotion can interfere:
  - Vigilance-avoidance
    - Respond to failure by avoiding investigation of tutor

Sensitivity/Vigilance

FRN 250 ms  P3a 350 ms

Math Tutor
Answer: (E) 6,400

Step 1: Label figure with edge length of the solid.

Step 2: Find the length, width, and height of the solid.

Step 3: Find the volume of the solid.
Volume of a rectangular solid: \( V = l \times w \times h \)

Volume = 20 \times 16 \times 20 = 6,400

Depth of Tutor Use

Error Correction

Mangels et al., 2011
When Emotion Blocks Learning

- Two ways that emotion can interfere:
  - Rumination-interference
    - Respond to failure by drawing thoughts internally, interfering with processing of external information

Rumination/ Sustained Arousal

Error Correction

Math Tutor
Answer: (E) 6,400

Step 1: Label figure with edge length of the solid.

Step 2: Find the volume of the solid.
Volume of a rectangular solid: $l \times w \times h$

Volume = 20 x 16 x 20
= 6,400
Focus on Learning and Equality

• Under non-threat, only depth of tutor use predicted rebound from failure
  – Even Math SAT was no longer predictive!

Mangels et al., 2011
Despite impairment on initial test, stereotype threat did not prevent rebound from failure overall.

Mangels et al., 2011
Rebound can happen even under stereotype threat...

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<th>Stereotype Threat: Performance Focus</th>
<th>Non-Threat: Process Focus</th>
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<td>- Learning <strong>undermined</strong> by emotional response to signs of poor ability</td>
<td>- Emotional responses to negative outcomes are <strong>less coupled</strong> to knowledge-seeking</td>
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<tr>
<td>- Better learners had <strong>less</strong> identification with math</td>
<td>- Better learners had <strong>more</strong> identification with math</td>
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<tr>
<td>- Prior ability (math SAT) was the <strong>strongest predictor</strong> of learning success ($b = .56$)</td>
<td>- Prior ability (math SAT) <strong>didn’t predict</strong> ability to learn from tutor ($b = .05$)</td>
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Can a performance goal or environment ever be adaptive?

- Yes, but two important qualifiers…
  - Performance coupled with **approach** motivation (not avoidance) (Elliot, 1999)
    - **Approach**: “It is important for me to do better than other students”
    - **Avoidance**: “I just want to avoid doing poorly in my courses”
  - When performance-approach individuals experience “fit” with their environment (Regulatory Engagement Theory, Higgins, 2006)
Manipulating Environment

Performance Focus Block (100 Questions)

“… we will assess your accuracy on these questions... will directly compare your individual performance to that of other university students…”

Mastery Focus Block (100 Questions)

“…interested in how people learn to solve different kinds of questions over time, rather than in their accuracy ... interested in determining the types of questions that people find useful and learn the most from…”

Rodriguez, Guerra-Carrillo, Higgins, & Mangels, in prep
Performance Focus Block (100 Questions)

Performance approach goals were best predictor of rebound from failure

Performance Approach Goals

- Increased attention to negative feedback
- Deeper processing of learning opportunity
- Greater Rebound from Failure

Rodriguez, Guerra-Carrillo, Higgins, & Mangels, in prep
Mastery-Avoidance Goals

- Decreased attention to negative feedback
- Deeper processing of learning opportunity
- Greater rebound from failure

Mastery Focus Block (100 Questions)

Mastery-avoidance goals were best predictor of rebound from failure

Rodriguez, Guerra-Carrillo, Higgins, & Mangels, in prep
Putting it all together...
Theories, Goals and Outcomes

Entity Theory, Performance (Avoidance) Goals, Stereotype Threat...

- **Continued poor** performance on more difficult tasks
- Real gaps in knowledge
- ↑ **Negative** feedback
- Threat appraisal
- ↓ **Quality or Quantity of Engagement with Learning**
Theories, Goals and Outcomes

Incremental Theory, Mastery Goals, Approach Goals, Goal-Environment “Fit”…

Resilient performance on more difficult tasks

Error remediation and increased self-efficacy

↑ Negative feedback

Challenge appraisal

Able to maintain “deeper” engagement in learning
“Success is the ability to go from one failure to another with no loss of enthusiasm.”

- Sir Winston Churchill
Teamwork

- Carol Dweck
- Catherine Good
- Josh Aronson
- Brady Butterfield
- Laura Deering
- Belen Guerra-Carrillo
- Justin Lamb
- Dan Lurie
- Brian Maniscalco
- Sylvia Rodriguez
- Ron Whiteman

- For more information about this research: jenimangels@gmail.com

- Learning ways to reduce stereotype threat: www.reducingstereotypethreat.org