The Influence of Motivation on Human Categorization and Decision Making

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Setting the Stage

- All human behavior is motivated
- Motivation influences behavior
  - Approach positive states and avoid negative states.
- Cognition influences behavior
- Motivation and Cognition need to be studied together
  - Until recently studied in different branches of Psychology
Overview of Talk

- Why we should care about motivation
- A framework for thinking about motivation and its influence on cognition and learning
- Application to:
  - Perceptual classification learning
  - Stereotype threat
  - Choking/Pressure
  - Choice
  - Signal Detection
Why we should care

- Motivation affects decision making
  - Preferences (Brendl, Markman, & Messner; Ferguson & Bargh)
    - Need to smoke increases preference for smoking related items and reduces preference for not smoking related items
  - Goal-adoptiion (Aarts et al, Fishbach & Shah)
    - People adopt goals of people around them.
  - Selection of optimal behavior (Bechara et al., Busemeyer & Townsend)

- All cognitive research has an (uncontrolled) motivational component
  - “motivate” to “try harder”

- “Motivation” brain regions reciprocally connected with “cognitive” brain regions
Motivational Framework

Regulatory Fit

- Extends concept developed by Higgins

- **Hypothesis**: When there is a “fit” between the regulatory focus (global task goal) and task reward structure (local task goal) more flexible cognitive processing (exploration) results.
Regulatory Fit = Flexibility: Why?

- Empirical support in several domains
- Connection to Neuroscience
  - Positive affect-frontal dopamine-flexibility hypothesis (Isen, Ashby, etc)
  - Regulatory focus-frontal activation findings (Amodio, Cunningham, etc)
  - LC-NE-exploration/exploitation relation (Ashton-Jones, Cohen, Daw)
<table>
<thead>
<tr>
<th>Focus Type</th>
<th>Reward/Incentive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotion Focus (Approach)</td>
<td>Achieve Global Task Performance Criterion → Raffle ticket for $50</td>
</tr>
<tr>
<td>Prevention Focus (Avoidance)</td>
<td>Achieve Global Task Performance Criterion → Keep $50 raffle ticket given initially</td>
</tr>
</tbody>
</table>
# Task Reward Structure

*(Local Trial-by-trial Task Goal)*

<table>
<thead>
<tr>
<th></th>
<th>Gains</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct Response = 3 points</td>
<td>Correct Response = -1 point</td>
</tr>
<tr>
<td></td>
<td>Incorrect Response = 1 point</td>
<td>Incorrect Response = -3 point</td>
</tr>
</tbody>
</table>

- Correct Response = 3 points
- Incorrect Response = 1 point
- Correct Response = -1 point
- Incorrect Response = -3 point
Consider the bigger picture

<table>
<thead>
<tr>
<th>Promotion Focus</th>
<th>Reward Structure of Task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gains</td>
</tr>
<tr>
<td></td>
<td>Fit</td>
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<tr>
<td></td>
<td>Mismatch</td>
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<td></td>
<td>Los ses</td>
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Consider the bigger picture

<table>
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<tr>
<th>Promotion Focus</th>
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<tbody>
<tr>
<td>Fit</td>
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<td>Fit</td>
</tr>
<tr>
<td>Mismatch</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Almost all cognitive research involves a promotion focus and a gains reward structure
  - **Promotion focus**: small monetary reward or social contract with experimenter.
  - **Gains**: reward for correct response, no reward for error
Regulatory Fit vs. Loss Aversion

- Fit differs from loss-aversion

- Loss aversion is a main effect.
  - “Losses loom larger than gains.”

- Regulatory fit is an interaction
  - The influence of losses depends on regulatory focus
  - Losses lead to **flexible** behavior under prevention
  - Losses lead to **inflexible** behavior under promotion
  - Whether this leads to good or bad overall performance depends on whether the task calls for flexibility
Studying Regulatory Fit Effects

- How can we study this systematically?
  - Need task for which we can manipulate the advantageousness of flexibility, while holding other task characteristics fixed
  - Need a good manipulation of regulatory focus
  - Need to be able to manipulate reward structure
Application 1: Perceptual Classification

Maddox, Baldwin & Markman (2006; Memory & Cognition)
Perceptual Classification Task

- Stimuli with small number of underlying dimensions
  - Lines that vary in length, orientation and position
- Experimenter control of category structure
- Extensive set of tools for modeling performance of individual participants
  - Can assess the strategies participants use in the task
Wrong, that was an A
Experiment Set 1
Flexibility is Advantageous

- Conjunctive Rule-Based Task
- Exploration of verbal rule space required

<table>
<thead>
<tr>
<th>Gains</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promotion (try to earn ticket)</td>
<td>Fit: Good</td>
</tr>
<tr>
<td>Prevention (try not to lose ticket)</td>
<td>Mismatch: Poor</td>
</tr>
</tbody>
</table>
Scatterplot of Stimuli

○ = category A = long, steep lines
+ = category B = all others
Possible Rule-based Strategies

83% accuracy

100% accuracy
Motivation Manipulations

- **Regulatory Focus**
  - **Promotion:** Entry into a cash drawing if performance criterion (86%) exceeded.
  - **Prevention:** Drawing entry at start, must exceed performance criterion (86%) to keep entry.

- **Reward Structure**
  - **Gains condition:** Gains on each trial
  - **Loss condition:** Losses on each trial
Experiment Screen Sample

Gains

Losses
Prediction

- Exceeding bonus requires exploration to find conjunctive strategy
- If a regulatory fit leads to increased flexible cognitive processing (exploration of the verbal rule space),
- Then performance should be best when there is a regulatory fit
Performance Results

Plots averaged over blocks. Effects generally larger early in learning
Model-based Analyses

- Decision-bound models (Ashby & Maddox) fit to each participant block-by-block
Possible Rule-based Strategies

100% accuracy
Model Fit Predictions

- Regulatory Fit Conditions should be more “flexible” and find the more complex conjunctive rule faster than the Regulatory Mismatch Conditions
Modeling Results

![Graph showing the proportion conjunctive rule use for gains and losses. The x-axis represents the reward structure (proportions 0.0 to 1.0), and the y-axis represents the proportion conjunctive rule use. The graph compares promotion and prevention strategies with black and white bars, respectively.]
Conclusions

- In a classification task where exploration of the verbal rule space is advantageous, a regulatory fit led to better performance.
Experiment Set 2
Flexibility is Disadvantageous

Information-Integration Task

<table>
<thead>
<tr>
<th>Promotion (try to earn ticket)</th>
<th>Gains</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fit: Poor</td>
<td>Mismatch : Good</td>
</tr>
<tr>
<td>Prevention (try not to lose ticket)</td>
<td>Mismatch: Good</td>
<td>Fit: Poor</td>
</tr>
</tbody>
</table>
Experimental Method identical to Experiment Set 1
Prediction

- If regulatory fit = more flexibility, then rule-based strategies should persist leading to poorer performance.

- COVIS assumes that rule-based strategies dominate early.

- Rule-based strategies must be abandoned in information-integration tasks.

- Exceeding the bonus requires abandoning rule-based strategies.
Performance Results

![Graph showing Performance Results with bars for Gains and Losses. The y-axis represents Proportion Correct, ranging from 0.7 to 0.85. The x-axis represents Reward Structure, with a comparison between Promotion and Prevention.]
Modeling Results

![Graph showing Modeling Results]

- **Proportion II Use**
  - **Gains**
  - **Losses**

- **Reward Structure**
  - Promotion
  - Prevention
Conclusions

- We observe a 3-way interaction between regulatory focus, task reward structure, and nature of the task.

- Flexibility advantageous: Fit is good

- Flexibility disadvantageous: Fit is bad
Application 2: Stereotype Threat

Grimm, Markman, Maddox & Baldwin (under review)
Stereotype Threat

- Stereotype threat is the risk of confirming a negative stereotype about one’s group (Steele & Aronson, 1995).

- Task-relevant stereotype causes task-specific decrements in performance
  - How?
Proposed stereotype threat mechanisms

- **Self-handicapping** (Stone et al., 1999; Brown & Josephs, 1999)
  - Blacks better when framed as diagnostic of “natural athletic ability”
  - Whites better when framed as diagnostic of “sports intelligence”

- **Low performance confidence** (Cadinu et al., 2003)
  - Lower expected level of performance, lower actual performance

- **Task-specific concerns** (Brown & Josephs, 1999)

- **Ideomotor priming** (Bargh et al., 1996)
  - People primed with elderly stereotype by unscrambling sentences relevant to stereotype. Those primed walked more slowly down hall

- **Arousal** (O’Brien & Crandall, 2003)

- **Reduced working memory load** (Beilock et al., 2007)

- **Regulatory focus** (Seibt & Förster, 2004)
Connecting Stereotype Threat and Regulatory Fit

- Seibt and Förster (2004)
  - Positive stereotype induces promotion; negative stereotype induces prevention
  - Promotion induces more elaborative processing while prevention induces more vigilant processing
- Others…
Framework

Positive stereotype ("Promotion")

Negative Stereotype ("Prevention")

Gains

Fit

Mismatch

Losses

Mismatch

Fit

Stereotype Threat

Stereotype "Threat"?

Regulatory fit allow for more flexible cognitive processing
Flexibility Predictions

Positive stereotype ("Promotion")
- Gains: Better
- Losses: Worse

Negative stereotype ("Prevention")
- Gains: Worse
- Losses: Better

Flexibility advantageous (rule-based)

Flexibility disadvantageous (information-integration)
Experiments 1 and 2: Flexibility Advantageous
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Positive stereotype</th>
<th>Negative Stereotype</th>
<th>Women</th>
<th>Men</th>
<th>Gains</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 1</td>
<td>Positive stereotype</td>
<td>Negative Stereotype</td>
<td>Women</td>
<td>Men</td>
<td>Fit</td>
<td>Mismatch</td>
</tr>
<tr>
<td>Experiment 2</td>
<td>Positive stereotype</td>
<td>Negative Stereotype</td>
<td>Women</td>
<td>Men</td>
<td>Fit</td>
<td>Mismatch</td>
</tr>
</tbody>
</table>
Stereotype Prime Example: Women are better in gains task

This is an experiment testing sex differences in spatial abilities. Previous research has shown that women perform better than men on tests of spatial ability.

In this experiment, you will earn some points for correct responses and no points for incorrect responses. In this task, women tend to earn more than 86 points per block of trials and men tend to earn fewer than 86 points per block of trials.

Please try your best in this task. Before continuing, please indicate whether you are male or female. If you are male, press the "M" key. If you are female, press the "F" key.
Experiment 1: Women Positive Stereotype

Experiment 2: Men Positive Stereotype
Model Results

Experiment 1: Women Positive Stereotype

Experiment 2: Men Positive Stereotype
Conclusions

- Stereotype threat manipulations led to behavior also observed under a prevention focus.
- When flexible strategy use is advantageous:
  - a negative stereotype is disadvantageous in a gains condition.
  - a negative stereotype is ADVANTAGEOUS in a losses condition.
Flexibility Predictions

Positive stereotype ("Promotion")
- Gains: Better
- Losses: Worse

Negative Stereotype ("Prevention")
- Gains: Worse
- Losses: Better

Flexibility advantageous (rule-based)

Flexibility disadvantageous (information-integration)
Information-integration Classification
<table>
<thead>
<tr>
<th>Experiment</th>
<th>Positive stereotype</th>
<th>Negative Stereotype</th>
<th>Gains</th>
<th>Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment 3</td>
<td>Men</td>
<td>Women</td>
<td>Fit</td>
<td>Mismatch</td>
</tr>
<tr>
<td>Experiment 4</td>
<td>Women</td>
<td>Men</td>
<td>Mismatch</td>
<td>Fit</td>
</tr>
<tr>
<td>Experiment 4</td>
<td>Positive stereotype</td>
<td>Women</td>
<td>Fit</td>
<td>Mismatch</td>
</tr>
<tr>
<td>Experiment 4</td>
<td>Negative Stereotype</td>
<td>Men</td>
<td>Mismatch</td>
<td>Fit</td>
</tr>
</tbody>
</table>
Task Accuracy
(Preliminary data)

Experiment 3: Men Positive Stereotype

Experiment 4: Women Positive Stereotype

Positive Stereotype = worse performance
Hypothesis supported for gains, but not losses
Preliminary Conclusions

When flexible strategy use is disadvantageous:

- a negative stereotype is ADVANTAGEOUS in gains and losses conditions.

- Data collection and modeling is ongoing.
Application 3: Choking Under Pressure

Markman, Maddox & Worthy (2006; Psychological Science)
Choking Under Pressure

- Anecdotal phenomenon (e.g. sports, test-taking, etc.)

- Much like stereotype threat, people perform worse than normal when under pressure

- Might pressure be similar to a prevention focus?
Choking Under Pressure

- Basketball data
- Free throw during last minute of game

Proportion of Free-Throws Made Relative Career Averages

![Chart](image)
Categorization Tasks

Rule-Based

Information-Integration
Method

- Gains only
- Low pressure – “do your best”
- High pressure:
  - Paired with a ‘partner’
  - If both of you reach criterion, both get $6
  - If one of you fails neither get $6 bonus
  - Partner reached criterion

<table>
<thead>
<tr>
<th>Low-Pressure</th>
<th>High-Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule-based</td>
<td>Rule-Based</td>
</tr>
<tr>
<td>Low-Pressure</td>
<td>High-Pressure</td>
</tr>
<tr>
<td>Information-</td>
<td>Information-</td>
</tr>
<tr>
<td>Integration</td>
<td>Integration</td>
</tr>
</tbody>
</table>
Predictions

- **Rule-based:**
  - Low pressure = Fit = flexible = good performance

- **Information-integration:**
  - Low pressure = Fit = flexible = poor performance

<table>
<thead>
<tr>
<th></th>
<th>Low Pressure</th>
<th>High Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rule-Based</strong></td>
<td>Fit: Good</td>
<td>Mismatch: Poor</td>
</tr>
<tr>
<td><strong>Information-integration</strong></td>
<td>Fit: Poor</td>
<td>Mismatch: Good</td>
</tr>
</tbody>
</table>
Results

Accuracy

<table>
<thead>
<tr>
<th>Information-Integration</th>
<th>Rule-Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure</td>
<td></td>
</tr>
<tr>
<td>Low Pressure</td>
<td></td>
</tr>
<tr>
<td>Proportion Correct</td>
<td></td>
</tr>
<tr>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>0.56</td>
<td></td>
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<tr>
<td>0.58</td>
<td></td>
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<tr>
<td>0.60</td>
<td></td>
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<tr>
<td>0.62</td>
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<td>0.64</td>
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<td>0.66</td>
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<tr>
<td>0.68</td>
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<tr>
<td>0.70</td>
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<tr>
<td>0.72</td>
<td></td>
</tr>
</tbody>
</table>
More low pressure (fit) subjects were best fit by the rule-based models.

More high pressure (mismatch) subjects are random.
Information integration modeling

- More high pressure subjects best fit by an information integration model.
- More low pressure subjects random.
Summary

- Pressure does appear to operate like a prevention focus during classification learning (at least with gains).

- Pressure (a mismatch with gains) hurts rule-based learning, but helps information-integration learning.

- Extensions to highly learned categories are ongoing.
Application 4: Choice-Gambling Task

Worthy, Maddox & Markman (in press; Psychonomic Bulletin and Review)
PICK A CARD!

Yes: 450
Bonus: 0
No: 174
PICK A CARD!

Yes
Bonus
No

450
181
0
PICK A CARD!

- Yes: -450
- Bonus: -311
- No: 0
PICK A CARD!

Yes

Bonus

No

-315

-450
Deck Characteristics

- Experiment 1: Flexibility (exploration) is good
  - Disadvantageous deck early becomes advantageous as more samples are taken

- Experiment 2: Flexibility (exploration) is bad
  - One deck advantageous
Flexibility Predictions

- Promotion
  - Better (Gains)
  - Worse (Losses)

- Prevention
  - Worse (Gains)
  - Better (Losses)

Flexibility disadvantageous

Flexibility advantageous
Flexibility is Advantageous Results

Average Distance from Criterion

Points Below Criterion

-40 -35 -30 -25 -20 -15 -10 -5 0

GAIN LOSS

Promotion Prevention

[Diagram showing bar graph with categories GAIN and LOSS, and labels for Promotion and Prevention]
Flexibility is Disadvantageous

Results

Average Distance from Criterion

-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0

Point Below Criterion

Promotion
Prevention
Model-based Analyses

- Applied a version of the softmax action selection model to individual subject data (Sutton, Barto, Daw, etc)

- Model estimates probability of selecting each deck based on estimated value.

- Includes an exploration/exploitation parameter
Modeling Results

Exploration/Exploitation Parameter Values

- **Promotion**
- **Prevention**

Flexibility is Good

Flexibility is Bad
Summary

- Regulatory Fit hypothesis applies to choice.
- Fit leads to greater exploration.
- Extensions to decks that require numerous switches are ongoing.
Application 5: Signal Detection
Overview

- Two-stimulus identification (line length)
  - 100ms exposure durations, 2 pixel length difference
  - Promotion/Prevention x Gains/Losses
  - Payoffs biased toward “short” mouth
Results: Sensitivity (d’)

<table>
<thead>
<tr>
<th>Block (100-trials per block)</th>
<th>Promotion-Gain</th>
<th>Promotion-Loss</th>
<th>Prevention-Gain</th>
<th>Prevention-Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
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<tr>
<td>3</td>
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<tr>
<td>Overall</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Results: Sensitivity ($\beta$)

![Graph showing sensitivity results for different blocks and conditions]

- **Promotion-Gain**
- **Promotion-Loss**
- **Prevention-Gain**
- **Prevention-Loss**

Block (100-trials per block)
Summary

- Predicted fit to lead to better decision criterion learning.
  - Prediction unsupported.

- Fit increased sensitivity.

- Studies with more extensive training are ongoing.

- Applications to depressed patients ongoing.
Overall Summary

- We outline a framework for understanding the motivation-learning interface.
- Global: promotion/prevention focus
- Local: gains/losses
- Most research involves a promotion focus and gains.
- We propose that a fit leads to more flexible (exploratory) processing
- This may or may not be advantageous
- We apply this to several domains
  - Classification, choice, signal detection
Open Questions

- Does a fit imply:
  - More efficient exploration of the strategy space, or
  - Less evidence to abandon a rule?

- Is flexibility always from simple to complex rules?
  - Bias toward complex rule initially, then gradually introduce simple rule that yields bonus.

- What is the relationship between exploration in the verbal rule-space and in the card task?
Future Directions

- Understand mental disorders
- Many disorders lead to cognitive deficits
  - Do these reflect disruptions of information processing?
  - Perhaps they reflect motivational issues
  - Anxiety disorders may lead to chronic prevention focus
  - Could lead to regulatory mismatches
Collaborators/Funding

Darrell Worthy
Lisa Grimm
Brian Glass
Grant Baldwin

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