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# The Motivation-Cognition Interface in Learning and Decision-Making

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## Abstract

In this article we discuss how incentive motivations and task demands affect performance. We present a three-factor framework that suggests that performance is determined from the interaction of global incentives, local incentives, and the psychological processes needed to achieve optimal task performance. We review work that examines the implications of the motivation-cognition interface in classification, choice and on phenomena such as stereotype threat and performance pressure. We show that under some conditions stereotype threat and pressure accentuate performance. We discuss the implications of this work for neuropsychological assessment, and outline a number of challenges for future research.

### Keywords

motivation; regulatory focus; stereotype threat; choking under pressure; classification; learning

## INTRODUCTION

How do incentives influence our motivation to think, act, and choose? Despite the importance of this topic, scientists are only beginning to understand the answer to this question. In this article, we start with the general question, “What does it mean to “motivate” someone to do “well” in a task, and how do we achieve this aim?” A common belief, and one espoused by many scientists, is that motivating someone involves getting them to “try harder.” “Try harder” is usually defined in terms of some local performance goal such as the number of tasks performed correctly, without a clear definition of what is required by the task to perform correctly. Motivational strategies to get people to “try harder” often involve offering some global positive incentive for good performance such as a promotion, a bonus, or praise that aim to boost interest in the task or a sense of self-efficacy (e.g., Locke & Latham, 2002). How many parents have offered monetary incentives for grades ($10 for each B, $20 for each A, etc) hoping to motivate their teenager to maximize GPA?

## A FRAMEWORK FOR THE MOTIVATION-COGNITION INTERFACE

Our research assumes that understanding the influence of incentives on thinking requires tasks for which the cognitive demands are well-understood (Markman, Beer, Grimm, Rein, & Maddox, 2009).Critically, this involves the application of formal modeling techniques that allow the researcher to dissect the task and isolate the underlying cognitive processes

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(Maddox & Ashby, 1993, , 2004). Using this approach, we find that there is a three-way interaction between global incentives, local incentives and the task demands associated with optimizing performance that determines the influence of an incentive on performance. Global incentives can involve approaching positive outcomes such as a promotion or a bonus, but can also involve avoiding negative outcomes such as avoiding a pay cut or a demotion. These are referred to as "promotion" foci and "prevention" foci, respectively, by Higgins (1997). Local incentives can involve maximizing performance indices such as the number of tasks performed correctly or the number of widgets manufactured correctly, but can also involve avoiding losses such as the number of task mistakes, or defective widgets produced. Finally, task demands, and the types of strategies necessary to perform well, are critical. Sometimes optimal performance on a task involves active, effortful exploration of a set of response strategies, referred to as cognitive flexibility. Flexible cognitive processing recruits explicit processes that are working-memory intensive. At other times, optimal performance involves exploiting a currently active strategy and avoiding alternative response strategies. This inflexible mode of responding recruits implicit (non-working-memory intensive) processes.

The general finding in our research is that a "match" between the global incentive and the local incentive leads to more flexible and exploratory cognitive processing than a mismatch (e.g., Maddox, Baldwin, & Markman, 2006). We illustrate this idea with a simple example. Imagine an employee in the Research and Development office at a widget factory, who has to find creative ways to make more widgets. This employee might be given a global approach incentive that if a particular sales goal is reached, she will get a large bonus. This is an approach incentive because she is trying to achieve something desirable. Alternatively, this employee could be promised a bonus and told she will get to keep it as long as a sales goal is met. This is an avoidance incentive because she is trying to avoid an undesirable outcome. Economically, these two incentives are the same, because the employee will get the bonus only if the sales goal is met.

The sales goal itself (the local incentive) can either be framed in terms of dollars in sales obtained (a local approach incentive) or in terms of dollars in potential sales lost (a local avoidance incentive). A match between the global and local incentive occurs either when a global approach incentive is paired with a local approach incentive or when a global avoidance incentive is paired with a local avoidance incentive. In both cases, the employee is most likely to think flexibly. Given that her job requires flexibility and creativity, she is more likely to be successful at her job given a match than given a mismatch.

Imagine a second employee who works on the Widget Production Line. His job requires making widgets using a known procedure. This employee's job requires perseverance, and so flexibility in cognitive processing is not a good thing. This employee might be promised a bonus if a particular widget production goal is met (global approach incentive), or might be promised a bonus and told he will get to keep it as long as a widget production goal is met (global avoidance incentive). The production goal could either be framed in terms of widgets successfully produced (a local approach incentive) or defective widgets successfully avoided (a local avoidance incentive). For him, a mismatch between the global and local incentives will lead to better performance than a match because a mismatch decreases cognitive flexibility that, in this case, is good. This pattern is summarized in Figure 1. Although future research needs to address why this complex interaction is observed (discussed in detail later), as the following sections make clear, the three-way interaction is robust across a broad range of domains.

## MOTIVATION AND CLASSIFICATION LEARNING

The first domain in which we studied this framework was classification learning. This domain is ideal for examining the influences of motivation both because quick and accurate classification is a crucial survival skill and because much is known about the underlying processes people use to learn to classify new items. Our work focuses on two kinds of classification problems: rule-based and information integration. Rule-based tasks are ones for which there is a rule people can state verbally that maximizes people's accuracy in the task. For example, the rule “Red on yellow, kill a fellow; red on black, friend of Jack” distinguishes the poisonous coral snake from similar nonpoisonous snakes. Information integration tasks are ones for which the criterion that distinguishes between the categories cannot be stated sensibly in words. For example, radiologists are able to diagnose tumors on x-rays, but have a hard time describing the qualities that distinguish between x-rays depicting tumors and normal x-rays.

Learning a new rule-based classification requires cognitive flexibility because many potential rules are available and must be tested and accepted or rejected explicitly. In contrast, information integration learning favors perseverance, because it involves conditioning of stimulus-response associations that require many trials to acquire. In fact, testing and accepting or rejecting explicit rules (i.e., cognitive flexibility) is disadvantageous for information-integration learning.

In classification tasks, the global incentive consists of an entry into a drawing to win cash. People given an approach incentive get a ticket if their performance exceeds a criterion. People given an avoidance incentive receive the ticket at the start of the study and are allowed to keep it if their performance exceeds a criterion. However, the conditions differ in whether people are trying to achieve the ticket or avoid losing it. The local incentives in this task are points that lead to the performance criterion. In the local approach condition, people gain points, but get more points if they are correct than if they are incorrect. In the local avoidance condition, people lose points, but they lose fewer points if they are correct than if they are incorrect.

The results of our study reflect the task analysis. A match between the global and local incentives leads to faster rule-based learning than does a mismatch because a match leads to increased cognitive flexibility. In contrast, a mismatch between the global and local incentives leads to faster information integration learning than does a mismatch because a mismatch leads to a decrease in cognitive flexibility and thus less explicit rule processing. (L.R. Grimm, Markman, Maddox, & Baldwin, 2007; Maddox, Baldwin, & Markman, 2006). We illustrate this pattern of results in Figure 2.

## MOTIVATION AND CHOICE

In the domain of choice, Worthy et al. (2007) found a similar pattern of results. In this task, people were presented with two decks of cards. On each trial, they chose a card from one of the decks and received a certain number of points (in the local approach condition) or lost a certain number of points (in the local avoidance condition). They continue choosing from one deck at a time with the goal of maximizing gains or minimizing losses. As in the classification studies, there was a global approach incentive to earn an entry into a cash drawing, or a global avoidance incentive to keep an entry given upon arriving at the lab.

In this task, exploratory behavior means selecting from the decks that do not currently yield the highest payoffs. This requires a form of cognitive flexibility. On the other hand, exploitative behavior means selecting from the decks that currently yield the highest payoffs. This does not require flexibility. We examined performance in versions of the task

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that favored exploring decks or exploiting the best deck. Participants with a match between the global and local incentives were systematically more exploratory in their choices than people with a mismatch. This was verified based on performance as well as from an exploration parameter in a reinforcement learning model that we developed. Thus, the people with a match were better when exploration was optimal, but were worse when exploitation was optimal, because people in a match were more exploratory overall.

## MOTIVATION AND STEREOTYPE THREAT

The global motivational state need not be induced by an explicit reward. For example, research on stereotype threat documents performance decrements resulting from the activation of a negative task-relevant stereotype (Steele & Aronson, 1995; Steele, Spencer, & Aronson, 2002; Stone, Lynch, Sjomeling, & Darley, 1999). For example, there is a pervasive stereotype in the USA that women are worse at math than men, and that stereotype leads women to perform worse than men of equal ability on math assessments. Grimm, Markman, Maddox and Baldwin (2009) suggested that stereotype threat can be reinterpreted as a mismatch between global and local incentives by drawing upon prior work suggesting that negative stereotypes induce a global avoidance incentive (Seibt & Forster, 2004).

If this is correct, then stereotype threat effects may reflect that those with a negative self-relevant stereotype are experiencing a mismatch between a global incentive (trying to avoid confirming the stereotype) and the local incentives of the task (gaining correct answers). On this view, stereotype threat effects should be eliminated when there are local avoidance incentives. Grimm et al (2009) found support for this hypothesis in a series of studies. For example, in one experiment using a chronic stereotype (gender) women underperformed men on a set of GRE math problems when they gained points for correct answers (a local approach incentive), but women who lost points during the study (a local avoidance incentive) performed just as well as the men.

## MOTIVATION AND PERFORMANCE PRESSURE

The detrimental effects of pressure on cognitive task performance (i.e., choking under pressure) are thought to be caused by interference with the ability to use explicit strategies or by sub-optimal levels of arousal (ala the Yerkes-Dodson law). This view suggests that pressure hurts performance in tasks that require learning a verbal rule, but improves performance in tasks for which explicit strategies hamper performance.

Worthy, Markman and Maddox (2009) suggested that the pressure may act like a global avoidance incentive. On this view, negative effects of pressure can be reversed by using local avoidance incentives that emphasize minimizing losses. Consistent with this hypothesis, Worthy et al. found a three-way interaction between pressure, local incentives, and the task demand. In the rule-based task, people under pressure performed better when asked to minimize losses on each trial, whereas control participants performed better when asked to maximize gains. In contrast, in the information-integration task, people under pressure performed better when asked to maximize gains, whereas control participants performed better when asked to minimize losses. These findings go beyond explanations such as the Yerkes-Dodson law or distraction hypotheses, which do not predict an interaction between local and global incentives.

## IMPLICATIONS AND CHALLENGES FOR FUTURE RESEARCH

This pattern of results is complex, but it clarifies why studying the effects of motivation on performance has been so difficult. There are no consistent main effects of global approach and avoidance incentives, nor are there consistent effects of local approach and avoidance incentives. Furthermore, whether a particular combination of global and local incentives yields good or bad performance in a particular situation depends on whether the task requires flexibility.

This interaction raises a number of implications for other areas of research. There are many situations in which there are group differences in behavior that may reflect differences in motivational states. For example, studies of clinical populations use tests of executive function and demonstrate differences in performance on these tasks between the clinical population and normal controls. Clearly some disorders may influence people's ability to carry out cognitive tasks. However, other disorders such as depression and anxiety have been shown to lead to cognitive deficits, which may reflect differences in motivational states between patients and controls rather than differences in the capacity to think. Permanent trait (personality) variables, such as impulsivity have clear motivational effects on cognition (Pickering, 2004).

There are a number of research challenges ahead. The primary challenge is to understand why this complex interaction is observed. It is clear that the influence of a match between the global and local incentive on task performance is a robust phenomenon, but it is less clear at present why it is observed. In our studies, we often collect additional measures that might provide insight into the source of the effect such as measures of state anxiety or of working memory. At present, none of these measures explains the observed interaction.

In our view, there are two approaches that provide the best avenues for answering this important question. One is to delve further into formal quantitative modeling formulations. Formal models allowed us to identify the cognitive operations necessary to solve each task, and thus provided the necessary tools for understanding the effects of motivation on cognition. The next step will be to formalize our motivational framework by investigating components of currently successful models such as the Expectancy Valence model (Busemeyer & Stout, 2002). A second avenue is to take a cognitive neuroscience approach to the motivation-cognition interface by attempting to identify the neural systems associated with a match or a mismatch. One intriguing possibility is that a match associated with a global and local approach incentive might be mediated by a different neural system from a match associated with a global and local avoidance. Ultimately, this understanding of motivation is crucial for theories of cognition.

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## Recommended Readings


Higgins ET. Making a good decision: Value from fit. American Psychologist. 2000; 55:1217–1230. [PubMed: 11280936] [An accessible introduction to regulatory focus, and the influence of regulatory fit on preference]

Beilock SL, Kulp CA, Holt LE, Carr TH. More on the fragility of performance: Choking under pressure in mathematical problem solving. Journal of Experimental Psychology: General. 2004; 133(4):584–600. [PubMed: 15584808] [A comprehensive discussion of choking under pressure along with some important experiments]

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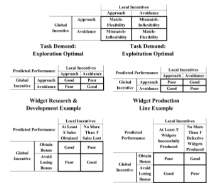

**Figure 1.**
(top) Overview of the motivation-cognition framework. When a global approach incentive is paired with a local approach incentive or when a global avoidance incentive is paired with a local avoidance incentive there is a match that leads to more flexible, exploratory cognitive processing. When a global approach incentive is paired with a local avoidance incentive or when a global avoidance incentive is paired with a local approach incentive there is a mismatch that leads to less flexibility and greater perseveration in cognitive processing. (middle left) Predicted performance when flexible, exploratory cognitive processing is optimal. Under these conditions a match is predicted to yield good performance, whereas a mismatch is predicted to yield poor performance. (middle right) Predicted performance when inflexible, perseverative cognitive processing is optimal. Under these conditions a mismatch is predicted to yield good performance, whereas a match is predicted to yield poor performance. (lower left) Predicted performance for a hypothetical situation in which an employee working in the Research and Development office in a widget factory needs to identify creative ways to make more widgets. The global incentive can be to obtain a bonus if a particular sales goal is met (approach incentive), or to be promised a bonus that can be lost if that sales goal is not met (avoidance incentive). The sales goal can be framed in terms of dollars in sales obtained (approach incentive) or in terms of dollars in potential sales lost (avoidance incentive). Because flexibility is advantageous, a match yields good performance whereas a mismatch yields poor performance. (lower right) Predicted performance for a hypothetical situation in which an employee working on the Production Line in a widget factory needs to persevere and continue to make widgets using a known procedure in an optimal fashion. The global incentive can be to obtain a bonus if a particular production goal is met (approach incentive), or to be promised a bonus that can be lost if that production goal is not met (avoidance incentive). The production goal can be framed in terms of widgets successfully produced (approach incentive) or in terms of defective widgets successfully avoided (avoidance incentive). Because perseverance (not flexibility) is advantageous, a mismatch yields good performance whereas a match yields poor performance.

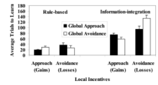


**Figure 2.**

Average number of trials needed to learn the rule-based and information-integration categories from Grimm, Markman, Maddox & Baldwin (2007). Overall, the rule-based categories are learned more easily than the information-integration categories. Of most relevance, however, is that rule-based learning is faster under a match for the rule-based task, but is faster under a mismatch for the information-integration task.




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