The Motivation–Cognition Interface in Learning and Decision Making

W. Todd Maddox and Arthur B. Markman
University of Texas

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 and 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

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 that person to "try harder." Trying 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 the task requirements are. 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 is meant to boost interest in the task or increase a person's 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.) in hopes of motivating their teenager to maximize his or her GPA?

A Framework for the Motivation–Cognition Interface

Our research assumes that studying the influence of incentives on thinking requires experimental 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

(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. Higgins (1997) refers to these as promotion foci and prevention foci, respectively. *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.

Corresponding Author:
W. Todd Maddox, 1 University Station A8000, Department of Psychology, University of Texas, Austin, Texas 78712
E-mail: Maddox@psy.utexas.edu

Table 1. Predicted Cognitive Processing and Performance From Matches and Mismatches Between Global and Local Incentives (Motivation–Cognition Framework)

Global incentive	Local incentive	
	Approach	Avoidance
Approach	Match—flexibility Optimal for exploration task	Mismatch—inflexibility Optimal for exploitation task
Avoidance	Mismatch—inflexibility Optimal for exploitation task	Match—flexibility Optimal for exploration task

Table 2. Widget Research and Development Performance as Predicted by Motivation–Cognition Framework

Global incentive	Local incentive	
	At least X sales obtained	No more than Y sales lost
Obtain bonus	Good	Poor
Avoid losing bonus	Poor	Good

Table 3. Widget Production Line Performance as Predicted by Motivation–Cognition Framework

Global incentive	Local incentive	
	At least X widgets successfully produced	No more than Y defective widgets produced
Obtain bonus	Poor	Good
Avoid losing bonus	Good	Poor

The general finding in our research, summarized in Table 1, is that a "match" between the global incentive and the local incentive leads to more flexible and exploratory cognitive processing than does a mismatch (e.g., Maddox, Baldwin, & Markman, 2006). We illustrate this idea with two simple examples, both from a widget factory. In the first example (Table 2), imagine an employee in the Research and Development office at a widget factory, who has to find creative ways to make more widgets (this requires cognitive flexibility). 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 be framed either 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 incentives 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 rather than inflexibly. Given that her job requires flexibility and creativity, she is more likely to be successful at her job when there is a match than when there is a mismatch.

Imagine a second employee who works on the Widget Production Line (Table 3). 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 be framed either in terms of widgets successfully produced (a local approach incentive) or in terms of defective widgets successfully avoided (a local avoidance incentive). For him, a mismatch between the global and local incentives will lead to better performance than will a match

because a mismatch decreases cognitive flexibility that, in this case, is good. 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.
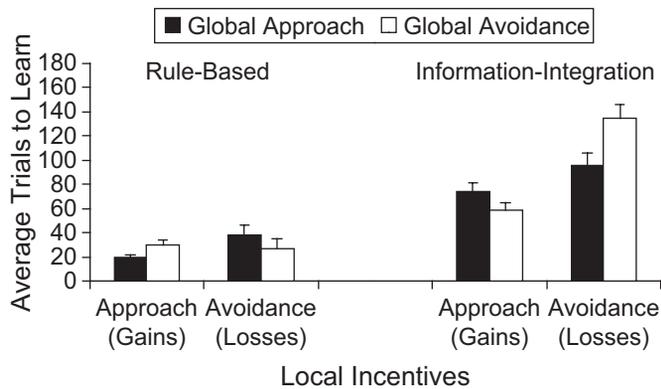
Fig. 1. Average number of trials needed to learn the rule-based and information-integration categories from Grimm, Markman, Maddox, and Baldwin (2008). The global approach incentive was an entry into a drawing for a 1-in-10 chance to win $50. The global avoidance incentive was the possibility of losing an entry into a drawing for a 1-in-10 chance to win $50 that was given to the participant at the start of the experiment. The local approach incentive was to obtain 10 correct responses in a row. The local avoidance incentive was to obtain a set number of correct responses in a row. The starting goal was 5 in a row, but for every incorrect response, the goal was increased by 1.

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. (Grimm, Markman, Maddox, & Baldwin, 2008; Maddox et al., 2006). We illustrate this pattern of results in Figure 1.

Motivation and Choice

In the domain of choice, Worthy, Maddox, and Markman (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 continued 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 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 were 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 United States 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 suboptimal levels of arousal (a la the Yerkes-Dodson law—that is, the law that states the performance increases with arousal but only up to a point, after which performance begins to decline). 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.

Recommended Readings

Beilock, S.L., Kulp, C.A., Holt, L.E., & Carr, T.H. (2004). More on the fragility of performance: Choking under pressure in mathematical problem solving. *Journal of Experimental Psychology: General, 133*, 584–600. A comprehensive discussion of choking under pressure along with some important experiments.

Grimm, L.R., Markman, A.B., Maddox, W.T., & Baldwin, G.C. (2009). (See References). An accessible introduction to the use of regulatory fit to understand stereotype threat.

Higgins, E.T. (2000). Making a good decision: Value from fit. *American Psychologist, 55*, 1217–1230. An accessible introduction to regulatory focus, and the influence of regulatory fit on preference.

Maddox, W.T., & Filoteo, J.V. (2007). Modeling visual attention and category learning in amnesiacs, striatal-damaged patients, and normal aging. In R.W.J. Neufeld (Ed.), *Advances in clinical-cognitive science: Formal modeling and assessment of processes and symptoms* (pp. 113–146). Washington, DC: American Psychological Association. A helpful tutorial describing classification learning strategies, formal modeling, and the use of formal modeling procedures to isolate the cognitive processes necessary to perform a task.

Worthy, D.A., Markman, A.B., & Maddox, W.T. (2009). (See References). A demonstration of the complete three-way regulatory focus interaction using social pressure as a motivational factor.

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Steele, C.M., Spencer, S.J., & Aronson, J. (2002). Contending with group image: The psychology of stereotype and social identity threat. In M. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 34, pp. 379–440). New York: Academic Press.

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