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Brain-based cognitive processes that underlie feedback between adult students and instructors

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Abstract: Feedback is ranked among the top 5 to 10 highest influences on academic achievement. Recent advances in neurosciences enable understanding feedback in post-secondary settings as a reciprocal process that is mediated by brain-based cognitive processes common to both students and instructors. We describe three of these processes. The first process explains how feedback often involves tacit emotional responses. The second process highlights how prior experiences with feedback influence current experience. The last process relates to the development of personal mental models of feedback. We offer a set of implications for best practices based on these cognitive processes shared by students and instructors.

Introduction

Feedback is ranked among the top 5 to 10 highest influences on academic achievement (Hattie & Timperley, 2007). Feedback is a predominant basis of communication between instructors and students in post-secondary education contexts and the primary means by which instructors can support students in developing lifelong learning skills. Feedback, defined as information perceived by an individual from any source about the nature and extent to which current performance states approximate goal or desired performance states (Kluger & DeNisi, 1996), can originate from a variety of sources, including one's self and non-human sources such as computers. Performance states and feedback can relate to tasks as well as cognitive processes (Butler & Winne, 1995). In post-secondary academic contexts instructors are frequently the primary source of feedback information for students. In turn, when students respond to instructor feedback, they provide information back to instructors. Instructors and students are participants in a reciprocal process that is mediated by brain-based cognitive processes common to both. To fully realize the impact feedback can have on promoting student development, instructors need to understand the nature of these brain-based processes.

In this paper we address the need to explain variability in individuals' experience with feedback. We describe the strengths and shortcomings of traditional approaches to examining feedback and then describe three brain-based cognitive processes shared by students and instructors. We conclude the paper with implications for instructors and students to optimize their feedback experiences.

Problem

Feedback has great potential to support student learning and performance outcomes; it also has great potential to impede them. In their 1996 meta-analysis of 607 effect sizes extracted from 131 studies, Kluger and DeNisi concluded that across a variety of academic contexts, feedback had a moderate positive effect on performance (average *ESsm* = .41); however 38% of the effects were negative. In a more comprehensive synthesis of 74 meta-analyses Hattie and Timperley (2007) found a similar average effect size and wide range in the effects for different strategies, from *ESsm* = 1.10 for cuing to *ESsm* = -.14 for programmed instruction. Experiences of students and instructors are consistent with these empirical findings. Students can clearly recall events in which they received "negative feedback" and their desire to try again quickly faded. They can also describe feedback exchanges with instructors that were particularly helpful, where gaps in performance became opportunities for further learning. Instructors, too, experience variability in their feedback exchanges with students. A strategy that worked well with one student can appear to have no influence on another student. Clearly, a greater understanding of the nature of feedback is needed that can help explain variability in individuals' experience with feedback and in its impact on learning and performance.

Background

Prior researchers have conceptualized feedback in academic settings in terms of feedback providers and receivers. Customarily, instructors have been assigned the role of feedback provider and students the role of feedback receiver. Prior researchers have explored experiences unique to each role. For example, Butler and Winne (1995) developed a model of feedback that provides valuable insights into the experiences of students as receivers of feedback. In their conceptual model of feedback in self-regulated learning, Butler and Winne described learners' perceptions and beliefs as a "lens" or "filter" through which they recognize, interpret, and apply feedback. In this model prior academic experiences, task and domain knowledge, and beliefs about learning all contribute to individual differences in how learners experience internal as well as external feedback. Kluger and DeNisi (1996) also focused on the role of students in their Feedback Intervention Theory based on a meta-analysis of feedback studies. The model includes factors and processes related to the self that influence feedback recipients' persistence and performance. The authors explained that learners have "affective reactions" (p. 266) to feedback that can influence attention to task details and utilization of resources. Learners can also form "erroneous hypotheses" (p. 265) about the nature of tasks, leading to ineffective changes in behavior.

Other researchers have focused on the role of feedback providers. In their model of feedback to enhance learning Hattie and Timperley (2007) described a variety of ways instructors can maximize the impact of feedback. They discriminated among four levels of feedback (task, process, self-regulation, and self) that can inform students about "Where am I going? How am I going? And Where to next?" (Hattie & Timperley, 2007, p. 89). Nicol and McFarlane-Dick (2006) offered another model highlighting the role of feedback providers. They critiqued the commonly held view that the primary role of instructors is to "transmit" feedback messages to students, and offered instead seven principles of good feedback practice for supporting students' own internal self-regulatory and feedback processes. Finally, Shute (2008) described factors related to instructional context, learner characteristics, and feedback elements to which instructors must attend to maximize formative feedback. Specifically, instructors must attend to the content of feedback, its function, and its mode of presentation as well as to understanding learners' prior experience, knowledge, and motivations related to the task.

The work of researchers like Hattie and Timperley (2007), Nicol and McFarlane-Dick (2006), and Shute (2008) benefit instructors by describing specific strategies instructors can use to optimize the impact of feedback for learners and by providing rationales for the strategies. These models fall short, however, in explaining the cognitive processes that underlie instructors' experiences in planning, enacting, and assessing the strategies they use. Researchers have exerted much more effort to understanding factors that impact students' experiences with feedback than instructors' experiences with feedback. Recent advances in neurosciences provide insights into cognitive processes experienced by both students and instructors during feedback. The processes lend support to a view of feedback as a reciprocal process that is mediated by brain-based activities common to both students and instructors; where engagement in feedback is a meaning-making and learning experience for both and the line between provider and receiver quickly become blurred.

Brain-based Cognitive Processes that Underlie Feedback

Seminal works that shaped perspectives and practices about feedback were completed prior to advances in neuroimaging technologies, such as functional magnetic resonance imaging (fMRI), that can locate and record neural activity in the brain associated with specific cognitive and physical activities. For example, students' "affective reactions" to feedback described by Kluger and DeNisi (1996) can now be explained in terms of activity in parts of the limbic system associated with emotional response to external stimuli. Researchers have yet to use fMRI to specifically examine brain activity during feedback exchanges between students and instructors in post-secondary settings. Nonetheless, by applying the outcomes of available studies adult educators can begin to appreciate neurocognitive processes common to both students and instructors engaged in feedback. Because prior experience plays a fundamental role in these processes, they are particularly relevant when both students and instructors are adults who bring to each new learning opportunity a unique set of prior experiences that can influence the ways they prepare, perceive, interpret, and apply feedback.

Experiences with Feedback Can Trigger Strong Emotional Responses

The brain receives signals from two sources: the external world is the source of exteroceptive signals and the internal world of the body is the source of interoceptive signals (Damasio, 2003). With the exception of olfactory signals, exteroceptive signals are first processes by the thalamus, a key component of the limbic system. If the signals represent an experience in one's environment that is new, unexpected, and/or especially strong, i.e., an experience that should be remembered, the thalamus sends neural messages to the amygdala. The amygdala coordinates an appropriate core emotional response to the stimuli. Each core emotional response (sadness, joy, fear, interest/surprise, anger, and disgust) is associated with a complex pattern of bodily responses coordinated by the brain stem, hypothalamus, and insula. Bodily responses can include increased heart rate, increased respiration, arterial constriction, skeletal muscle paralysis, crying, and facial expressions. These emotional responses happen at a tacit level. Only after information about the emotional response reaches the cerebral cortex will an individual have a conscious feeling associated with the response.

By attributing an emotional "tag" (Damasio, 2003) to experiences, the amygdala helps to ensure that attributes of an experience will be "mapped" in memory (consolidation) and available for retrieval (reconsolidation). The tag enables a coordinated and appropriate response to stimuli with similar attributes in the future. The memories associated with emotional responses and the physical reactions they may trigger also occur, initially, at a subconscious level (LeDoux, 1996). LeDoux (1996) contrasted this implicit emotional memory system coordinated by the amygdala to the explicit memory system coordinated by the hippocampus. Most individuals are familiar with the later memory system because it is responsible for the consolidation and reconsolidation of conscious memories; however, the emotional memory system exerts a powerful influence on thought and actions.

Because the content of feedback is invariably about the self (Kluger & DeNisi, 1996) in terms of gaps between current states and desired or goal states, feedback messages often trigger core emotional responses, particularly if the nature of the feedback was not expected. This is true for both students and instructors as recipients of feedback messages. All individuals have particularly strong emotional responses to circumstances in which feedback is associated with threat to safety or well-being. Human brains have evolved to have a "negativity bias" (Smith, Cacioppo, Larsen, & Chartrand, 2003) so that stressful experiences are marked with extra strong neurochemical signals to ensure they are remembered and similar experiences are avoided in the future. This can explain why meta-analyses of feedback studies consistently show that the lowest effects on performance are associated with feedback that threatens self-esteem, feedback administered in a controlling manner, and feedback when task complexity is very high (Hattie & Timperley, 2007). The brain's negativity bias can also explain why, in reviewing end-of-semester course evaluations, an instructor may glance over the more "positive" comments yet ruminate over one "negative" comment.

Features of Current Feedback Experiences Can Reactivate Memories of Prior Feedback Experiences

The second brain-based cognitive process follows directly from the first process in which feedback experiences are initially processed by the emotion center in the brain. When individuals engage in feedback, features of the experience are consolidated in memory. Garrett (2009) described consolidation as "the process in which the brain forms a more or less permanent physical representation of a memory" (p. 366). Both implicit and explicit memories are formed in this way. When engaged in feedback, students and instructor form their own memories of the exchange. Through an analogical mapping process (Holyoak, 2006), features of a new feedback experience are encoded and then "mapped" to similar features of prior experiences stored in memory. Analogical mapping occurs without intention and at a subconscious level. Interconnected sets of neuronal "maps" (Myer & Damasio, 2009) represent accumulated knowledge and emotions associated with feedback experiences. Because of this process, when a student or instructor is engaged in a new feedback exchange if features of the current exchange have similarity with features of prior feedback experiences, existing neuronal maps will be reactivated (Nyberg, Habib, McIntosh, & Tulving, 2000).

Reactivation of feedback memories based on similarities with current experiences is a key cognitive process underlying the use of cues in feedback. Researchers (e.g., Kluger & DeNisi, 1996) have long recognized cues as one of the most effective forms of feedback. Instructors can intentionally embed cues in their feedback messages to students to support self-regulation in learning. When students encounter the cues in future tasks the cues trigger students' memories associated with prior feedback enabling them to apply the feedback to new tasks on their own.

Reactivation of feedback memories can also impede learning if it involves reactivation of strong negative emotional responses associated with the memories. This is true for both students and instructors. For example, one adult student reported "freezing in fear" upon opening a document in which the instructor inserted comments in red type font. The red font triggered in the student a subconscious emotional fear response immediately followed by vivid memories of an especially harsh middle-school teacher who had a penchant for red pens. The unwitting instructor struggled to understand why this student was the only one in the class who did not schedule a mid-semester conference to review goals and progress. The student's lack of response became a message of feedback for the instructor, and the experience was mapped on to the instructor's existing knowledge and emotions associated with feedback.

Individuals' Mental Models of Feedback Shape Their Engagement in All Aspects of Feedback

In the example above, the instructor made incorrect assumptions in efforts to understand the student's inaction. Eventually the student shared his reaction with the instructor and the instructor corrected her assumptions; she also changed to blue font for all her comments from that point on. The instructor's experience can be explained in terms of a third brain-based process that can result in erroneous assumptions as well as correcting a course of action.

Because features of prior experiences are never a perfect match to features of current experiences, sets of related neuronal maps have "gaps" where matches are incomplete. These gaps are bridged through cognitive processes involving abstraction, generalization, and inference (Holyoke, 2005). A *schema* is a group of related abstractions in a specific domain. According to Markman and Gentner (2001) because schemata include components that are based on inferences they can be erroneous. *Mental models* represent even higher levels of abstraction and generalization of multiple schemata and include knowledge, goals, values, and beliefs. Due to differences in prior experience, adult students and instructors can have very different mental models in all aspects of feedback, including task, process, content, and function (Shute, 2008).

Mental models shape the choices individuals make regarding their learning (Eckert & Bell, 2006). Individuals may either not perceive or disregard feedback if it does not align closely with their current mental models (Orgnero, 2007). The cognitive processes involved in the development of mental models is consistent with Kluger and DeNisi's (1996) observation that with regard to feedback, learners develop hypothesis that guide their behavior "either until the results of the behavior match the hypothesis . . . or until one gives up on that hypothesis" (p. 263). Though mental models tend to be durable, they can change to accommodate new perspectives and experiences. Students and instructors can intentionally share their assumptions about feedback to develop shared mental models, defined as "a similar view of expectations and awareness about behaviors, abilities, knowledge, and skill levels; . . . understanding of the task and goals; and a mutual interpretation of shared events" (London & Sessa, 2006, p. 308).

Implications for Practice

The three brain-based cognitive processes experienced by both students and instructors engaged in feedback are interrelated and have implications for practice, especially for supporting adult students. Each feedback exchange between adult students and instructors is influenced by emotional responses associated with their respective prior experiences with feedback. Because of the brain's strong negativity bias, students and instructors need to frame their feedback messages in ways that are not perceived as degrading or threatening or they run the risk of breaking down the feedback cycle. In addition to emotions, mental models developed from past feedback experiences guide both students and instructors as they enter a new feedback exchange, and can either facilitate or impede the exchange. For these reasons both students and instructors need to make explicit and share their knowledge and assumptions about the purpose of feedback in terms of tasks and goals, as well as the processes and formats used to exchange feedback. Shared mental models of feedback establish the framework for students and instructors to learn from each other.

Currently a void exists in the adult education and learning literature with regard to applying advances in neuroscience to inform the practice of feedback. In this paper we have described three brain-based processes that help to explain concepts about feedback posited by earlier researchers. By understanding feedback in academic settings in terms of commonalities in experiences between students and instructors great potential exists to optimize adult learning.

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