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How the timing of performance feedback impacts individual performance☆

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ABSTRACT

Using a multi-step task setting where learning can help improve individual task performance, I experimentally examine the effect of the timing of performance feedback in an initial period on future task performance when this feedback is absent. I find an inverted-U relation between the timing of feedback and future performance. When feedback is provided before implementation of an initial decision, high learning costs discourage individuals from learning in the initial period to the detriment of future performance. Further, when feedback is provided after extended delays beyond implementation of a decision, learning costs increase relative to those present when feedback is provided after a short delay, resulting in lower learning and future performance. As such, I find that providing feedback immediately following implementation of a decision most effectively promotes learning and future performance as this is the point at which learning costs are lowest. My study extends prior research on feedback timing by incorporating the notion that learning costs fluctuate throughout the phases of a multi-step task and offers practical implications for designing performance evaluation and feedback systems.

1. Introduction

Firms and individuals often engage in developing novel or innovative output. For example, a pharmaceutical company may develop a new drug, a manufacturing company may design a novel advertising campaign, or a researcher may develop new theory to explain a phenomenon. Developing this type of output can be viewed as the result of a multi-step task, with the implementation of each step resulting in success or failure. An understanding of what constitutes success and failure at each step is often needed to learn how to achieve the final output (e.g., an effective new drug, increased sales due to the advertising campaign, or theory that both explains and predicts). A lack of learning can lead to unrecognized failure with its accompanying costs, making recognition of failure highly valuable to firms and individuals.

In these examples, those engaging in the task can receive guidance (e.g., from clinical trials, from focus groups, or from other researchers) in the form of feedback of whether or not the firm or individual is on the right or wrong track to achieving the successful final output. I refer to this form of feedback as decision-quality feedback. Decision-quality feedback can improve learning and performance, yet much less is known about *when* in a multi-step task to provide this feedback in order to maximize learning and future performance. Hence, this study seeks to shed light on the effect of performance feedback timing (i.e., the phase of the task when decision-quality feedback is provided) on performance, particularly its effect on learning as measured by future performance.

This research is important for a number of reasons. First, performance feedback about decision making within an organization contributes to employee motivation and is a critical feature of performance evaluation and feedback systems (Luckett & Eggleton,

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1991; Bonner & Sprinkle, 2002; Sprinkle & Williamson, 2007; Hannan, Krishnan, & Newman, 2008; Christ, Emett, Summers, & Wood, 2012). The timing of when to communicate performance feedback is particularly relevant because it is often under the discretion of management and is likely to substantially influence key outcomes of learning and performance.

Second, prior research on the effect of feedback timing has largely shown that delays in feedback *hurt* performance and learning (Brehmer, 1995; Diehl & Sterman, 1995; Gibson, 2000). However, this research has generally conceptualized feedback timing as just a *time* difference before receiving feedback and has not taken into consideration the timing of different *phases* of a task, each of which have unique informational and psychological characteristics. In essence, the timing of feedback in the current study is less about the actual passage of time and more about the ordinal phase in the task in which feedback is given. Key phases in a multistep task include the phase before implementing a decision, immediately following implementation of a decision, and sometime after implementing a decision. Given that prior research has omitted this key feature of feedback timing – that delays correspond to changes in the phases of a task – a fresh examination is warranted.

To accomplish this, I develop and test theory that posits an inverted-U relation between the timing of feedback and future performance, in which future performance increases in the delay of feedback up to a point (i.e., immediately following implementation of a decision) and then decreases with additional delay of feedback. When an individual performs a task in which learning is key to future performance, there are certain costs that the individual must incur in order to learn (i.e., learning costs). First, individuals must devote costly time and effort towards learning (Bonner & Sprinkle, 2002; Sprinkle, 2000). Second, individuals may need to incur additional psychological costs (e.g., apprehension, cognitive dissonance, reluctance, etc.) in order to learn (Edmondson, 1999; Gray & Cooper, 2010). The level of these costs (both perceived and real) is likely to fluctuate over the different phases of the task, causing the level of learning to also fluctuate.

When decision-quality performance feedback is provided before implementation of a decision, learning costs will be relatively high – comprised of time and effort costs to learn as well as costs of implementing a known failure. These latter costs include not only the opportunity cost of foregoing the benefits of an alternative action, but also include psychological costs of implementing the failure (i.e., proceeding down a known incorrect path) (Gray & Cooper, 2010). When feedback is provided immediately after implementing a decision, the learning costs are lower – comprised of only the cost of the time and effort devoted to learning. This higher level of learning costs for individuals given decision-quality feedback before implementing a decision will steer these individuals away from learning, resulting in lower future performance than for individuals given feedback immediately following the implementation of a decision. After implementation of a decision, increasing the delay before providing decision-quality feedback brings with it an added measure of complexity in order to learn (Anderson, 1982; Lewis & Anderson, 1985). This added complexity increases learning costs to the individual in both time and cognitive effort required (Iselin, 1988; Tuttle & Burton, 1999), resulting in less learning and lower future performance as the delay in feedback increases. Thus, theory suggests that future performance will be highest when performance feedback is provided immediately following the implementation of a decision because learning costs are relatively lower compared to when performance feedback occurs prior to implementing a decision or after an extended delay after implementation of the decision.

To test this theory, I use an experimental task to examine how the timing of performance feedback affects individual performance. Participants complete a series of mazes in each of two periods and are paid a performance-based wage. The mazes contain visual cues allowing participants to learn how to quickly navigate through the mazes in both periods. In the first period, feedback regarding the correctness of a directional choice (i.e., decision-quality feedback) is provided either 1) immediately after a directional decision but before implementing the initial directional decision (i.e., after no delay), 2) after a short delay, 3) after an intermediate delay, or 4) after a long delay. In the latter three conditions, participants must implement the initial directional decision. In the second period, this decision-quality feedback is no longer available.

I find support for an inverted-U relation between the timing of performance feedback and future performance. Specifically, participants given feedback after no delay in the first period perform significantly worse in the second period than those given feedback after a short delay. This performance difference is associated with participants given immediate feedback avoiding a necessary cost to learn by failing to proceed down known incorrect paths to gather additional information needed to learn the cue patterns contained in the mazes. Furthermore, I find that participants given feedback after extended delays following implementation of a decision in the first period perform increasingly worse in the second period than those given feedback after a short delay. Additional analyses support the interpretation that this performance difference is attributable to individuals failing to devote additional time and effort to learn as the complexity of learning in the task increases with a delay in feedback.

This study contributes to the performance feedback literature in two ways. First, this study provides insight into the effect of the timing of performance feedback in settings where the delay in feedback is accompanied by natural variations in the cost of learning. Second, this study contributes to the performance feedback literature by investigating how individuals respond to the receipt of feedback at various phases of a multi-step task (e.g., pre-/post-implementation of a decision). Understanding factors that affect individuals' use of performance feedback can help improve its use in organizations and in understanding the specific environments in which delayed performance feedback is harmful or helpful (Libby & Luft, 1993; Luft & Shields, 2010).

These findings can also inform managers and management accountants on the potential benefits and pitfalls of delaying decision-quality feedback, an action management can often control, for individual learning in multi-step tasks. This study highlights the need for managers to be cognizant of *when* in the phases of the task to provide decision-quality feedback, keeping in mind the fluctuating level of learning costs facing those tasked to learn. Feedback provided too early (i.e., before implementation of an initial decision) comes with an additional psychological learning cost (i.e., proceeding down a known "wrong" path) whereas feedback provided too late comes with an additional learning cost to process the increasing complexity associated with the delay.

The remainder of this paper is organized as follows: Section 2 describes the research setting to examine the effect of feedback timing on individual performance. Section 3 reviews the literature relating to learning costs, developing hypotheses stemming from this literature. Section 4 presents the experimental task and Section 5 presents the results of the experiment. In Section 6, I conclude and provide suggestions for future research.

2. Research setting

The setting in which I examine the effect of performance feedback timing is of particular importance to managers and management accountants. This setting is important because it mirrors many settings in which an individual engages in developing a novel or innovative output. In this setting, an individual performs a task that has a clear, objective ultimate payoff. However, how to realize this payoff consistently is less clear. As such, the individual must learn how to achieve this payoff using information gathered throughout the process of performing the task.

This task has a number of key characteristics. First, the task is a multi-step task with each step being characterized as a "success" (i.e., correct path) or a "failure" (i.e., incorrect path). A failure creates a need for additional costly steps to reach the payoff, akin to "going back to the drawing board" or "starting from scratch". Second, implementing each decision step produces a set of cues, signs, or potential indicators of success or failure (referred hereafter as a cue set). By comparing cue sets appearing after failures to those cue sets appearing after successes, one can learn the discriminating cues that appear after failure.[1] Thus, in order to learn (the discriminating cues) an individual must view cue sets after both successes and failures. Third, in the absence of feedback or prior learning of cues to distinguish between successes and failures (i.e., discriminating cues), individuals do not know if a recent decision is a success or failure. Fourth, when an individual does not know whether her/his most recent decision is a success or failure (because s/he has no feedback or has not yet learned the discriminating cues), s/he is likely to incur additional failure costs by continuing down a wrong path. Fifth, before learning for oneself, there are two ways to identify success and fail decisions – 1) feedback from task outcomes (prior decisions leading to a poor outcome must have been the result of fail decisions and vice versa) and 2) feedback from a more experienced source. Sixth, feedback from task outcomes occur at varying levels of delay, some of which can be fairly long.[2] Seventh, feedback regarding the correctness or incorrectness of the individual's choices (i.e., decision-quality feedback) from a more experienced source can be provided after certain intervals of ordinal delay in the phase of the task, not just a time delay. For example, an individual could receive feedback about a decision regarding how to proceed in the task 1) after making a decision but before actually carrying through with that decision (i.e., pre-implementation), 2) immediately after carrying through a decision (i.e., post-implementation), or 3) after making one or more additional decision(s) after the initial decision (i.e., sometime after implementation).[3]

In this setting, an individual performs the task in two distinct periods. In the first, or learning period, feedback regarding the correctness or incorrectness of the individual's choices (i.e., decision-quality feedback) is available to the individual. In the second period, decision-quality feedback is no longer available and the individual must perform the task based on what was learned in the first period. Real-world examples of a period in which performance feedback is no longer available (or even limited) include situations in which the learning period on the task has ended, the source of the feedback is not available, the individual becomes one who is expected to *give* feedback, the test commences, etc. In many audit settings (such as performing analytical procedures), performance feedback is often unavailable (Brewster, 2011) requiring auditors to rely on their training and prior learning to perform at a high level.

In this setting, the second period is designed to be longer than the first period. This characteristic is relevant to real-world settings, as it represents the notion that, while performance during the current or learning period is important, future performance (i.e., after the learning period) is more important to the long-term benefit of both the firm and the individual.

To investigate the effect of feedback timing on future performance, it is important to note what is represented by a delay in feedback. Prior research on the effect of the timing of feedback has failed to consider the potential for the level of learning costs to vary with the phase of the task in which feedback is provided (Brehmer, 1995; Diehl & Sterman, 1995; Gibson, 2000).[4] In many real-world scenarios that mirror this setting, individuals must continue to work on the task at hand while waiting to receive performance feedback. For example, one's supervisor may be temporarily unavailable to give feedback about the quality of one's decisions in a particular task. During this interval, individuals have the opportunity to gather additional information about what "success" and "failure" paths look like (i.e., view additional cue sets) *before* receiving feedback. Individuals who are not obligated to wait to receive feedback can also obtain this additional information, but must seek it *after* receiving feedback.

This task setting allows for individual learning to occur. Recall that the task contains features that indicate to the individual that s/he is on the incorrect path to obtaining the payoff (i.e., discriminating cues) and that learning the discriminating cues requires individuals to *at least* view cue sets on both correct and incorrect paths. Learning the discriminating cues will benefit individual performance both when feedback is available *and* when it is not available. Discovery of these cues is facilitated in the first (or learning) period due to the presence of decision-quality feedback and is extremely difficult in the absence of decision-quality feedback (i.e., during the second period). The individual is charged with performing the task as best as possible in both periods and is aware of the need to learn the discriminating cues to ensure high future performance.

A key feature of this setting is that all participants are allowed to see additional cue sets after feedback is given by pursuing incorrect decisions. They are instructed that this additional information may be necessary for learning and improved future performance. In this study, the total number of cue sets available to individuals is held constant as the actual movements in the task are not constrained. Accordingly, the total number of cue sets viewed by the individual is, in part, exogenously determined by the extent of feedback delay but ultimately is *endogenously* determined by the individual's choices to seek for additional cue sets. It is also important to note that automatically exposing individuals to additional cue sets due to a delay in feedback does not mean that the discriminating cues are also automatically provided, since an individual must still cognitively process the cue sets to correctly identify the discriminating cues.

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[1] It is important to note that in my study discriminating cues are clear and certain once ascertained, while these cues in other settings may appear with some degree of probability (i.e., noisier settings). However, the logic of how to identify the discriminating cues should apply to both settings.

[2] Throughout this study, the term "feedback" generally refers to that of a more experienced source, or decision-quality feedback, which is generally more controllable by managers, and not the feedback that comes from task outcomes, which is less controllable.

[3] Feedback on the correctness of a choice (i.e., decision-quality feedback) provided after implementation of a decision clearly qualifies as outcome feedback, a common and often readily available tool for managers (Einhorn & Hogarth, 1981). However, for consistency throughout the paper, I refer to the feedback provided in this setting, regardless of the implementation of the decision, as decision-quality feedback as this term describes the feedback provided both pre- and post-implementation of the decision.

[4] Actual measured time (e.g., milliseconds, minutes, days, etc.) may differ between the levels of delay, but the effect of the time element only has not been shown to have a clear effect one way or the other on individual performance (Butler, Karpicke & Roediger, 2007; Kulik & Kulik, 1988; Salmoni et al., 1984; Schmidt, 1991). In this study, the actual measured time delay has an insignificant effect on the dependent variable of interest – future performance.

3. Literature review & hypothesis development

When an individual has a task to perform in which learning is key to future performance, there are certain costs that the individual must incur in order to learn (i.e., learning costs). First, an individual has to devote time towards learning, which is generally viewed as costly to the individual as this time could be spent on other utility-maximizing activities (Baiman, 1982). In this study, costly time is made salient by affixing a monetary cost to each second used in the task (Sprinkle, 2000). Second, an individual must devote effort towards learning, something that has been extensively documented as costly to the individual (Bettman, Johnson, & Payne, 1990; Bonner & Sprinkle, 2002). In this study, the effort that individuals must exert to learn is to compare and contrast the cue sets from the incorrect paths and those from the correct paths in order to identify the discriminating cue (i.e., the one that appears only on incorrect paths). Lastly, individuals may incur additional psychological costs (i.e., cognitive dissonance, apprehension, reluctance, etc.) in order to learn. For example, Edmondson (1999) finds that learning in work teams is limited when those teams are lower in psychological safety (i.e., a shared belief that the team is safe for taking on interpersonal risks). Also, Gray and Cooper (2010) note that to learn one might need to pursue failure, something individuals generally are reluctant to embrace.

In the face of learning costs, what will individuals do? In general, the higher the perceived costs to learn, the less likely learning will take place. Throughout the course of working on a multi-step task, the level of learning costs (both perceived and real) is likely to fluctuate depending on the phase of the task, causing learning to also fluctuate.

3.1. *Learning costs before implementation of incorrect decision*

When individuals are given decision-quality feedback before implementing an incorrect decision, they are not required to pursue that incorrect decision choice, but can proceed to another choice instead. In order to learn the discriminating cues in this situation (when decision-quality feedback is given before implementing a decision), individuals must choose to incur learning costs that include both the time and effort required as well as at least one additional psychological cost – that of implementing a known failure (i.e., proceeding down a known incorrect path) (Gray & Cooper, 2010; Harmon-Jones, 2000; Jermias, 2001). Implementing a known failure not only requires individuals to sacrifice the returns of an alternative course of action (i.e., opportunity cost), but also creates cognitive dissonance – a psychological cost – because to do so requires an individual to, at least temporarily, overlook indications that the decision choice was incorrect in the first place and proceed as if the decision choice was correct. This inconsistent state (i.e., temporarily acting as if the incorrect choice is correct) increases the cognitive dissonance felt by the individual (Festinger, 1957; Jermias, 2001), increasing the total level of costs in order to learn.

However, individuals given feedback immediately after implementing an incorrect decision have less choice in the incurrence of learning costs. They already have implemented the incorrect decision and would not have the cognitive dissonance of pursuing failure since they had no choice in that matter. While they still face some learning costs due to the time and cognitive effort needed to discriminate between the cues that appear on incorrect versus correct paths, the overall cost to learn is substantially lower than for individuals given feedback before implementing a decision. As the cost to learn is lower for individuals receiving feedback immediately after implementing an incorrect decision, I expect that more learning will take place causing future performance to increase. This leads to the following hypothesis:

H1. Future performance will be higher for individuals given decision-quality feedback immediately following implementation of an incorrect decision (i.e., after a short delay) than for individuals given feedback before implementation of an incorrect decision (i.e., after no delay).

3.2. *Learning costs after implementation of incorrect decision*

Once an individual is obliged to implement an incorrect decision, s/he has received the minimum number of cue sets needed to learn the discriminating cues, having seen a cue set on both a correct and an incorrect path.[5] However, the difficulty of learning these cues, and thus the cost to learn, can increase with extended delays of feedback. Prior literature on cognitive learning, particularly learning how to identify proper courses of action given environmental and task cues (Lewis & Anderson, 1985), sheds some light on how the difficulty of learning can vary with a delay in feedback. ACT* theory of operator discrimination (Anderson, 1982; Lewis & Anderson, 1985) posits that individuals learn cue patterns (i.e., operators, discriminating cues) in an iterative fashion. Individuals develop a system of rules through their initial experience with the operators, whether right or wrong. When individuals receive feedback regarding the incorrectness of a decision based on these operators, individuals incrementally revise the rules to incorporate this information. For example, while learning to identify which vehicles are fire engines, a child gathers enough information to determine that fire engines are red. However, after incorrectly identifying a red sportscar as a fire engine, the child alters her/his discrimination strategy to include two conditions – fire engines are red *and* are big. This process then continues until an accurate strategy for correctly identifying fire engines is developed.

Developing an accurate strategy for learning cue patterns (i.e., operators, discriminating cues) requires an understanding of cue sets that appear on both correct and incorrect paths. With a shorter delay in providing feedback, information about both correct and incorrect discriminators is likely to be in participants' working memory given the proximity of the feedback to the initial decision, thus increasing the likelihood that the individual will observe the discriminating features and learn the cue pattern. Consistent with the ACT* theory of operator discrimination, extending the delay in providing feedback causes the process of learning the cue patterns to be more difficult. This is due to the incremental revision of the rules being less likely to result in correct identification of the cue patterns (i.e., key operators) since "the discrimination process only selects from features present in working memory when feedback is given" (Lewis & Anderson, 1985, p. 45). As working memory is fixed in its capacity (Awh, Barton, & Vogel, 2007; Miller, 1956), more information about cue sets of incorrect discriminators can crowd out of working memory the relevant information about correct discriminators. To continue the above example, after incorrectly identifying a red delivery truck as a fire engine, the ability to discriminate which features are those of a fire engine (e.g., fire engines are red *and* are big *and* have flashing lights on top) becomes increasingly difficult if the child has seen thousands of vehicles since last observing a real fire engine since her/his working memory has been filled with features of vehicles that are not fire engines. As the operators (i.e., cue sets) indicating correct discrimination are increasingly less likely to be in the working memory of individuals when feedback is provided after extended

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[5] An individual's starting point is considered to be on the correct path, making this statement accurate even for implementation of one's first decision.

delays, the revised set of rules is less likely to result in learned operators (i.e., learning the cue patterns).

Further, even if the difficulty of learning the cue patterns were the same regardless of the delay in feedback (e.g., individuals take notes of the cue sets to reduce the strain on working memory), research on information load suggests that, as the number of cue sets provided to individuals (through the delay of performance feedback) increases, so too does the amount of time and effort required to be able to process this information to learn the cues (Casey, 1980; Iselin, 1988; Jacoby, Speller, & Berning, 1974; Shields, 1983; Tuttle & Burton, 1999). Individuals with more cue sets available due to increased delays in feedback would have to devote increasing amounts of time and effort to recall and process the additional cue sets, an unlikely course of behavior given performance incentives. In other words, as the difficulty of learning increases with a delay in performance feedback after the minimum number of cue sets needed to learn are available (i.e., immediately after implementing an incorrect decision), so too do the learning costs of time and effort required to learn. With higher learning costs, the likelihood of individuals incurring these costs for the given benefit of learning reduces. As such, I hypothesize a decrease in future performance (a manifestation of learned cue patterns) as the delay in provision of feedback increases beyond the point at which the minimum number of cue sets to learn are available. This is formally stated below:

H2. After implementation of an incorrect decision, future performance will be lower for individuals given decision-quality feedback after increasing delays (i.e., after intermediate and long delays).

The discussion to this point has focused only on how the costs of learning fluctuate with the timing of feedback and has not considered the benefits of learning nor the tradeoff between learning costs and learning benefits. The preceding discussion does assume rational individual behavior regarding learning costs. However, it is possible that individuals might misestimate the benefits of learning or might miscalculate the tradeoff between the costs and benefits of learning. If individuals do engage in these irrational behaviors, these errors are likely to exacerbate the hypothesized effects and not counteract them. For example, prior literature has found that individuals tend to discount *in excess* future and/or uncertain benefits of actions. Hales and Williamson (2010) find that when the benefits of an action (e.g., reputation building) are uncertain, individuals underinvest in upfront costs that cannot be accounted for by standard levels of risk aversion. Anderhub, Güth, Gneezy, and Sonsino (2001) find that risk-averse individuals discount the future more heavily than less risk-averse and risk-seeking individuals, likely due to the uncertainty encapsulated in future payoffs (Keren & Roelofsma, 1995). In other words, if individuals do misinvest in learning – an outcome with uncertain, future benefits and certain, current costs – they are likely to favor under-investment in learning instead of over-investment, which is consistent with H1 and H2 above. In this study, I hold constant the actual benefits of learning and focus the theoretical development and research setting on learning costs and how these play a role in the effect of feedback timing on performance, leaving for future research individuals' perceptions of the benefits of learning and the tradeoff between the costs and benefits of learning.

3.3. Inverted-U relation

In summary, I predict that providing performance feedback before implementing an incorrect decision (i.e., immediate feedback) will lead to lower future performance than providing it after implementation of the decision (i.e., short-delay of feedback) due to higher learning costs facing individuals given feedback immediately, namely the psychological cost of pursuing a known failure. I also predict that delaying the provision of performance feedback after implementation of an incorrect decision will lead to poorer future performance (H2) due to individuals failing to devote the increased time and effort required to learn as learning becomes more difficult. By combining predictions from H1 and H2, the relationship between the timing of performance feedback and future performance can be characterized as an inverted-U relationship. Fig. 1 graphically presents H1 and H2.

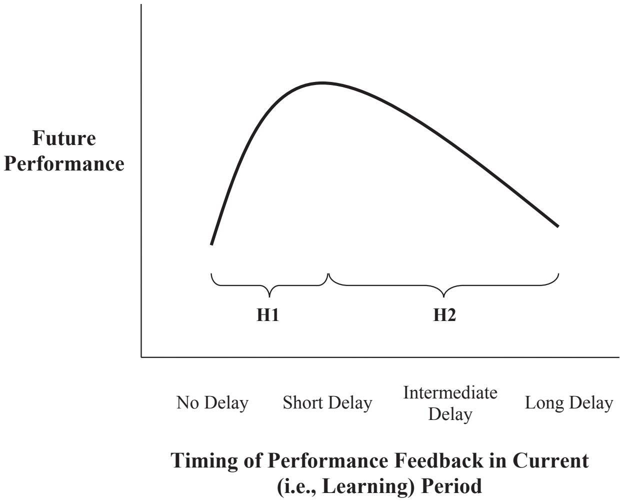

Fig. 1. Graphical Representation of Hypotheses 1 &2. Above is a representation of the future performance expectations across various delays of performance feedback during the first period (i.e., learning period).

4. Method & design

4.1. Participants

Ninety accounting students recruited from upper division accounting courses participated in the experiment. The participants were 21.7 years old, on average, and had 3.5 years of college experience. Forty-four percent of the participants were female. Participants were randomly assigned to one of four experimental conditions. Participants worked on the task individually and were given monetary compensation for participating in the study.

4.2. Instructions and task

The task employed to test the hypotheses is a computerized maze task adapted from Lewis and Anderson (1985). This multistep task captures important aspects of many decision-making settings in which employees choose a path to follow and have the ability to learn from the task environment. Increases in the delay of feedback in this task require individuals to be exposed to an increasing number of cue sets before receiving feedback. However, a key feature of the task is the ability for participants to seek additional cue sets (e.g., by searching around the maze) to better learn how to perform the task in the future, irrespective of when they receive feedback. This task does not allow for much, if any, transfer of previously learned skills, which effectively controls for prior knowledge.

Participants were informed that they would be participating in two periods of the maze task, comprising twelve minutes in the first period and twenty-four minutes in the second period.

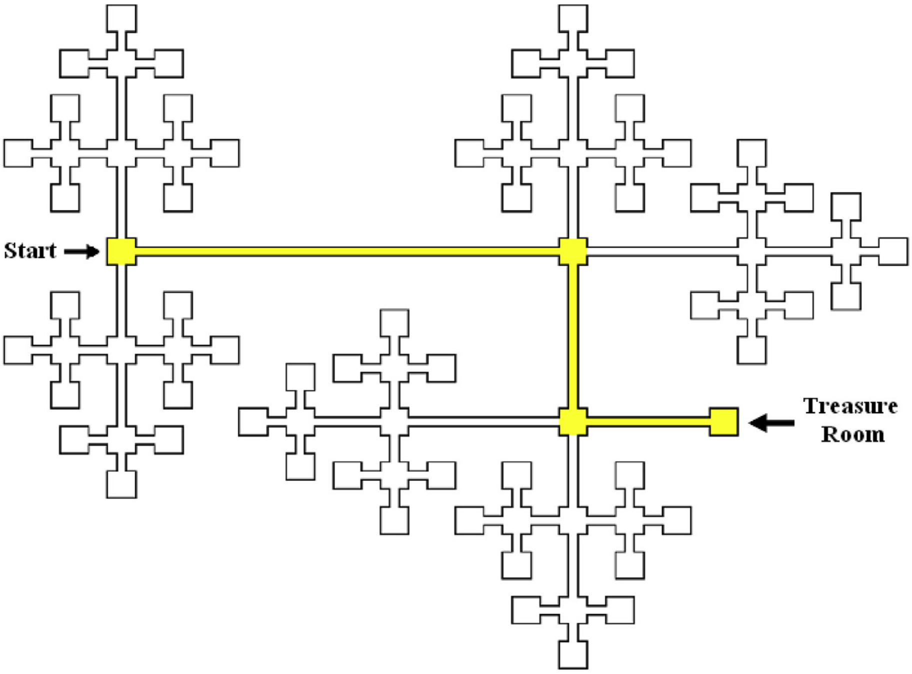

Fig. 2. Sample Maze Schematic from Maze Task Instructions. Above is the schematic of a sample maze that was provided to all participants. Each maze consists of a series of connected rooms that fan out from each other like roots and, as such, are not interconnected. Hence, there is only one correct path to the end of the maze (i.e., the "Treasure Room").

They were informed of the importance of completing as many mazes as possible in each period. All participants were paid for their performance during the two periods of the experiment immediately after completing the post-experimental questionnaire. Participants received $0.50 for each maze completed up to the disclosed maximum of twenty mazes in the first period and forty mazes in the second period. Additionally, any participant who finished the allotted mazes in either period received a $0.01 per second bonus for any time remaining upon completion of the mazes.[6] The magnitude of potential second-period payout was emphasized through a quiz immediately prior to performing the task.

Each maze consists of a series of connected rooms that fan out from each other like roots and, as such, are not interconnected. Hence, there is only one correct path to the end of the maze (i.e., the "Treasure Room"). Included in the participant instructions was a schematic of a sample maze, as illustrated in Fig. 2.

Fig. 3 shows a screenshot from a sample room within a maze. Each room has four doors – one from which the participant enters and three from which to choose in order to proceed further in the maze.[7] In both the correct and incorrect rooms, there are visual cues (e.g., presence or absence of certain key objects) from which participants can learn that they have entered an incorrect path. Learning the cue patterns (i.e., discriminating cues) is crucial to performance, particularly when performance feedback is unavailable. For the three types of mazes in the task, each distinguished by a different color, there is a specific object that is present on incorrect paths and absent on correct paths – the discriminating cue. Only by searching both correct and incorrect rooms can these cues be discovered, a key feature of the task. All participants were instructed that this was the way in which cues could be learned.[8] All participants were also informed of the importance of learning the cue patterns and that the cue patterns would be consistent between the first and second periods.[9] The instructions to and structure of the task emphasize to participants the need to learn the cue patterns in the first period in order to maximize total compensation across both periods.

The experiment consists of two periods. In the first period (i.e., "learning period"), individuals are given feedback regarding the correctness of a directional decision (i.e., decision-quality feedback). In the second period (i.e., "post-learning period"), no participants are given feedback. All participants were informed of this feature of the task in the instructions. This design allows the effect that the timing of feedback has on future performance to be separated from its effect on current performance (Salmoni, Schmidt, & Walter, 1984). This feature of the design (i.e., the removal of feedback for the second period) allows participants to demonstrate their learning of the task, which cannot be clearly observed if the feedback is always present. Further, this feature maps into many real-world settings in which performance feedback is significantly reduced or becomes unavailable.

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[6] This $0.01 per second bonus for finishing the maximum mazes before time expires in the period was included in the experimental design to encourage participants to place a value on their time/effort spent in the task (Sprinkle, 2000).

[7] The starting room of each maze only has three doors.

[8] From the experimental instructions – "[T]here are TWO ways to navigate through a maze. The first way is to search through the maze until you find the Treasure Room. The second way is to identify visual "cues" that indicate that you are on the INCORRECT path. As such, it would be beneficial to spend time studying incorrect paths. Using these cues will assist in a more timely completion of the mazes in the first round as well as the mazes in the second round."

[9] These instructions (a form of process feedback) were given to all participants to create a common mental representation of the task across conditions. The feedback is given to trigger information search behaviors to clarify the provided mental model, not create a new one. However, in this study, I am unable to determine which participants had an accurate mental model of the task outside of their performance behaviors.

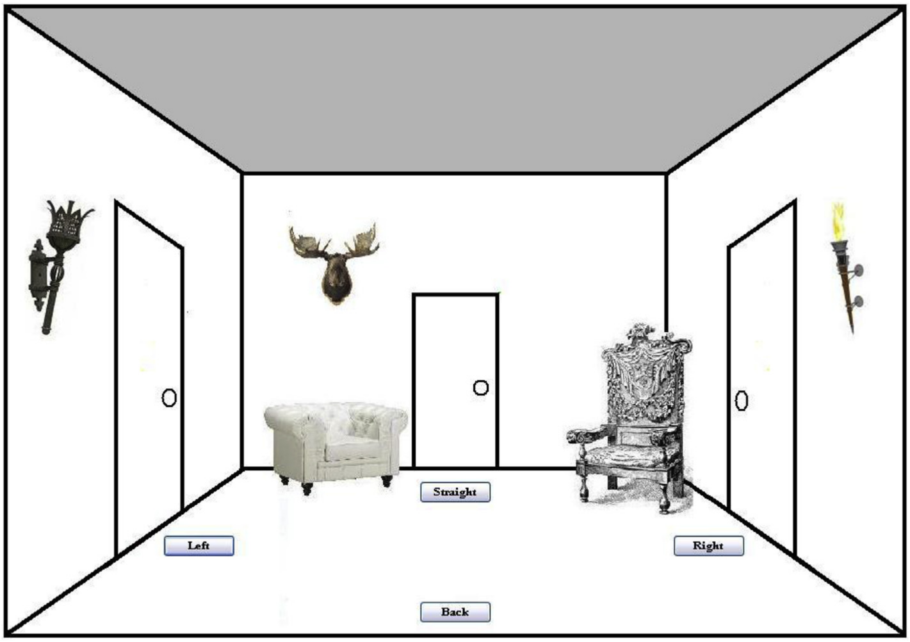

Fig. 3. Sample Screenshot from Maze Task Instructions. Above is a screenshot of a sample room within a maze. Each room has four doors – one from which the participant enters and three from which to choose in order to proceed further in the maze. In both the correct and incorrect rooms, there are visual cues (e.g., presence or absence of certain key objects) from which participants can learn that they have entered an incorrect path. For the three types of mazes in the task, each distinguished by a different color, there is a specific object that is present on incorrect paths and absent on correct paths.

4.3. Experimental design and treatments

I test the hypotheses using a 1 × 4 between-subject experimental design, manipulating the delay of the decision-quality performance feedback (feedback given after no delay, after a short delay, after an intermediate delay, or after a long delay) in the first period of the experimental task. In the second period, decision-quality feedback is unavailable for all participants.

In the first period, participants given feedback after no delay were notified by a message that appeared immediately if a selected path was incorrect without requiring them to proceed onto the incorrect path. If the selected direction was correct, the participant proceeded forward. Participants given feedback after a[n] short [intermediate] delay were notified that they had entered an incorrect path once they entered the first [second] room on the selected incorrect path. Participants given feedback after a long delay were notified that they were on an incorrect path once they entered the third room on a selected incorrect path, which is the dead-end room.

In order to keep *total* number of available cue sets constant, all participants were free to continue down any incorrect path, regardless of feedback condition, and all were informed of the availability of this action. The quantity of cue sets provided to individuals *at the time they first receive feedback* depends on the condition to which they were assigned. For example, those assigned to the no-delay condition are only forced to see the cue set in the first room before receiving feedback on the accuracy of their directional choice, whereas those assigned to the short-delay condition must enter an additional room (with its accompanying cue set) before receiving feedback on their directional choice. The instructions and comprehension checks were designed to ensure that participants understood that more cue sets can be viewed by continuing down incorrect paths. Additionally, the strategy to view additional cue sets was highlighted as the way to best learn the cues contained in the mazes.

4.4. Dependent measure

The main dependent variable of interest is performance in the post-learning period (i.e., second period), measured as the number of mazes participants completed per minute during the respective period. Given that decision-quality feedback is not present in the post-learning period, participants can more clearly demonstrate their learning of the task in the post-learning period, thus isolating the differential effects of the timing of feedback in the learning period on future performance. I use the number of mazes completed per minute as the dependent measure instead of total mazes completed because the former better captures the effects of learning by incorporating the speed of performance into the measure.[10] I do, however, present both dependent variables in the descriptive statistics and the tabulated hypotheses tests.

5. Results

5.1. Tests of hypotheses

Table 1 presents the mean number of mazes completed per minute, total mazes completed, and compensation earned for both the learning period (Panel A) and the post-learning period (Panel B). Fig. 4 graphs the primary dependent variable of the experiment. Specifically, Fig. 4 shows the mean number of mazes completed per minute by each performance feedback condition for the post-learning period.

The main dependent variable of interest for H1 and H2 is the number of mazes completed per minute in the post-learning

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[10] As an example, the measure of total mazes completed in the post-learning period treats completion of the maximum of 40 mazes available in 24 min the same as completing the same number of mazes in 20 min. However, completing these mazes in less time is a manifestation of better learning of the cue patterns during the learning period. As such, using total mazes completed instead of mazes completed per minute would bias against finding the predicted results.

Table 1
Descriptive statistics.

Delay of decision-quality performance feedback in learning period[a]	Mean mazes per minute[b] (standard deviation)	Mean mazes completed[c] (standard deviation)	Compensation (in $)[d]	Number of Participants
Panel A: Learning period performance				
No delay	3.13 (1.06)	19.70 (1.46)	12.85	23
Short delay	2.31 (1.00)	18.22 (3.94)	10.97	23
Intermediate delay	1.69 (0.55)	17.45 (3.93)	9.46	22
Long delay	1.06 (0.40)	12.73 (4.78)	6.36	22
Panel B: Post-learning period performance				
No delay	0.19 (0.24)	4.48 (5.69)	2.24	23
Short delay	1.29 (1.62)	17.13 (17.53)	10.80	23
Intermediate delay	1.17 (1.63)	15.68 (15.39)	9.61	22
Long delay	0.55 (0.68)	11.82 (13.18)	6.31	22

[a] This represents the timing of when decision-quality performance feedback was provided in the learning period. I manipulated this condition by providing feedback immediately after a directional decision but before entering an incorrect path (No-Delay condition), after a one-room delay into an incorrect path (Short-Delay condition), after a two-room delay into an incorrect path (Intermediate-Delay condition), and after a three-room delay into an incorrect path (Long-Delay condition).

[b] This variable represents the number of mazes competed by the participant divided by the number of minutes it took to complete these mazes in the referenced performance period (either the learning or post-learning period).

[c] This variable represents the number of mazes competed by the participant in the referenced performance period (either the learning or post-learning period).

[d] This variable is computed by multiplying the number of mazes completed in the respective period by $0.50. To this I added $0.01 per second of time remaining in the period in the event that the participant completed the maximum number of mazes available.

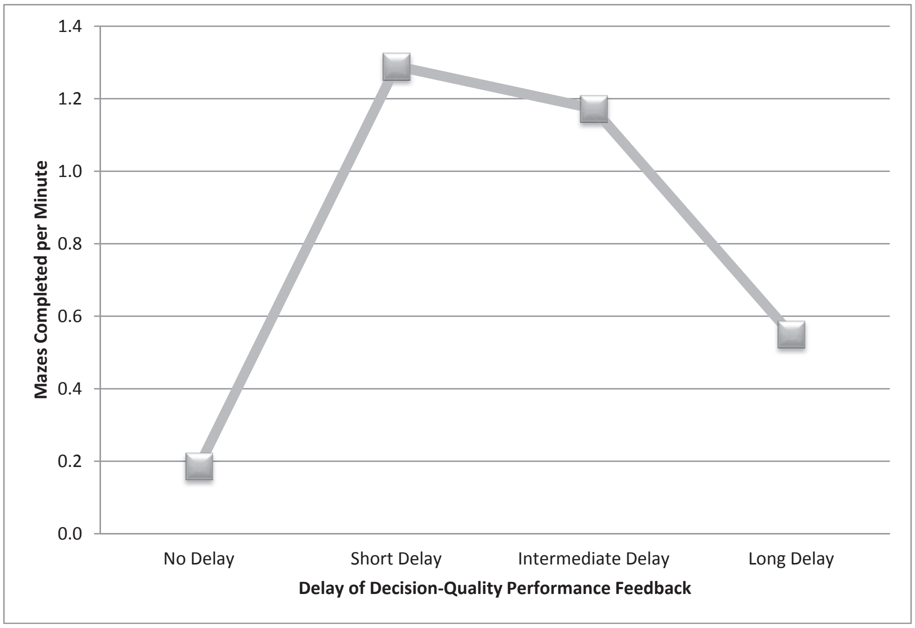

Fig. 4. Mean Number of Mazes Completed per Minute in Post-Learning Period[a] by Feedback Delay[b]. This figure provides additional support of the main results of this paper. There is an inverted-U relation between the delay of performance feedback and post-learning period performance. [a] This variable is the number of mazes successfully completed by the participant in the second period (i.e., the post-learning period). [b] This represents the timing of when decision-quality performance feedback was provided in the learning period. I manipulated this condition by providing feedback immediately after a directional decision but before entering an incorrect path (No-Delay condition), after a one-room delay into an incorrect path (Short-Delay condition), after a two-room delay into an incorrect path (Intermediate-Delay condition), and after a three-room delay into an incorrect path (Long-Delay condition).

period.[11] The purpose of H1 is to test whether participants given feedback after no delay perform worse than participants given feedback after a short delay. The difference in performance between these conditions is significant ($t = 3.224$; $p = 0.001$, one-tailed) with participants given feedback after no delay completing fewer mazes per minute than participants given feedback after a short delay. This result is presented in Panel A of Table 2, which provides support for H1.

The purpose of H2 is to test the diminishing effect on performance of further delays of performance feedback beyond a short delay. To test H2, I perform a one-way ANOVA trend analysis (Kirk, 1995; Rosenthal & Rosnow, 1991) and find a significant linear trend ($F = 3.176$; $p = 0.039$, one-tailed) of decreasing post-learning period performance with increasing delay of feedback (from short delay to

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[11] The *ex ante* strategy of finishing the allotted mazes in the first period as fast as possible without regard for learning the cues patterns (with the accompanying second period benefit) is unlikely to be superior to *ex ante* strategy of learning the cue patterns in the first period and reaping the performance rewards in the second period (see Supplemental Analyses for support of this assertion). Unless participants expected *beforehand* the likelihood of learning the cue patterns to be sufficiently low, the superior strategy would be to search for cue patterns as this was explained as the best pattern to complete the mazes, particularly in the second period when feedback was unavailable. The instructions to the participants were silent as to the likelihood of learning the cues.

Table 2
Pairwise comparisons and one-way ANOVA trend analyses for the effect of timing of performance feedback on performance in the post-learning period.

	t-statistics (p-value[d])	
Feedback conditions[c]	Mazes per minute[a]	Total mazes[b]
Panel A: Pairwise comparisons		
No delay versus short delay	−3.224 (**0.001**)	−3.292 (**0.001**)
Short delay versus intermediate delay	0.241 (0.811)	0.294 (0.770)
Short delay versus long delay	1.975 (**0.028**)	1.145 (**0.129**)
Intermediate delay versus long delay	1.648 (**0.054**)	0.894 (**0.188**)
No delay versus intermediate delay	−2.863 (0.006)	−3.267 (0.002)
No delay versus long delay	−2.409 (0.020)	−2.445 (0.020)
	F-statistic (p-value[d])	
Feedback conditions[c]	Mazes per minute[a]	Total mazes[b]
Panel B: One-Way ANOVA Linear Trend Analyses		
Short, Intermediate, and Long delays	3.176 (**0.039**)	1.320 (**0.127**)
Panel C: One-Way ANOVA Quadratic Trend Analyses		
No, Short, Intermediate, and Long delays	11.505 (< **0.001**)	8.195 (**0.003**)

[a] This variable represents the number of mazes competed by the participant in the post-learning period divided by the total number of minutes it took to complete these mazes.

[b] This variable represents the number of mazes completed by the participant in the post-learning period.

[c] This represents the timing of when decision-quality performance feedback was provided in the learning period. I manipulated this condition by providing feedback immediately after a directional decision but before entering an incorrect path (No-Delay condition), after a one-room delay into an incorrect path (Short-Delay condition), after a two-room delay into an incorrect path (Intermediate-Delay condition), and after a three-room delay into an incorrect path (Long-Delay condition).

[d] Reported p-values are two-tailed unless testing a one-tailed prediction as indicated by bold face.

intermediate delay to long delay), providing support for H2. [12] This result is presented in Panel B of Table 2. Further, as presented in Panel A of Table 2, I find post-learning period performance for participants given feedback after a long delay is significantly lower than for participants given feedback after a short [intermediate] delay ($t = 1.975$ [1.648]; $p = 0.028$ [0.054], one-tailed).[13]

The pattern of means for the experimental conditions follows an inverted-U relation. To statistically examine this relation, I again perform a one-way ANOVA trend analysis and find that the overall linear trend is insignificant ($F = 0.733$, $p = 0.394$), while the quadratic trend is highly significant ($F = 11.505$; $p < 0.001$, one-tailed).[14] This result supports the inverted-U relation between the delay of feedback and future performance and is presented in Panel C of Table 2.[15]

5.2. Supplemental analyses

The purposes of these supplemental analyses are 1) to provide insight into the psychological cost of implementing a known failure and 2) to examine alternative measures of performance.

5.2.1. Psychological cost of implementing a known failure

In developing the theory for H1, I argue that the learning costs are greater for individuals who receive decision-quality feedback before implementing their incorrect choice, driven by a reluctance to proceed down a known incorrect path (i.e., pursue failure). To provide evidence that participants did shun this needed course of action, I isolate all of the movement decisions made immediately following the receipt of the feedback in order to determine the extent to which participants sought additional cue sets after receiving the feedback. I find that participants provided feedback after no delay proceed onto the incorrect path only 4.5% of the available opportunities, on average, supporting the notion that there is a psychological cost associated with pursuing failure.[16]

5.2.2. Alternative performance measures

Since participants were compensated for performance in both periods, examining the effect of feedback timing on *total* compensation and *total* performance would be helpful to understanding the extent to which the benefits of delayed feedback in the post-learning period are offset (or possibly eliminated) by the costs of delaying feedback in the learning period. In particular, was obligating participants to implement their incorrect path choice (i.e., decision-quality feedback provided after a short delay) beneficial in terms of overall performance (in both the learning and the post-learning periods) as well as participant pay? Was delaying feedback provision after implementation of the initial directional decision detrimental to overall performance and participant pay? Table 3 presents the descriptive statistics, pairwise comparisons, and one-way ANOVA trend analyses of the effect of feedback timing on total compensation (in $) and total performance (as measured by mazes per minute). Of particular note in Table 3, Panel B, the pairwise comparisons testing H1 are significant ($p < 0.01$, one-tailed, for both performance measures). Also, presented in Table 3, Panel C, the trend analyses for total compensation and total performance result in a significant negative linear trend (all with $p < 0.01$, two-tailed) from the short-delay to the intermediate-delay to the long-delay conditions. Lastly, the untabulated overall trend analysis for total compensation [total performance] results in a significant quadratic trend ($F = 11.079$, $p = 0.001$ [$F = 12.699$, $p = 0.001$]) and an insignificant linear trend ($F = 1.280$, $p = 0.261$ [$F = 0.298$, $p = 0.587$]), supporting the inverted-U relation.[17] In sum, employing total compensation and total performance as dependent measures of individual performance to test hypotheses H1 and H2 does not change the inferences of the main findings of this study.

6. Summary & discussion

Performance feedback is a key element of performance measurement and evaluation and is an important tool used by management and management accountants to improve employee performance and learning. The objective of this study is to examine the effect of the timing of performance feedback (i.e., the phase in

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[12] The quadratic trend is insignificant ($F = 0.487$, $p = 0.488$).

[13] Performance for participants given feedback after a short delay is not statistically different than for those given feedback after an intermediate delay ($t = 0.241$; $p = 0.811$, two-tailed).

[14] The cubic trend is insignificant ($F = 0.395$, $p = 0.532$).

[15] As presented in Table 2, by using total mazes completed in the post-learning period as the dependent variable for the hypotheses tests, H1 is supported and H2 is not. However, the inverted-U relation is statistically supported. The weakened results using the total mazes completed instead of mazes per minute are due to the speed with which participants in the short delay and intermediate delay conditions completed all of the available mazes in the post-learning period. Those in the short (intermediate) delay condition completed the maximum of 40 mazes in the post-learning period with, on average, 3.72 (2.95) minutes remaining, compared to participants in the long delay condition, who did so with only 0.66 min remaining. This statistically significant difference [$p = 0.012$, one-tailed ($p = 0.044$, one-tailed)] in the speed of completion reflects more effective learning of the cue patterns for participants in the short (intermediate) delay conditions than for those in the long delay condition.

[16] Participants given feedback after a short delay, while not strictly needing additional cue sets to learn, sought additional cue sets by proceeding further on the incorrect path after 8.0% of the available opportunities.

[17] The cubic trends are also insignificant ($F = 0.415$, $p = 0.521$ [$F = 0.466$, $p = 0.496$]).

Table 3

Pairwise comparisons and one-way ANOVA trend analyses for the effect of timing of performance feedback on total compensation[a] and total mazes per minute.[b].

Panel A: Descriptive statistics

	Total compensation, in $ (standard deviation)	Total mazes per minute (standard deviation)	Number of Participants
Delay of decision-quality performance feedback in learning period			
No delay	15.08 (2.92)	0.78 (0.17)	23
Short delay	21.77 (11.91)	1.41 (1.05)	23
Intermediate delay	19.07 (11.60)	1.22 (0.99)	22
Long delay	12.67 (7.97)	0.71 (0.46)	22

Panel B: Pairwise comparisons

	t-statistics (p-value[d])	
Feedback conditions[c]	Total compensation, in $	Total mazes per minute
No delay versus Short delay	−2.612 **(0.006)**	−2.846 **(0.008)**
Short delay versus Intermediate delay	0.768 (0.447)	0.613 (0.543)
Short delay versus Long delay	2.996 **(0.003)**	2.870 **(0.003)**
Intermediate delay versus Long delay	2.134 **(0.020)**	2.208 **(0.017)**
No delay versus Intermediate delay	−1.597 (0.118)	−2.127 (0.039)
No delay versus Long delay	1.362 (0.180)	0.664 (0.510)

Panel C: One-way ANOVA linear trend analyses

	F-statistic (p-value [d])	
Feedback conditions[c]	Total compensation, in $	Total mazes per minute
Short, Intermediate, and Long delays	8.176 **(0.003)**	7.159 **(0.005)**

[a] This variable is computed by multiplying the combined number of mazes completed in both periods by $0.50. To this I added $0.01 per second of time remaining in each period in the event that the participant completed the maximum number of mazes available.

[b] This variable represents the combined total number of mazes competed in both periods by the participant divided by the total number of minutes it took to complete these mazes.

[c] This represents the timing of when decision-quality performance feedback was provided in the learning period. I manipulated this condition by providing feedback immediately after a directional decision but before entering an incorrect path (No-Delay condition), after a one-room delay into an incorrect path (Short-Delay condition), after a two-room delay into an incorrect path (Intermediate-Delay condition), and after a three-room delay into an incorrect path (Long-Delay condition).

[d] Reported p-values are two-tailed unless testing a one-tailed prediction as indicated by bold face.

the task when decision-quality feedback is provided) on individual performance in a setting in which performance feedback is available for a certain period and unavailable for a future period. I hypothesize an inverted-U relation between the delay of performance feedback and future performance, in which future performance is lowest when feedback is given after no delay (i.e., before implementation of a decision), is increasing in the delay of feedback to a point (i.e., immediately following implementation of decision), and is decreasing in further delay of feedback. I also investigate the mechanisms that explain the relation between the timing of performance feedback and individual future performance.

Results support an inverted-U relation between the delay of performance feedback and future performance. Specifically, I find that feedback given after no delay adversely affects future performance relative to when feedback is given after a short delay. This result is consistent with higher learning costs for individuals given decision-quality feedback before implementing an incorrect decision than for those given feedback immediately after implementing an incorrect decision. These higher learning costs discourage individuals to learn, resulting in notable reduced future performance. I also find support that further delays in performance feedback limit future performance. This result is consistent with learning becoming more difficult (i.e., learning costs increase) with increased delays in feedback.

Since learning is valuable in that it causes individuals to recognize failure and avoid the costly path of persisting in unrecognized failure, these results can benefit management and management accountants by demonstrating the varying effect on learning that the timing of when performance feedback is disseminated to individuals can have. In particular, managers should consider the perceived learning costs that individuals face at each phase of a task and provide decision quality feedback at the phase when these costs are lowest. Further, managers should keep in mind the importance of allowing employees to follow through with low-cost incorrect choices in order to encourage the benefit that this process can have on learning and future performance. Lastly, once sufficient information to learn is available, managers should consider the added complexity and cost to learning that additional delay of feedback can cause.

The limitations of this study highlight the need for future research on the effect that the timing of performance feedback has on future performance. In this study, decision-quality feedback is restricted to indicating whether the individual made a correct or an incorrect decision. However, in many real-world scenarios, this type of feedback is often provided alongside process feedback, which is more descriptive as to *why* the decision was or was not correct (Bonner & Walker, 1994). While the findings of this study speak to settings in which process feedback is not available and to settings in which process feedback might be available and not communicated (i.e., the provider of decision-quality feedback cannot or chooses not to incur the cost to provide this process feedback), they may not generalize to settings in which both decision-quality and process feedback are provided together. Another limitation is that, depending on the experimental condition, participants were forced to wait to receive performance feedback. However, as individuals can self-select into organizations in which performance feedback is given after certain levels of delay, future research could focus on making the timing of performance feedback an endogenous choice. Lastly, recent research in systems-based thinking in auditing (Brewster, 2011; Peecher, Schwartz, & Solomon, 2007) identifies a potential personality variable (i.e., systems thinking versus reductionist thinking) that could interact with the effect of the timing of feedback and future performance and provide some insight into why some participants learned and some did not. For example, it is plausible that systems-based thinkers would not need to be forced to view additional cue sets through a delay of feedback to be able to learn the task, due to their increased ability to connect elements of a task, while reductionist thinkers may need this delay to learn more effectively.

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