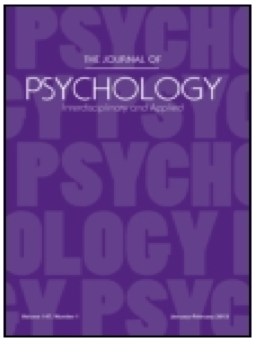

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Error Framing Effects on Performance: Cognitive, Motivational, and Affective Pathways

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ABSTRACT. Our purpose was to examine whether positive error framing, that is, making errors salient and cuing individuals to see errors as useful, can benefit learning when task exploration is constrained. Recent research has demonstrated the benefits of a newer approach to training, that is, error management training, that includes the opportunity to actively explore the task and framing errors as beneficial to learning complex tasks (Keith & Frese, 2008). Other research has highlighted the important role of errors in on–the–job learning in complex domains (Hutchins, 1995). Participants ($N = 168$) from a large undergraduate university performed a class scheduling task. Results provided support for a hypothesized path model in which error framing influenced cognitive, motivational, and affective factors which in turn differentially affected performance quantity and quality. Within this model, error framing had significant direct effects on metacognition and self-efficacy. Our results suggest that positive error framing can have beneficial effects even when tasks cannot be structured to support extensive exploration. Whereas future research can expand our understanding of error framing effects on outcomes, results from the current study suggest that positive error framing can facilitate learning from errors in real-time performance of tasks.

Keywords: error framing, performance, subjective task complexity, training

MODERN ORGANIZATIONS FACE MAJOR CHALLENGES, among them rapid change, hypercompetition, and increasingly sophisticated technology (Cascio & Aguinis, 2005, p. 380). Increasingly, organizations need to provide opportunities for employees to engage in continuous learning to respond effectively to rapidly changing, complex jobs (Cascio & Aguinis, p. 380; Salas & Kozlowski, 2010). Certainly, substantial research has demonstrated the beneficial

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effects of training in general on organizational effectiveness (e.g., Noe, 1999; Salas & Cannon–Bowers, 2001; Salas & Kozlowski). Moreover, recent researchers have demonstrated the benefits of a newer approach to training, that is, error management training, that includes the opportunity to actively explore the task and framing errors as beneficial to learning complex tasks, that is, positive error framing (Keith & Frese, 2008). However, other researchers have noted that substantial learning occurs on the job rather than in formal training (e.g., Cascio & Aguinis, 2005), and more specifically, have highlighted the important role of errors in on-the-job learning in complex domains (e.g., Hutchins, 1995). That is, in many real-world contexts, individuals need to learn on the job, meaning there will be errors, but individuals might have little opportunity to engage in task exploration due to job demands. As a result, our purpose was to examine whether positive error framing, that is, making errors salient and cuing individuals to see errors as useful, can benefit learning when task exploration is constrained. We expected that positive error framing would have beneficial effects on cognitive, motivational, and affective factors that in turn influence task performance, including both performance quality and quantity.

Hutchins (1995) suggested that much of what employees need to know about their work is learned not during formal training but during real-time performance of their jobs. In real-time work contexts, an individual is likely to have little opportunity to actively explore while performing job tasks. Moreover, to the extent that one expects employees to learn while they perform their work, one must expect errors. As such, an important issue is how employees learn from errors during task performance and how one can support such learning, including understanding the role of error framing.

We define positive versus negative error framing as making errors salient to individuals and associating either positive or negative valence with those errors. In positive error framing, individuals are encouraged to notice errors and view them as useful and helpful, as a way to learn more about and better understand a task. In negative error framing, individuals are encouraged to notice errors but to view them as something to avoid, as an indication of inefficiency or as a failure to follow instructions or perform the task. Positive and negative error framing is consistent with and builds on prior research. For example, Frese et al. (1991) described the disadvantages of discouraging trainees from making mistakes, referring to such training approaches as error avoidant. Other researchers have endorsed alternative training approaches that acknowledge the usefulness of errors in learning, referring to such approaches by various labels including error, error based, or error management training and suggesting that errors might help individuals explore the task and lead to a refinement of task schemas (e.g., Dormann & Frese, 1994). Although some studies have shown negative results for error management training (e.g., Debowski, Wood, & Bandura, 2001; Gully, Payne, Koles, & Whiteman, 2002; Lazar & Norcio, 2003), most research has revealed positive effects on a variety of outcomes including task performance, satisfaction, self-efficacy, and

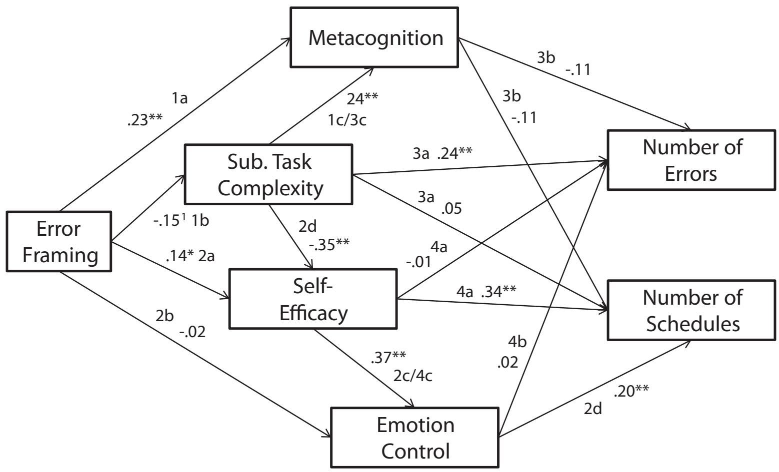

FIGURE 1. Hypothesized error framing model with standardized path coefficients. Path numbering refers to hypotheses; direct path are indicated by a or b, e.g., 1a refers to Hypothesis 1a. Indirect paths are labeled as follows: Hypothesis 1c includes paths 1a and 1c; Hypothesis 2c includes paths 2a and 2c; Hypothesis 2d includes paths 1a, 2d, and 2c; Hypothesis 3c includes paths 3c and 3b; Hypothesis 4c includes paths 4c and 4b. *indicates paths significant at $p < .05$. **indicates paths significant at $p < .01$. Also measurement errors for endogenous variables were estimated but are not displayed. [1]$p < .10$.

intrinsic motivation (e.g., Chillarege, Nordstrom, & Williams, 2003; Frese et al., 1991; Keith & Frese, 2005; Nordstrom, Wenland, & Williams, 1998; van der Linden, Sonnentag, Frese, & van Dyck, 2001; Wood et al., 2000). Further, a recent meta-analysis has revealed a substantial benefit for error management training over error avoidant training ($d = .44$; Keith & Frese). Although research on error management training has focused both on task exploration opportunities and error framing, we posit that error framing can be beneficial when opportunities for task exploration are limited.

Furthermore, we propose a model describing effects of positive versus negative error framing on multiple factors that in turn influence performance (see Figure 1). Specifically, we posit that positive versus negative error framing influences cognitive (specifically, metacognition and subjective task complexity), motivational (specifically, self-efficacy), and affective factors (specifically, emotion control) and that these factors influence performance quantity (i.e., number of tasks completed), and quality (i.e., number of errors), perhaps differentially. Our model is consistent with and extends prior research. For example, research has suggested that error management training influences performance through cognitive, motivational, and affective pathways (e.g., Bell & Kozlowski, 2008). Also, research has suggested that error management training has beneficial effects on various performance criteria (e.g., number of tasks completed, number of errors; Keith & Frese, 2008). We extend prior research by exploring how error framing might influence learning during job performance, a context in which opportunities to actively explore a task are unlikely to be available in real-time.

Error Framing Effects on Cognitive Factors

We posited that error framing (positive versus negative) would have effects on two cognitive factors: metacognition and subjective task complexity. Consistent with Keith and Frese (2008), we used the term metacognition to refer to planning, monitoring, and other activities used to manage learning or performance. We expected that positive error framing would encourage individuals to engage in greater metacognitive activity. That is, encouraging individuals to think about errors and use them to try to understand the task, for example, positive error framing, would trigger more planning, monitoring, and other metacognitive activities. In contrast, we expected that encouraging individuals to avoid errors, i.e., negative error framing, would result in a greater focus on trying to follow the rules or task instructions and less of a focus on using errors as a learning tool. Research has supported these notions. Fisher and Lipson (1986) suggested that making mistakes allows individuals to engage in deeper level processes, reflecting metacognitive processes. Other research has suggested that error management training has greater beneficial effects on metacognition relative to error avoidant training (e.g., Bell & Kozlowski, 2008; Keith & Frese).

Further, we posited that framing errors as a normal part of learning, as useful and helpful rather than problematic or obstacles, should lead the individual to perceive the task as less complex. In contrast, encouraging individuals to view errors as something to be avoided and as an indication of inefficiency or failure, would cause individuals to perceive the task as more complex. Researchers have offered models of objective task complexity, addressing task characteristics or behavioral demands of the task (Campbell, 1988; Wood, 1986). However, Campbell suggested that subjective task complexity (i.e., perceptions of task complexity) and objective task complexity reflect distinct constructs. Moreover, researchers have provided evidence that subjective task complexity accounts for unique variance in task performance, controlling for the effects of objective task complexity (Mangos & Steele-Johnson, 2001; Maynard & Hakel, 1997). Thus, we examined whether positive error framing decreased subjective task complexity.

Additionally, we posited a structure underpinning these cognitive processes. Specifically, we posited that error framing, that is, making errors salient but cuing individuals to see errors as useful, would cue increased metacognitive activity and also reduce perceived task complexity. However, perceptions of decreased task demands (i.e., lower subjective task complexity) at the same time might cue individuals to engage in less metacognitive activity. Thus, subjective task complexity is a construct that might have important differential effects on processes through which error framing influences learning and performance.

> *Hypothesis 1a*: Error framing influences metacognition.
>
> *Hypothesis 1b*: Error framing influences subjective task complexity.
>
> *Hypothesis 1c*: Error framing has indirect effects on metacognition through subjective task complexity.

Error Framing Effects on Motivational and Affective Factors

We posited that error framing (positive versus negative) would have effects on a motivational factor (i.e., self-efficacy) and an affective factor (i.e., emotion control). Bandura (1997, p. 3) defined self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments." Consistent with Bell and Kozlowski (2008), we identified self-efficacy as reflecting a motivational process. Researchers (e.g., Bandura; Locke & Latham, 1990) have described self-efficacy as a motivation construct, often comparing it to effectance motivation or expectancy theory. We expected that positive error framing would lead to increases in self-efficacy. That is, encouraging individuals to view errors as useful in trying to understand the task should strengthen individuals' beliefs in their capabilities to learn and perform the task. In contrast, negative error framing should weaken individuals' beliefs in their capabilities. Indeed, prior research has demonstrated that error framing influences self-efficacy (e.g., Bell & Kozlowski).

Furthermore, we extended prior research by positing that error framing would influence affective processes directly as well as indirectly through cognitive and motivational processes. Drawing from prior research (Bell & Kozlowski, 2008; Keith & Frese, 2005), we defined emotion control as regulating emotions, that is, monitoring and managing feelings of anxiety, frustration, and personal control. We expected that positive error framing would increase individuals' ability to monitor and manage their emotions, decreasing anxiety and frustration and increasing perceptions of personal control. We expected negative framing to have the opposite effect. Hajcak and Foti (2008) suggested that making mistakes might cause individuals to experience negative emotional arousal. Similarly, Zhao (2011) observed that cuing individuals to perceive their managers as intolerant of errors resulted in negative affect. Other research has demonstrated that emotion control (affective pathway) mediates error management training effects on learning outcomes (Bell & Kozlowski; Keith & Frese). We extended this research, positing that training could be structured through the use of positive error framing to increase individuals' focus on regulating their emotions, that is, on emotion control.

Considering affective and motivational processes as related to each other but distinct is not a new idea. Kraiger, Ford, and Salas (1993) distinguished between cognitive, skill–based, and a broad category of other training outcomes they labeled affective outcomes. This broad category included attitudinal (affective evaluations related to objects and affect strength) and motivational outcomes (motivational disposition, self–efficacy, and goal setting). Kraiger et al. felt justified in collecting attitudes and motivation constructs within this broad category because both types of constructs reflected internal states that influence behavior (p. 318).

Kraiger et al. (1993) distinguished between types of "affective" outcomes, and other research has demonstrated the value of distinguishing between affect and motivation constructs (e.g., Bandura, 1997; Bell & Kozlowski, 2008; Locke & Latham, 1990). Thus, we retained this distinction, which enabled us to more clearly address relationships between motivational and affective processes. Specifically, consistent with Bell & Kozlowski's results, Bandura (pp. 106, 111) and Locke and Latham (p. 74) both described evidence that affect (i.e., mood) influences self–efficacy. However, Bandura (p. 137) reviewed research showing that self-efficacy also plays a role in emotional self-regulation. That is, higher self-efficacy leads to greater emotional self-regulation. Moreover, prior research has demonstrated that subjective task complexity is negatively related to self-efficacy (e.g., Mangos & Steele-Johnson, 2001). In general, individuals who perceive a task as less complex tend to feel more confident that they can perform the task. Thus, we posited that error framing would influence affective processes (emotion control) directly and indirectly through cognitive (subjective task complexity) and motivational processes (self-efficacy).

Hypothesis 2a: Error framing influences self-efficacy.

Hypothesis 2b: Error framing influences emotion control.

Hypothesis 2c: Error framing has indirect effects on emotion control through self-efficacy.

Hypothesis 2d: Error framing has indirect effects on emotion control through subjective task complexity and self-efficacy.

Effects of Cognitive, Motivational, and Affective Factors on Performance

Finally, we posited that subjective task complexity and self-efficacy would have direct effects on performance as well as indirect effects through metacognition and emotion control. Campbell (1988) suggested and subsequent research has demonstrated that subjective task complexity is related to performance (Mangos & Steele-Johnson, 2001; Maynard & Hakel, 1997). Using the aforementioned outlined reasoning, we expected subjective task complexity would influence metacognition. Also, prior research (e.g., Keith & Frese, 2005, 2008) has suggested that metacognition mediates error management effects on performance. Thus, we posited that individuals who perceived a task as more complex and more demanding would engage in greater metacognition which, in turn, would benefit performance.

Hypothesis 3a: Subjective task complexity influences performance.

Hypothesis 3b: Metacognition influences performance.

Hypothesis 3c: Subjective task complexity has indirect effects on performance through metacognition.

Also, prior research has demonstrated the beneficial effects of self-efficacy on performance (see Bandura, 1997, for a review) and has provided meta-analytic estimates of correlations ranging from .23 to .38 (Judge & Bono, 2001; Stajkovic & Luthans, 1998). Other research has suggested that emotion control is a mediator of error management effects on performance (e.g., Keith & Frese, 2008). Thus, we posited that individuals who have higher self-efficacy would be more proactive and engage in greater emotion control which, in turn, would benefit performance.

Hypothesis 4a: Self-efficacy influence performance.

Hypothesis 4b: Emotion control influence performance.

Hypothesis 4c: Self-efficacy has indirect effects on performance through emotion control.

Finally, we extended prior research by examining potential differential effects of these processes on two aspects of performance—quality and quantity. Conflicting results from prior research prevented us from stating a hypothesis and caused us instead to address this issue as a research question. That is, meta-analytic results have demonstrated beneficial effects for error management training on both performance quantity and errors (Keith & Frese, 2008). However, other research (e.g., Austin & Bobko, 1985; Erez, 1990) has indicated that there is value in distinguishing between performance quality as an outcome (e.g., accuracy, errors) and performance quantity (i.e., speed, number of actions completed). This research has shown that in some situations interventions have different effects on performance quantity than on quality. An interesting question, then, is whether error framing and factors influenced by error framing have differential effects on performance quantity versus quality. This question allows us to extend prior research (e.g., Bell & Kozlowski, 2008; Keith & Frese) by parsing the performance domain to further elucidate potential differential pathways. Further, understanding potential differential effects might influence training design. That is, if performance quality is influenced through different mechanisms than is performance quantity, trainers might design training to focus on those mechanisms most likely to benefit their targeted performance outcome.

Research Question 1: Are error framing effects on performance quantity and performance quality differentially mediated by cognitive, motivational, and affective processes?

Method

Participants and Design

Participants ($N = 168$) were undergraduate students enrolled in an introductory psychology course at a mid-western university. Participants were randomly assigned to either the positive or negative error framing condition. Participants' average age was approximately 20 years; most were female (59%), white (75%), and either college freshmen or sophomores (85%).

Task Description

Participants performed a moderately difficult, computerized simulation of a class scheduling task, similar to the one used in Mangos and Steele-Johnson (2001). Participants chose courses from a database to develop schedules for college students that conformed to six pre-specified rules. An example rule was "You must assign a lab section for any course in which a lab is required." Participants received feedback regarding the number of schedules completed as well as the number and nature of errors committed. Participants in both error framing conditions performed the same task and had the same opportunities to explore the task. Furthermore, participants in both conditions received the same task instructions, rules constraining task performance, and types of feedback. Instructions did not provide any information regarding possible strategies for performing the task. Only the error framing manipulation differed, cuing participants to pay attention to different aspects of the feedback.

Participants in both conditions worked on two versions of the task: training and transfer. The transfer task reflected near transfer, that is, analogical transfer; that is, the requirements of the transfer task were similar to those of the training task (see Keith & Frese, 2008, for a discussion). There were two differences between the training and transfer tasks. We added a seventh rule to the transfer task: "A student's schedule must not exceed 3 consecutive hours of lecture time without having a break." Adding this rule increased task complexity and decreased performance during the transfer trials (i.e., Trials 5 and 6), compared to the training trials (Trials 1 through 4). Also, we introduced new task instructions during the transfer trials. Specifically, we instructed participants to try to produce both as many class schedules and as few errors as possible.

Error Framing Manipulation

In the *positive error framing* condition, a paragraph induction encouraged participants to view errors, positively, that is, as useful and helpful. Specifically, participants were told to "…feel free to explore the task…" and to "…discover why you made that error. Understanding how and why the error occurred will help you improve your performance…" Also, they were told that "Errors are a natural part of learning and aid in developing your understanding of the task…" Finally, participants were told that "…it is okay to make mistakes . . . ” and “When you encounter an error, do not feel stressed . . . ” Participants were shown a reminder between training task trials to focus on the content of the error messages. Furthermore, four positive framing statements (taken from Heimbeck, Frese, Sonnentag, & Keith, 2003) were posted on the computer monitor. One framing statement was, “Errors are a natural part of the learning process.”

In the *negative error framing* condition, a paragraph induction encouraged participants to view errors negatively, that is, as something to avoid. Specifically, participants were told to “ . . . follow the instructions given to you . . . ” and that “The rules and guides will help learning . . . ” Also, they were told that “Errors force you to work inefficiently . . . ”, and “ . . . you want to try to avoid mistakes . . . ” Finally, participants were told that “You want to avoid errors at all costs . . . ” and “ . . . errors are counted . . . ” Participants were shown a reminder between trials to focus on the number of schedules produced, the number of errors made, and the cumulative score during the trial. Consistent with prior research (e.g., Heimbeck et al., 2003), these participants did not receive framing statements. Often training is designed to avoid the commission of mistakes, so reminders of error-avoidance would be redundant with training expectations.

Measures

Learning From Errors (Manipulation Check Measure)

We adapted items from the Learning from Errors subscale of the Error Orientation Questionnaire (EOQ) developed by Rybowiak, Garst, Frese, and Batinic (reported alpha = .89; 1999). We adapted the four items to be task specific and added three additional items to reflect the task and manipulation instructions. An example item is, “My mistakes had helped me to learn the task better.” Confirmatory factor analyses suggested that the added items along with the adapted EOQ items reflected one factor. Participants responded using a 7-point Likert–type scale (1 = strongly disagree, 7 = strongly agree). The alpha in the current sample was .87.

Subjective Task Complexity

We used a 6-item measure of subjective task complexity adapted from Steele-Johnson, Beauregard, Hoover, and Schmidt (reported alphas ranged from .71–.76, 2000). Participants responded using a 7-point Likert-type scale (1 = not at all, 7 = very). The alpha in the current sample was .73. An example item is “How challenging is this task?”

Self-Efficacy

We used a 9-item measure of self-efficacy (Riggs et al., 1994; reported alpha = .86). Participants responded using a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). The alpha in the current sample was .78. An example is "I have confidence in my ability to perform this task."

Metacognition

We used an adaptation of the Cognitive Self-Consciousness subscale (reported alpha = .72) from Cartwright-Hatton and Wells' (1997) Meta-Cognitions Scale for Worry and Intrusive Thoughts. We revised the six items to reflect the state aspects of metacognitions by altering the items from present to past tense and qualifying each statement with a clause that made the task salient. Participants responded to the adapted measure using a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). The alpha in the current sample was .87. An example item is, "I monitored my thoughts while working on the task."

Emotion Control

We measured emotion control with an 8-item measure used by Keith and Frese (2005, reported alpha = .80). Participants responded using a 5-point Likert-type scale (1 = False, 5 = True). The alpha in the current sample was .82. All items began with the stem "When difficulties arose . . . " An example item that completed this stem is, " . . . I did not allow myself to lose my composure."

Performance

We employed two measures of performance: number of course schedules completed and number of errors. The number of course schedules completed within one trial provided an indication of performance quantity. The number of errors that participants made in each trial provided an indication of performance quality. Making few errors reflected high performance quality. Transfer performance was number of schedules completed or number of errors averaged across Trials 5 and 6. Only transfer performance data was used in analyses.

Demographics

Participants reported demographic information, including gender, race, age, class (e.g., freshman), ACT score, computer experience, and familiarity with the task.

Procedure

Participants received task instructions and the task rules. After this, participants were exposed to their respective manipulation, completed a 10-minute practice trial to familiarize themselves with the task, and completed the manipulation check measure. Next, participants complete three training trials without interruption (except for the reminder between trials to focus on specific feedback relevant to their assigned condition) and completed the second administration of

TABLE 1. Means, Standard Deviations, and Intercorrelations Between Study Variables

	M	SD	1	2	3	4	5	6
1 Error Framing[a]	0.47	0.50	—					
2 Subj. Task Cpx.	3.70	1.25	−.15[b]	.73				
3 Self-efficacy	5.47	1.00	.19*	−.37***	.78			
4 Metacognition	4.72	1.39	.19*	.21**	.06	.87		
5 Emotion Control	4.26	0.77	.09	−.08	.37***	.09	.82	
6 Number of Errors (Perf. Quality)	1.96	2.70	−.03	.22**	−.09	−.06	−.01	—
7 Number of Schedules Compl. (Perf. Quantity)	4.59	2.11	.07	−.12	.39***	−.06	.31***	.10

Note. Subj. Task Cpx. = subjective task complexity. Perf. = performance. Compl. = completed. Internal consistency reliabilities for measures are reported on the diagonal.
[a]Error Framing Condition is coded as 1 for positive error framing ($n = 79$) and 0 for negative error framing ($n = 89$).
[b]$p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

the manipulation check measure and measures of subjective task complexity, self-efficacy, metacognition, and emotion control. Participants then were instructed to try to both make as many schedules and as few errors as possible during the transfer trials and were told that the next trials (i.e., transfer trials) reflected a new version of the task that presented a more difficult challenge for participants than experienced in previous trials. Participants re-read the task rules (including the additional rule), performed two 10-minute trials of the transfer task, and completed the subjective task complexity measure again and the demographics measure.

Results

Sample Characteristics and Initial Group Differences

Data from 168 participants was available for analysis. We examined the distribution of participant characteristics across the error framing conditions, examining similarity in the two conditions in terms of gender, computer and task experience, and ACT scores (a proxy for cognitive ability). Participants in the two conditions did not differ in gender distribution, $\chi^2(1) = 1.61$, $p = .21$, computer experience, $F(1, 166) = 0.02$, $p = .89$, or experience with similar class scheduling tasks, $F(1, 166) = 0.05$, $p = .82$. Also, participants ($n = 122$) in the two conditions did not differ in ACT scores, $F(1, 120) = 0.30$, $p = .58$. Descriptive statistics and correlations between study variables are provided in Table 1.

Manipulation Checks

ANOVA results revealed that participants in the positive error framing condition reported greater learning from errors, $M = 5.17$, $SD = 1.22$, compared to participants in the negative error framing condition, $M = 4.62$, $SD = 1.38$, $F(1,166) = 7.33$, $p < .01$. Also, results from a repeated measures ANOVA indicated that subjective task complexity levels reported by participants were significantly higher after the transfer trials, $M = 4.05$, $SD = 1.32$, than at the end of the training trials, $M = 3.70$, $SD = 1.25$, $F(1, 166) = 13.70$, $p < .001$. This suggested that our manipulations of error framing and training versus transfer task versions were successful.

Tests of Hypotheses

To test our hypotheses, we constructed and compared two path models, including paths relevant to tests of our hypotheses. We used a path modeling approach because our sample size was small relative to the complexity of our model. Also, we conducted specific tests in Mplus using bootstrapping (Shrout & Bolger, 2002) to test predicted indirect effects in the hypothesized model. Results of these tests are reported in Table 2.

Test of Hypothesized Model

The hypothesized model demonstrated adequate fit, $\chi^2(6) = 6.97$, $p = .323$, CFI = .991, RMSEA = .031, and SRMR = .039. Path coefficients are shown in Figure 1. We then examined the fit of our hypothesized model against an alternative, less parsimonious model that included three additional paths: from self-efficacy to meta-cognition, from subjective task complexity to emotion control,

TABLE 2. Tests of Indirect Effects

	Hypothesized Indirect Effect	β	t	p
H_{1c}:	EF → STC → MC	−.036	−1.66	<.10
H_{2c}:	EF → SEff → EC	.052	1.83	<.10
H_{2d}:	EF → STC → SEff → EC	.019	1.69	<.10
H_{3c}:	STC → MC → Errors	−.027	−1.34	ns
H_{3c}:	STC → MC → Schedules	−.028	−1.45	ns
H_{4c}:	SEff → EC → Errors	.009	.29	ns
H_{4c}:	SEff → EC → Schedules	.073	2.37	<.05

EF = Error Framing; STC = subjective task complexity; MC = metacognition; SEff = self–efficacy; EC = emotion control; Errors = number of errors (performance quality); Schedules = number of schedules completed (performance quantity); ns = non-significant.

and from meta-cognition to emotion control. The alternative model demonstrated an adequate fit, $\chi^2(3) = 3.11$, $p = .373$, CFI = .999, RMSEA = .015, and SRMR = .022. However, the alternative model failed to demonstrate a better fit than the hypothesized model, $\chi^2_{\text{diff}}(3) = 3.76$, $p > .05$. Therefore, we accepted the more parsimonious, hypothesized model. Results are discussed in the following sections in relation to specific predictions.

Direct and Indirect Effects of Error Framing on Subjective Task Complexity and Metacognition (Hypotheses 1a, 1b, and 1c)

Results provided partial support for our predictions. Results indicated a significant path from error framing to metacognition in support of Hypothesis 1a. The path from error framing to subjective task complexity was not significant, failing to support Hypothesis 1b. Also results revealed a significant path from subjective task complexity to metacognition. A test of indirect effects using bootstrapping was not significant, failing to support Hypothesis 1c (see Table 2). Results provided evidence that participants in the positive error framing condition engaged in greater metacognitive activity relative to those in the negative error framing condition and that greater subjective task complexity was associated with greater metacognitive activity.

Direct and Indirect Effects of Error Framing on Subjective Task Complexity, Self-Efficacy, and Emotion Control (Hypotheses 2a, 2b, 2c, and 2d)

Results provided partial support for our predictions. Results indicated a significant path from error framing to self-efficacy in support of Hypothesis 2a. Also, the path from self-efficacy to emotion control was significant. However, the path from error framing to emotion control was not significant, failing to support Hypothesis 2b. Finally, a test of indirect effects using bootstrapping failed to provide evidence of an indirect effect through self-efficacy (Hypothesis 2c) or an indirect effect through subjective task complexity and self-efficacy (Hypothesis 2d, see Table 2). Results provided evidence that participants in the positive error framing condition reported higher levels of self-efficacy, and higher self-efficacy was associated with higher levels of emotion control.

Direct and Indirect Effects of Subjective Task Complexity and Metacognition on Number of Errors and Number of Schedules Completed (Hypotheses 3a, 3b, and 3c)

Results provided partial support for our predictions. Results indicated a significant path from subjective task complexity to number of errors but not number of course schedules completed, partially supporting Hypothesis 3a. Also, as reported in the previous section, subjective task complexity was related to metacognition. However, results indicated nonsignificant effects from metacognition to number of errors and number of schedules completed, failing to support Hypothesis

3b. Finally, tests of indirect effects using bootstrapping provided no evidence of an indirect effect on either number of errors and number of schedules completed through metacognition, failing to support Hypothesis 3c (see Table 2). Higher perceived task complexity was associated with greater metacognitive activity and more errors. Also these results addressed the research question, providing evidence that subjective task complexity has different effects on performance quality (number of errors) and performance quantity (number of schedules completed).

Direct and Indirect Effects of Self-Efficacy and Emotion Control on Number of Errors and Number of Schedules Completed (Hypotheses 4a, 4b, and 4c)

Results provided partial support for our predictions. Results indicated a significant path from self-efficacy to number of schedules completed but not number of errors, partially supporting Hypothesis 4a. Similarly, results indicated a significant effect from emotion control to number of schedules completed but not number of errors, partially supporting Hypothesis 4b. Finally, tests of indirect effects using bootstrapping provided evidence of an indirect effect of self-efficacy on number of schedules completed through emotion control in partial support of Hypothesis 4c but no evidence of an indirect effect on number of errors (see Table 2). Higher self-efficacy was associated with greater emotion control and more schedules completed. These results addressed the research question as well, providing evidence that self-efficacy and emotion control have different effects on number of errors and number of schedules completed.

Discussion

Our results supported and extended prior research by providing evidence relating to the influence of error framing on cognitive, motivational, and affective processes while holding task context constant and the influence of these processes on different aspects of task performance. Noting that altering a task context to increase opportunities for exploration or provide emotion control training might not always be feasible in applied settings, we sought to extend prior research by examining the extent to which error framing would influence performance quality and quantity through cognitive, motivational, and affective pathways. Our results provided evidence that positive error framing can be beneficial in learning from errors on the job.

More specifically, the hypothesized model fit the data well, but we observed mixed results for specific model paths. As predicted, positive error framing was associated with greater metacognition (a cognitive process) and greater self-efficacy (a motivational process). Also as predicted, higher subjective task complexity (a cognitive process) was associated with more errors (a measure of performance quality), and higher self-efficacy was associated with greater emotion control (an affective process) and more schedules completed (a measure of performance quantity). As predicted, self-efficacy had an indirect effect on number of schedules completed through emotion control. Finally, although not specifically predicted, results revealed that higher subjective task complexity was associated with greater metacognition and higher self-efficacy.

Theoretical Implications and Future Research

Results contributed to our understanding by providing evidence supporting a proposed model relating error framing with cognitive, motivational, and affective processes and, in turn, performance. Our focus integrated error management training research (e.g., Keith & Frese, 2008) with research on learning from errors in real-time on the job (e.g., Hutchins, 1995). Our results were mixed, though, with respect to supporting specific paths within the proposed model.

Specifically, in support of our predictions, results provided evidence that error framing influenced cognitive and motivational processes. That is, positive error framing had a beneficial effect on metacognition, a cognitive process; positive error framing encouraged participants to think more about the task and how to accomplish it. Also, positive error framing had a beneficial effect on self-efficacy, a motivational process; participants who received positive error framing had greater confidence in their ability to perform the task. Together, these results suggest that encouraging individuals to frame errors as useful and informative can increase cognitive and motivational processes that prior research (e.g., Bandura, 1997; Keith & Frese, 2005) has shown to have beneficial effects on learning and performance. Moreover, we observed these effects in a work context in which individuals were required to learn during real-time task performance and in which individuals' opportunities to explore the task were constrained. Hutchins (1995) highlighted the important role of errors in on-the-job learning in complex work domains. Our results provide evidence that we can enhance learning from errors by using positive error framing to encourage higher levels of metacognition and self-efficacy.

Additionally, our results suggested several directions for future research. For example, we failed to observe a significant direct effect of error framing on subjective task complexity or emotion control. Error framing was related to subjective task complexity at $p < .10$, though, suggesting that it might be wise to further examine this relationship before accepting the null hypothesis. Similarly, it might be beneficial to further examine whether error framing has an indirect effect on metacognition through subjective task complexity. Further, future research is needed examining the effects of error framing on emotion control. Perhaps we needed a better measure. However, Keith and Frese (2005) observed effects involving emotion control using this measure, and we observed an effect for emotion control on performance. Thus, future research might examine an error framing manipulation that focuses to a greater extent on managing emotions or whether cuing emotion control is insufficient if individuals are not familiar with emotion control strategies.

Also, other paths in the hypothesized model have implications and suggest the need for future research. For example, metacognition had no effect on performance in our study. This contrasts with prior research (e.g., Keith & Frese, 2005) demonstrating beneficial effects of metacognition on performance. Possibly, our task was insufficiently complex to require substantial metacognition; alternatively, perhaps our task was complex but individuals required more task experience to allow metacognitive effects to emerge. As another example, given the tendency ($p < .10$) for individuals in the positive error framing condition to perceive the task as less complex, one might expect to observe lower metacognition, but positive error framing was associated with greater metacognition. Research is needed to disentangle error framing and subjective task complexity effects on metacognition. Finally, results provided evidence of differential effects of cognitive (i.e., subjective task complexity), motivational (i.e., self–efficacy), and affective (i.e., emotion control) processes on performance quality and quantity. At high levels of skill acquisition, one would expect to see high quantity with few errors (e.g., Anderson, 1990, pp. 258–260). However, at lower levels of skill acquisition, quantity and quality might be inversely related or unrelated and might be differentially affected by cognitive, motivational, and affective processes. Research is needed further examining when and why these factors differentially influence performance quality and quantity.

Practical Implications

Our results have practical implications. First, in settings in which it would be difficult to increase opportunities for task exploration, our results suggest that cuing individuals to perceive errors positively might be beneficial. That is, simply telling individuals that errors are useful might have beneficial effects on metacognitive activity and self-efficacy, relative to telling individuals that errors are to be avoided, and prior research has demonstrated that metacognitive activity and self-efficacy enhance learning and performance. Second, our results suggest that trainers can focus on cognitive versus motivation and/or affective mechanisms, respectively, if their focus is on improving performance quality versus quantity, particularly at low-to-moderate levels of skill acquisition. That is, subjective task complexity (cognitive pathway) more strongly influenced performance quality, and self-efficacy (motivational pathway) and emotion control (affective pathway) more strongly influenced performance quantity.

Limitations

As with any piece of research, our study had several limitations. One might question whether our task was sufficiently complex to see the benefits of error framing. However, the task was sufficiently complex that students did not master the task during training, and we might have observed larger effects if we had provided a more extensive training period. Also, including a neutral error framing condition might have been informative. Furthermore, we relied on existing measures of emotion control and metacognition; we might benefit from finding or designing measures better designed to capture error framing effects. Finally, because of constraints imposed by our sample size relative to the complexity of our model, we used path analysis to examine effects rather than structural equations modeling.

Conclusions

In conclusion, our results demonstrated the usefulness of positive error framing, that is, incorporating cues related to positive error valence. Our results demonstrated beneficial direct effects for positive error framing on cognitive and motivational processes while holding task context constant, provided support for a hypothesized model addressing cognitive (e.g., metacognition, subjective task complexity), motivational (e.g., self–efficacy), and affective processes (e.g., emotion control), and demonstrated differential effects for these processes on performance quality versus quantity. Our results showed that benefits can be gained through positive error framing alone, suggesting that benefits can be gained even when tasks cannot be structured to support extensive exploration or to provide extensive emotion control training. Whereas, further research can expand our understanding of error framing effects on outcomes, results from the current study suggest that positive error framing can facilitate learning from errors in real-time performance of tasks.

AUTHOR NOTES

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