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A DYNAMIC, SELF-REGULATORY EXAMINATION OF EMOTIONS AND COMPLEX TASK LEARNING

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BY

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To my grandparents, Rod and Jan Larson, who passed far too soon. Although you are no longer with us, you provided so much support along the way and I can honestly say I would not be where I am today without all your love and support. Thanks for always being proud of me!

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Abstract

The purpose of this laboratory study involving undergraduates learning a complex videogame was to address gaps in the empirical literature regarding the role of emotions in self-regulated learning by testing opposing predictions made by the hedonic tone and dual pathway perspectives. Whereas hedonic tone perspective suggests pleasant emotions facilitate performance, the dual pathway perspective suggests that the activation potential of emotions takes precedence over the pleasantness of emotions, and in doing so predicts that changes in negative activating (e.g., angry, frustrated) and positive deactivating emotions (e.g., calm, relaxed) are positively and negatively related to performance, respectively. Using a repeated-measures design and discontinuous mixed-effects growth modeling, analyses focused on within-person relationships between emotions and videogame performance over periods of skill acquisition, transition adaption, and reacquisition adaption. Results supported the hedonic perspective. Specifically, increases in positive and negative emotions in skill acquisition and adaptation were associated with increases and decreases in performance, respectively, regardless of activation potential. Additionally, dynamic effects were found for both negative-activating, promotion-focused emotions and negative deactivating emotions. In particular, negative associations with performance became weaker throughout adaptation. Results are discussed regarding implications for considering the role of emotions when training involves a complex, dynamic, and fast-paced task.

Keywords: Emotions, skill acquisition, adaptive performance, complex task learning, self-regulated learning

Introduction

Learning a complex task and adapting to unforeseen changes in task demands are difficult, and often emotional processes. As such, how learners self-regulate their affective, cognitive, and behavioral processes is critical to skill acquisition and adaptive performance (Sitzman & Ely, 2001). Although the empirical literature on self-regulated learning is robust and continues to grow (Sitzmann & Ely, 2011), the empirical literature on the role of emotions is conspicuously lacking in both depth and scope. With respect to depth, despite a long-standing theoretical distinction between trait- and state-based variance in affect (Baas, De Dreu, & Nijstad, 2008; De Dreu, Baas, & Nijstad, 2008; To, Fisher, Ashkanasy, & Rowe, 2012), surprisingly little empirical attention has been devoted to disentangling between- (i.e., trait) from within-person (i.e., state) variance in examining the effects of emotions on skill acquisition and adaptive performance. With respect to scope, research on self-regulated learning has predominantly focused on the role of anxiety with a lack of consideration to a fuller spectrum of emotions, particularly how specific emotions differ not just in terms of hedonic tone (i.e., pleasant or unpleasant) but also their activation potential and regulatory focus (Baas, De Dreu, & Nijstad, 2008; De Dreu, Baas, & Nijstad, 2008; Higgins 1997; Higgins 2001; To, Fisher, Ashkanasy, & Rowe, 2012). This lack of scope and depth in the empirical research on self-regulated learning does not provide a complete understanding of the role of emotions in self-regulated learning. Consequently, practical recommendations regarding the management of emotions may be too simplistic if not misguided (De Dreu et al., 2008; Sitzmann & Ely, 2011; To et al., 2012). For instance, it is commonly thought that individuals should focus on positive thoughts (Bell & Kozlowski, 2008; Keith & Frese, 2005; Kanfer & Ackerman, 1990; Niessen & Jimmieson, 2015) and keep “negative emotions at bay” (Niessen & Jimmieson, 2015, p. 2). However, recent advances in emotions and creativity research suggest the role of emotions in relation to performance may be more complex.

The basic premise of the present research is that emotions might play a more nuanced role in skill acquisition and adaptive performance than the extant literature suggests. In other words, positive emotions may not be universally beneficial to performance, and it may not always be beneficial to keep “negative emotions at bay” (Niessen & Jimmieson, 2015, p. 2). Effects may depend on the activation potential as well as regulatory focus of emotions, and effects may also be dynamic in relation to how the allocation of attentional resources changes when acquiring skills and adapting to unforeseen changes in task demands.

Therefore, the purpose of the present research is to contribute to a more nuanced understanding of the dynamic role of emotions on skill acquisition and adaptive performance by integrating resource allocation theory (Kanfer & Ackerman, 1989) with the dual pathway model of creativity (De Dreu et al., 2008) and regulatory focus theory (Higgins 1997; Higgins 2001). I examined competing perspectives concerning the within-person effects of emotion dimensions as a function of their hedonic tone, activation potential, and regulatory focus. The study incorporated a task-change paradigm in the context of a learning a complex computer task (Lang & Bliese, 2009) whereby participants first underwent a period of basic instruction and skill acquisition followed by a period in which they were confronted with unforeseen changes in the task demands that required adaptive behavior. Repeated measures of objective performance and self-reports of emotions were taken during both skill acquisition and adaptation. A combination of discontinuous growth modeling and hierarchical linear modeling was used to examine the competing perspectives of the role of within-person emotions on performance across skill acquisition and adaptation trials.

Self-Regulated Learning, Skill Acquisition, and Adaptive Performance

Self-regulation is defined as the "modulation of affective, cognitive, and behavioral processes throughout a learning experience to reach a desired level of achievement" (Sitzman & Ely, 2011, p. 421). Recent research on self-regulated learning has emphasized the importance of distinguishing within- from between-person effects with respect to self-efficacy (Vancouver & Kendall, 2006), goal orientation (Yeo, Loft, Xiao, & Kiewitz, 2009), and exploration (Hardy, Day, Hughes, Wang, & Schuelke, 2014). In some instances, a relationship may be positive at the between-person level but negative at the within-person level (Vancouver & Kendall, 2006; Yeo et al., 2009). For example, researchers have found that self-efficacy is positively related to performance at the between-person level; however, at the within-person level, self-efficacy is often negatively related to performance (Vancouver & Kendall, 2006). Research suggests that this relationship is negative at the within-person level because as self-efficacy increases, individuals become more confident and allocate fewer attentional resources to the task. Because these fluctuations are not captured at the between-person level, it is important to disentangle these effects, which can ultimately lead to a better understanding of how self-regulatory processes relate to acquisition and performance adaptation.

Self-regulation is critical to skill acquisition. According to the ACT-R theory (Anderson et al., 2004), learning occurs in three stages—declarative, compilation, and proceduralization—that each place different demands on attentional resources. In the declarative stage, attentional demands are high because strategies for effective performance are unclear, and individuals must focus on acquiring the relevant facts about the task demands and procedures. Performance is initially low because of the complexity of the task and lack of knowledge. Effective self-regulation of complex task learning involves focusing attentional resources to the task despite feeling overwhelmed initially (Anderson et al., 2004). As facts are acquired, they must also be compiled into a relatively coherent structure. Thus, compilation initially requires relatively high levels of attentional resources as factual and procedural information is consolidated into a streamlined set of task strategies. Over time, less attentional resources are needed to execute one's learned task strategies. Finally, proceduralization involves more automated processing in which fewer attentional resources are needed to perform the task. Performance at this stage plateaus, such that improvements in performance diminish (i.e., ceiling effects). Part of this can be explained by individuals' tendency to settle on effective yet suboptimal task strategies (Dörner, 1980). There are diminishing returns to the allocation of attentional resources to task demands in the proceduralization stage. However, sustained allocation of attentional resources to task demands is needed to prevent settling on suboptimal solutions and to promote learning more advanced task strategies (Dörner, 1980; Hardy, Day, Hughes, Wang, & Schuelke, 2014).

Furthermore, focused attention may be even more important when there is a task change. Adaptive performance refers to how well individuals modify task strategies in response to unforeseen changes in task demands (Bell & Kozlowski, 2008; Lang &

Bliese, 2009). When adapting to changes, individuals need to allocate attentional resources to the task demands to learn new strategies and replace or modify previous strategies.

To distinguish acquisition from adaptation effects, researchers have employed a task change paradigm and modeled performance across repeated trials prior to (i.e., acquisition) and following (i.e., adaptation) a change in task demands (Lang & Bliese, 2009). The task change typically reflects an increase in task complexity and it disrupts the effectiveness of acquired task strategies. The change is administered after performance has begun to plateau. Transition adaptation refers to the amount of change (i.e., loss) in performance following the task change. Reacquisition adaptation refers to the rate of change (i.e., gains) in performance across the trials following the task change. The modeling of performance across repeated trials both pre- and post-change is useful because it allows researchers to examine and distinguish acquisition from adaptation processes.

For instance, successful adaptation involves the allocation of attentional resources to discovering and making sense of task demands and determining which acquired task strategies need to be modified or replaced altogether. The adaptation process is fairly similar to that of acquisition as described previously. However, the sudden increased demand for attentional resources affected by the task change stems from a combination of new learning and unlearning. I posit that the combination of learning and unlearning makes the process of adaption inherently more difficult than the acquisition process, and thus successful adaptation puts a higher premium on self-regulation. This proposition is consistent with research showing slower reacquisition adaptation compared to acquisition (e.g., Lang & Bliese, 2009). Therefore, one of the important goals of this study was to compare the effects of different emotions during adaptation versus acquisition trials. Put another way, this study examined whether the role played by specific emotions is stronger, weaker, or different in adaptation versus acquisition.

Dimensions of Emotions

Figure 1 shows a breakdown of emotion dimensions discussed in the literature, and the emotions I examined. As mentioned previously, the present study emphasizes the activation potential of emotions which has been overlooked in the training and skill acquisition literature. Previous literature has focused primarily on the hedonic tone of emotion in regard to skill acquisition without considering how activation potential might impact the allocation of attentional resources (Sitzmann & Ely, 2011).

Hedonic tone refers to whether the emotion experienced is pleasant (e.g., calm, happy) or unpleasant (e.g., discouraged, angry). Within the creativity literature, the hedonic tone perspective posits that positive emotions are more likely to promote creativity than negative and neutral emotional states and this perspective has been supported by studies showing how increases in positive emotions promote creativity through increased cognitive flexibility and broadened attention (Baas, De Dreu, & Nijstad, 2008; Frederickson, 2001; Frederickson & Brannigan, 2005; Goschke, 2006; Isen & Daubman, 1984). However, other studies report positive relationships between increases in negative emotions and creativity (George & Zhou, 2002; Kaufmann, 2003). These inconsistencies led researchers to examine other components of emotions that might interact with hedonic tone, suggesting there is more to emotions than just how pleasant/unpleasant they make us feel (Baas et al., 2008; Smith & Ellsworth, 1985).

For example, activation potential has been linked to the relationship between stress and performance, such that there is a curvilinear relationship between arousal and activation (Yerkes & Dodson, 1908). Within the creativity literature, the dual pathway perspective suggests that, regardless of hedonic tone, activating emotions should be more beneficial to creative performance than deactivating emotions because they stimulate on-task attention (e.g., exploring task strategies), whereas deactivating emotions are detrimental because they divert attentional resources to off-task thoughts (e.g., self-doubt) (Baas et al., 2008; De Dreu et al., 2008). For example, To et al. (2012) found a negative relationship between both positive (e.g., relaxed) and negative deactivating emotions (e.g., discouraged) and creative process engagement, indicating that participants who experienced increased positive and negative deactivating emotions while performing a task did not engage in the creative process. In a similar vein, researchers examining activating and deactivating emotions have shown positive relationships between both positive (e.g., happy, elated) and negative activating emotions (e.g., angry, worried) and creative processes, with null relationships between positive (e.g., calm, relaxed) and negative deactivating emotions (e.g., fatigued, discouraged) and creative processes (De Dreu et al., 2008). Furthermore, positive effects of negative activating emotions may be lagged, occurring downstream via persistence (To et al., 2012).

However, the positive effect of negative activating emotions is less clear when regulatory focus—promotion versus prevention—is considered. According to Higgins

(1997), promotion and prevention foci stem from nurturance and security needs, respectively, and they underlie approach-avoidance behavior. Promotion focus entails approach behaviors with goal pursuit centered on accomplishments (e.g., success), whereas prevention focus involves avoidance behaviors with goal pursuit focused more on threats (e.g., failure). While there is no discrepancy regarding negative-activating, promotion-focused emotions (i.e., both dual pathway and regulatory focus perspectives would predict positive effects), there is a discrepancy between the two perspectives regarding negative-activating, prevention-focused emotions. In particular, the activation hypothesis suggests that emotions like tension and anxiety are beneficial to performance via on-task attention (De Dreu et al., 2008), whereas regulatory focus theory suggests these emotions are detrimental because they divert attention to off-task thoughts (e.g., avoiding mistakes, poor performance) rather than thoughts of making improvements (Higgins, 1997).

Competing Perspectives Regarding Performance

Previous research has established at the between-person (i.e., interindividual) level of analysis that positive affect is associated with positive effects and negative affect is associated with negative effects (Judge & Illies, 2004; Kanfer & Ackerman, 1989; Kaplan, Bradley, Luchman, & Haynes, 2009). In a similar vein, within the creativity literature, at the between-person level, negative emotions detract from creative performance by focusing attentional resources to off-task thoughts, whereas positive emotions are beneficial to performance by focusing attentional resources to on-task thoughts (De Dreu et al., 2008; To et al., 2012).

At the within-person level, there are competing perspectives regarding the relationship between emotions and performance based on the dimension of the emotions (i.e., hedonic tone, activation potential, or regulatory focus). Although the hedonic tone hypothesis (Baas et al, 2008) suggests that positive emotions will yield positive relationships with performance in contrast to negative emotions, the dual pathway model (De Dreu et al., 2008) emphasizes the need to consider the activation potential of the emotion. Thus, the effects of fluctuations in emotions are less clear. In particular, can within-person effects be explained simply in terms of hedonic tone? If so, then effects at the within-person level would be the same as those at the between-person level. Alternatively, can within-person effects be explained simply in terms of activation potential or regulatory focus? Also, are the within-person effects of certain emotions dynamic such that their magnitude (or even direction) changes across periods of acquisition, transition adaptation, and reacquisition adaptation? In other words, do certain emotions play stronger, weaker, or different roles in adaptation versus acquisition?

Similarities

Consistent with both hedonic tone and dual pathway perspectives, negative deactivating emotions should be harmful to performance because negative deactivating emotions (e.g., disappointed, discouraged) are unpleasant, divert attention away from the task, and are likely to diminish motivation, whereas positive activating emotions (e.g., excited, happy) are pleasant and direct attentional resources to task demands via broadened attention, which is consistent with broaden-and-build theory (De Dreu et al., 2008; Frederickson, 2001; Frederickson & Brannigan, 2005). Thus, both hedonic tone and dual pathway perspectives predict positive and negative relationships between fluctuations in positive activating emotions and negative deactivating emotions and performance, respectively.

Differences

The hedonic tone perspective predicts a positive relationship between positive deactivating emotions (e.g., calm, content) and performance, whereas the dual pathway perspective predicts that deactivating emotions are not beneficial to task engagement because they divert attention away from the task (De Dreu et al., 2008; Frederickson & Brannigan, 2005; Isen & Daubman, 1984). From the dual pathway perspective, positive deactivating emotions are harmful to performance because they signal that the state of affairs is acceptable, thus additional attentional resources to task engagement are unnecessary.

The hedonic tone and dual pathway perspectives also make opposing predictions regarding the role of negative activating emotions. The hedonic tone perspective predicts a negative relationship between negative-activating, promotion-focused emotions (e.g., angry, frustrated) and performance because their unpleasantness diverts attention away from task demands. However, the dual pathway perspective predicts positive relationships between negative-activating, promotion-focused emotions and negative-activating, prevention-focused emotions and performance. Negative activating emotions signal threat, leading to more narrowed attention to specific task-demands and making improvements (De Dreu et al., 2008).

However, dual pathway and regulatory focus perspectives differ regarding negative-activating, prevention-focused emotions (e.g., anxious, tense). Both hedonic tone and regulatory focus predict negative relationships between negative-activating, prevention-focused emotions and performance. Although negative-activating, prevention-focused emotions are high in activation, these emotions engender an avoidance strategy, which may give rise to self-doubt and worry (Higgins, 1997). On the other hand, the dual pathway predicts a positive relationship between negative-activating, prevention-focused emotions and performance. Negative-activating emotions might encourage individuals to narrow attention to making performance improvements.

In considering the dual pathway perspective, dynamic effects might also be predicted. When facing a new and complex task, individuals will likely experience intrusive thoughts about their capabilities. Therefore, fluctuations in positive activating emotions are particularly important early in acquisition because individuals need to be open to possibilities and these emotions encourage individuals to explore a variety of task strategies (Frederickson, 2001; Frederickson & Brannigan, 2005). Further, positive activating emotions should affect performance after a task change in much the same way as during initial acquisition. However, positive activating emotions might be even more important to adaptation because of the increased complexity associated with unlearning old strategies, modifying existing strategies, and developing new ones (Klein & Baxter, 2006). Thus, one might expect stronger positive effects for positive activating emotions early in skill acquisition and during adaptation. It could also be argued that positive activating emotions are more important to adaptation than acquisition given the difficulties arising from sudden, unexpected task changes. However, it is not clear if the dynamics of positive activating emotions would differ during reacquisition adaptation as compared to acquisition.

From a dual pathway perspective, both negative-activating, promotion-focused and negative-activating, prevention-focused emotions should be particularly important later in skill acquisition when individuals have acquired reasonably effective, yet suboptimal task strategies. Negative activating emotions, regardless of regulatory focus, should promote allocation of attentional resources to the task by narrowing attention and prompting the individual to refine existing strategies or seek more optimal ones. This narrowed attention is associated with cognitive persistence and perseverance, which helps promote creative fluency and originality (De Dreu et al., 2008). In this vein, negative activating emotions should also yield a greater overall positive effect during adaptation. Therefore, one might expect stronger positive effects for negative activating emotions later in skill acquisition and during adaptation. However, given the incongruity between the dual pathway and regulatory focus perspectives for negative-activating, prevention-focused emotions, it is not clear what kind of dynamic effects might be expected regarding these emotions.

Method

Participants

Two hundred thirty-two undergraduate students attending a large public university in the Southwestern U.S. participated in exchange for research credit in a psychology course. Data from 18 participants were removed from analyses due to incomplete data (n = 12), repeatedly flatlining on performance measures (n = 4), or not following instructions (n = 2), resulting in a final sample of 214 participants (125 males, 89 females). Participants ranged in age from 17 to 32 years (M = 19.20, SD = 1.70). One hundred thirty-four participants (62.6%) reported their ethnicity as Caucasian, 14

(6.5%) as Black/African American, 18 (8.4%) as Hispanic/Latino, 12 (5.6%) as Native American, 23 (10.7%) as Asian, 8 (3.7%) as Multiple (two or more ethnicities), and 5 (2.3%) as other.

Performance Task

The experimental task used in this study was Unreal Tournament 2004 (UT2004; Epic Games, 2004), a commercially available first-person shooter computer game that has been used in previous research on complex skill acquisition (e.g., Hardy et al., 2014; Hughes et al., 2013). The objective of the task was to destroy computer-controlled opponents while minimizing the destruction of one's own character. Participants could collect new weapons or resources (i.e., power-ups) during each trial to increase their character's health or offensive and defensive capabilities. When a participant's character or opponent was destroyed, it reappeared in a random location with the default weapons and capabilities. The game was "every character for him- or herself," meaning that the computer-controlled characters were in competition with each other as well as the participant. UT2004 is a fast-paced, dynamic task involving cognitive and perceptual-motor demands. Participants used a mouse and keyboard simultaneously to move and control their character, all the while learning the strengths and weaknesses of different weapons and strategies, and quickly deciding which to use given the current situation.

Procedure

Individuals participated in cohorts of no more than seven, and were told that the purpose of the present study was to investigate how people learn to play a dynamic and complex videogame. They first completed an informed consent form followed by a battery of individual difference measures to serve as control variables. Participants were told that they would be entered into a lottery to win one of five, $25 gift cards for each trial in which their score was in the top 50% of all study participants for that given trial. Participants watched a 15-minute training presentation on UT2004 explaining the basic game controls, rules, and power-ups, followed by a 1-minute practice trial for becoming familiar with the controls, display, and the game environment without any opponents.

Participants then completed 14 sessions each consisting of two 4-minute trials. Following each session, participants completed the state-based self-report measure of emotions. For the first seven sessions, participants competed against two computer-controlled opponents at a difficulty setting of 5 (on a 1-to-8 scale). Following the seventh session (i.e., the midway point; 14th pre-change trial), several key elements of the task were changed without warning, which increased its complexity (Hughes et al., 2013). Players competed against nine computer-controlled opponents at a difficulty setting of 6. In addition, the game environment (i.e., map) was much larger, with wider spaces, multiple levels of platforms, and edges over which characters could fall to their destruction. The game characteristics for the pre- and post-change trials were the same as those used by Hardy et al. (2014) to measure analogical and adaptive transfer performance, respectively. Participants were debriefed following the 14th session (i.e., 14th post-change trial).

Measures

Task performance. Task performance scores for each trial were calculated using the same index as Hardy et al. (2014): player kills (i.e., number of times a participant destroyed an opponent) divided by the quantity of kills plus deaths (i.e., number of kills plus the number of times a participant's own character was destroyed) plus player rank (i.e., the participant's rank relative to the computer opponents in that trial). For ease in interpretability, performance scores were then multiplied by 100. Performance for each session was calculated by taking the average of the scores for both trials in that session.

Emotion tone, activation potential, and regulatory focus. State emotions were measured using an adapted version of the Positive Affect Negative Affect Scale (PANAS; Watson, Clark, & Telegan, 1988) that was used in previous research (Baas et al., 2008; De Dreu et al., 2008; To et al., 2012), and included only adjectives that were relevant to the performance context of the present study (see Figure 1). Items asked participants to rate the extent to which they experienced the emotion during the previous two games. For all items, participants responded using a 9-point Likert scale (1 = very slight/not at all, 9 = extremely). Specifically, "happy" and "excited" (M = 3.95, SD = 1.75, min. = 1.00, max. = 8.68) were used to measure positive activating emotions. "Calm" and "relaxed" (M = 4.17, SD = 1.60, min. = 1.00, max. = 9.00) were used to measure positive deactivating emotions. "Angry" and "frustrated" (M = 3.75, SD = 1.85, min. = 1.00, max. = 8.68) were used to measure negative-activating, promotion-focused emotions. "Anxious" and "tense" (M = 3.59, SD = 1.70, min. = 1.00, max. = 7.93) were used to measure negative-activating, prevention-focused emotions. "Discouraged" and "disappointed," (M = 3.47, SD = 1.88, min. = 1.00, max. = 8.61) were used to measure negative deactivating emotions. Average coefficient alphas for the emotion adjective pairs across the 14 sessions were .85, .79, .82, .76, and .87 for happy/excited, calm/relaxed, angry/frustrated, anxious/tense, and discouraged/disappointed, respectively.

Covariate measures. Self-reported ACT scores (M = 26.79, SD = 4.09) were used as an index of general mental ability (GMA). A 4-item scale was used to measure prior videogame experience, which served as a proxy for pre-training videogame knowledge. For the first two items, participants responded using a 5-point Likert scale (1 = not at all, 2 = rarely, just a few times, 3 = monthly, 4 = weekly, 5 = daily) to the following questions: (a) "Over the last 12 months, how frequently have you typically played video/computer games?" (M = 2.92, SD = 1.43) and (b) "Over the last 12 months, how frequently have you typically played first-person shooter video/computer games (e.g., Call of Duty, Half-Life, Halo, Unreal Tournament)?" (M = 2.35, SD = 1.33). For the second two items, participants indicated how many hours per week they typically played video/computer games (M = 4.61, SD = 6.60, min. = 0.00, max. = 35.00) and more specifically, first-person shooter video/computer games (M = 2.03, SD = 4.04, min. = 0.00, max. = 30.00). Scores for these four items were standardized and then averaged to create a composite score (α = .72).

Results

Table 1 displays the descriptive statistics and correlations for all the study variables with average scores across all sessions for the emotion dimensions and performance. As shown in Table 1, the intraclass correlation coefficient (ICC) for performance indicated that 28% of the variance existed within participants (i.e., intraindividual). For emotions, the ICCs indicated that 40-47% of the variance existed within participants. Figure 2 displays the trends of the emotion variables and performance over time. In general, positive activating emotions tended to decrease over time with little discontinuity immediately following the change in task demands. Positive deactivating emotions tended to increase over time, but there was also a discontinuous drop following the task change. In general, all negative emotions decreased over time. However, there was also a sharp increase following the task change for all the negative emotions.

With respect to positive emotions, as can be seen in Panels A and B in Figure 2, the aforementioned trends were observed up until the second-to-last session. There was a steep increase in positive activating and deactivating emotions on the last session. Upon further exploration, it appeared that a small cluster of participants rated the emotions at a very low level on the second-to-last session but switched to the opposite end of the spectrum on the last session. Emotions in the last session appeared to be associated with finishing the study rather than performance. Therefore, I dropped scores from the last session when testing the hypotheses and research questions.

As shown in Panel F in Figure 2, discontinuity was observed between pre-change and post-change sessions for performance. Initially, performance increased over the course of pre-change sessions, however, there was a drop in performance following the task change. During the post-change sessions, performance increased at a linear rate, however, the average performance did not reach the same level as that of the pre-change sessions.

Descriptive statistics and correlations between average emotion variables and performance separated by pre-change and post-change sessions are presented in Table 2. As would be expected, in both the pre-change and post-change sessions, positive emotions were positively correlated with each other and negative emotions were positively correlated with each other. Negative correlations were found between the positive emotions and negative emotions. Furthermore, positive emotions were positively correlated with performance and negative emotions were negatively correlated with performance in both the pre-change and post-change sessions.

Modeling Performance Trends

Discontinuous mixed-effects growth modeling was used to model performance across skill acquisition (SA), transition adaptation (TA), and reacquisition adaptation (RA). Table 3 shows the dummy coding I used for the growth components as recommended by Bliese and Lang (2016). Specifically, skill acquisition refers to the linear rate of acquisition (i.e., performance improvements) in the pre-change period. Transition adaptation models discontinuity with a dummy coded variable indicating when the task change has occurred. In the present study, transition adaptation reflects the expected drop in performance following the unexpected task change, comparing post-change performance to pre-change performance. Reacquisition adaptation refers to the linear rate of acquisition following the task change considering the linear rate of acquisition prior to the task change. Quadratic skill acquisition and quadratic reacquisition adaptation were also included to account for the curvilinear change in the pre-change and post-change periods (Lang & Bliese, 2009). It is important to note that the interpretation of the coefficients transition adaptation and reacquisition adaptation are interpreted relative to skill acquisition. The effect of transition adaptation reflects a difference in performance after the task change relative to the value predicted by skill acquisition immediately following the task change. Reacquisition adaptation reflects the change in the rate of acquisition following the task change relative to the rate of acquisition in skill acquisition. R, an open source software, was used to conduct the discontinuous mixed-effects growth modeling and analyses (Pinheiro, Bates, DebRoy, & Sarkar, 2016; R Development Core Team, 2016). Level 1 models accounted for autocorrelation in error structures.

I tested a series of models following suggestions by Bliese and Lang (2016). I started by testing the basic growth model. The random intercept model was tested to estimate the intraclass correlation coefficient (ICC), which indicates the proportion of variance that resides within- and between-persons. As discussed previously, the ICCs for performance and the emotion variables indicated that there were differences that existed within participants. In Step 1, I tested the effects for each time variable included in the equation below (see Model 1; Table 4):

$$Y_{ij} = \gamma_{00} + \gamma_{10}SA + \gamma_{20}TA + \gamma_{30}RA + \gamma_{40}SA2 + \gamma_{50}RA2 + \varepsilon_{ij}$$

The results showed a significant rate of SA $t(2563) = 21.96$, $p < .01$, a negative TA $t(2563) = -20.23$, $p < .01$, and a significantly lower rate of RA $t(2563) = -7.62$, $p < .01$. The quadratic trend for skill acquisition was also significant, $t(2563) = -9.12$, $p < .01$ and indicated that increases in performance decelerated across pre-change sessions. However, the quadratic trend for reacquisition adaptation was not significant, thus it was not included in further model tests.

In Step 2, I added the covariate and covariate interactions (see Model 2; Table 4). ACT and videogame experience were grand-mean centered. The main effects of ACT ($t(209) = 5.24$, $p < .01$) and videogame experience ($t(209) = 5.41$, $p < .01$) on performance were positive and significant. Prior videogame experience and higher ACT scores were associated with higher performance scores. In addition, the main effect of gender on performance was negative and significant $t(209) = -10.66$, $p < .01$, reflecting that females exhibited lower levels of performance than males. The interaction between gender and TA was positive and significant $t(2555) = 3.58$, $p < .01$, indicating that the gender difference in performance was smaller following the task change. No other interaction involving the covariate and growth terms reached a conventional level of statistical significance ($p < .05$).

Modeling the Effects of Emotions

In Step 3, we added the main effect of emotions at the between-person level and their interactions with growth variables (see Model 3; Tables 5-9). In Step 4, I added the main effect of emotions at the within-person level (see Model 4; Tables 5-9). In support of the hedonic tone perspective, the results showed the within-person (WP) effects were similar to the between-person (BP) effects for every emotion dimension. Positive activating (BP: $t(209) = 3.89$, $p < .01$; WP: $t(2551) = 15.80$, $p < .01$) and deactivating emotions (BP: $t(209) = 2.69$, $p < .05$; WP: $t(2551) = 5.92$, $p < .01$) were associated with higher performance scores. Negative-activating, promotion-focused (BP: $t(209) = –3.46$, $p < .01$; WP: $t(2551) = –13.63$, $p < .01$), negative-activating, prevention-focused (BP: $t(209) = –2.06$, $p < .05$; WP: $t(2551) = –3.58$, $p < .01$), and negative deactivating emotions (BP: $t(209) = –3.35$, $p < .01$; WP: ($t(2551) = –11.13$, $p < .01$) were associated with lower performance scores.

In addition, as shown in Table 9, there was a positive interaction between interindividual negative deactivating emotions and TA ($t(2552) = 2.17$, $p < .05$) and between positive activating emotions and SA ($t(2552) = 2.25$, $p < .05$). Results indicated the drop in performance was smaller for individuals with higher interindividual negative deactivating emotions and the positive effect of positive activating emotions was stronger later in skill acquisition.

Last, in Step 5, I added in the interactions between intraindividual emotions and growth variables (see Model 5; Tables 5-9). In general, the pattern of results for this step did not support the dynamic effects predicted when considering the dual pathway perspective. Regarding positive activating emotions, as reflected by the AIC values, there was poorer fit for the step that included the interactions with the growth variables (i.e., Table 5, Model 5, *AIC* = 20229.57; Model 4, *AIC* = 20224.87). Contrary to what might be predicted from the dual pathway perspective, the results for negative-activating, promotion-focused emotions shown in Table 7 indicated a negative SA interaction ($t(2548) = –2.10$, $p < .05$) and a positive RA interaction ($t(2548) = 2.98$, $p < .01$). These interactions reflect how the negative effect of negative-activating promotion-focused emotions was stronger in later skill acquisition but weaker in adaptation. Regarding negative-activating, prevention-focused emotions, as reflected by the AIC values, there was poorer fit for the step that included the interactions with the growth variables (i.e., Table 8, Model 5, *AIC* = 20491.17; Model 4, *AIC* = 20484.20). Therefore, despite a statistically significant RA interaction, the results did not show support for the dynamic effects of negative-activating, prevention-focused emotions.

Although no interactions were expected, as shown in Table 9, the results revealed positive TA ($t(2548) = 2.06$, $p < .05$) and RA interactions ($t(2548) = 2.22$, $p < .05$) for negative deactivating emotions. This pattern of results reflect how the negative effect of negative deactivating emotions became weaker in and across adaptation sessions. No SA, TA, or RA interactions were observed for positive deactivating emotions.

Discussion

This lab study disentangled the between- and within-person effects of emotion in relation to the acquisition and adaptation of a complex skill. I compared two competing perspectives on the role of emotions: the hedonic tone perspective, which suggests that positive and negative emotions are respectively beneficial and detrimental to performance (Bell & Kozlowski, 2008; Keith & Frese, 2005; Kanfer & Ackerman, 1990; Niessen & Jimmieson, 2015), and the dual pathway model, which suggests that activating emotions are beneficial to performance, regardless of their hedonic tone (De Dreu et al., 2008; To et al., 2012). Results supported the hedonic tone perspective, and also revealed dynamic effects for specific negative emotions (i.e., negative-activating, promotion-focused and negative deactivating) during acquisition and adaptation. In the following sections, I review the findings regarding the effects of within-person emotions in relation to acquisition and adaptive performance and I will discuss how the effects of specific emotions were dynamic within and across acquisition and adaptation. Then I will discuss limitations and directions for future research, followed by the practical implications of this study.

Within-Person Emotions and Performance

The present study employed a repeated measures design to examine the role of emotions during skill acquisition and adaptation. Regarding the main effect of emotions on performance, effects at the within- and between-person level were similar. Fluctuations in positive emotions yielded positive relationships with performance and fluctuations in negative emotions yielded negative relationships with performance, which is consistent with past research that examined the role of emotions at the between-person level (e.g., Judge & Illies, 2004; Kaplan, Bradley, Luchman, & Haynes, 2009). These findings support the hedonic tone perspective, while failing to support the dual pathway model and other research suggesting that negative emotions might facilitate performance via cognitive persistence (De Dreu et al., 2008; To et al., 2012).

The hedonic tone perspective posits that positive emotions are beneficial to creative performance due to increased cognitive flexibility, whereas negative emotions do not (Baas et al., 2008). One explanation for the present findings is that positive emotions are likely to broaden attention and thus are beneficial to performance because the emotions direct attentional resources to task demands, which is consistent with broaden-and-build theory (Frederickson, 2001; Frederickson & Brannigan, 2005). In a similar vein, previous research has found that when primed with negative moods, individuals are more likely to focus on off-task thoughts and withdraw attentional resources from the task (Smallwood, Fitzgerald, Miles, & Phillips, 2009). Although dual pathway perspective was not supported, it is important to acknowledge that the magnitude of the effects for positive emotions were linked to their activation potential. Specifically, there were stronger between- and within-person effects for positive activating emotions (i.e., Table 5, Model 4; BP: $t(209) = 3.89$, $p < .01$; WP: $t(2551) = 15.80$, $p < .01$) than positive deactivating emotions (i.e., Table 6, Model 4; BP: $t(209) = 2.69$, $p < .05$; WP: $t(2551) = 5.92$, $p < .01$). The relatively stronger positive effects for positive activating emotions is consistent with prior research demonstrating the importance of cognitive flexibility for creative problem solving (Baas et al., 2008; De Dreu et al., 2008).

Unlike the hedonic tone perspective, the dual pathway model suggests dynamic effects of emotion on performance. Although emotion-performance relationships were inconsistent with the dual pathway perspective, findings did suggest dynamic effects. For negative-activating, promotion-focused emotions (i.e., angry, frustrated), effects were stronger in later skill acquisition trials and weaker in adaptation. For negative deactivating emotions (i.e., discouraged, disappointed), negative effects were smaller during adaptation, especially in later adaptation trials. I speculate that this pattern of effects reflects differences in the processes that underlie effective adaptation versus effective acquisition and thus speak to how adaptive transfer is meaningfully distinct from acquisition (Barnett & Ceci, 2002). The results suggest that the negative effects of the aforementioned negative emotions were less detrimental in adaptation than in acquisition.

Attribution theory could potentially help explain this pattern of results (Heider, 1958; Weiner, 1972). According to Weiner (1972), there are two dimensions relevant to how individuals make causal attributions about outcomes. Locus of control refers to whether or not the individual believes that the outcome is a result of internal or external causes. Stability refers to whether or not the attributes that contribute to the outcomes are stable or unstable. Combinations of the two dimensions produce four main causal attributions: internal/stable (e.g., ability), external/stable (e.g., task difficulty), internal/unstable (e.g., effort), and external/unstable (e.g., luck). One could speculate that during acquisition, individuals may attribute much of their performance to their own ability (i.e., internal/stable causal attribution). When individuals attribute their performance to their ability, and they experience negative emotions (e.g., angry, discouraged), then it is likely they would experience off-task thoughts that are focused on negative aspects of the self (e.g., worry, self-doubt). However, when facing unexpected changes to task demands, especially those that raise task complexity, individuals may attribute their performance to the difficulty of the task more so than their ability (i.e., external/stable causal attribution). Therefore, the negative emotions may be less detrimental over time because the negative emotions are no longer associated with off-task thoughts that are related to the self.

Limitations and Future Research

There are several limitations that must be considered when trying to interpret and generalize my results to other contexts. First, an active learning context involving a computer task was used in this study and results may not generalize to less traditional learning contexts (e.g., proceduralized learning). Active learning contexts are thought to be beneficial for training individuals to adapt to changes and are commonly characterized by allowing individuals to explore the task, rather than providing explicit step-by-step instructions for how to complete the task like in proceduralized learning (Bell & Kozlowski, 2008; 2009; Keith & Wolff, 2015). Another characteristic of the active learning context is that individuals are allowed to explore the task at their own pace and they are responsible for what they learn. One of the caveats of using an active learning context is that it might lead to stress or anxiety when individuals are trying to learn because it is unclear what they should be learning, and they do not have explicit instructions for how to perform the task (Bell & Kozlowski, 2009). Therefore, while the findings of the study may generalize to other active learning contexts, the extent to which the findings generalize to other contexts may be questioned.

Proceduralized learning contexts emphasize giving individuals the steps needed to complete a task and the individual is treated as a "passive" recipient (Bell & Kozlowski, 2008; 2009; Keith & Wolff, 2015). One could speculate in proceduralized learning contexts that the negative effects stemming from negative emotions could be smaller (perhaps even positive) because the more "step-by-step" prescriptive nature of the instruction helps sustain learners' attentional resources on the task at hand. Moreover, effects of emotions in a period of adaptation could differ based on whether active learning or proceduralized training was used prior to adaptation. Despite challenges associated with an active learning context, an active learning approach is still thought to be useful for environments that require adaptability because active learning training promotes self-regulation skills needed for effective adaptation (e.g., Bell & Kozlowski, 2008; Frese et al., 1988). However, future research is needed to compare emotion effects in proceduralized versus active learning contexts.

Another limitation was the lack of time for reflection coupled with the complex, fast-paced nature of the performance task. Together, the lack of time for reflection and the nature of the task could explain the lack of support for dual pathway and regulatory focus perspectives. Both perspectives have often been studied with respect to creativity, with research showing the importance of allowing periods of reflection to adequately weigh the usefulness of various ideas and strategies (Baas et al., 2008; De Dreu et al., 2008; To et al., 2012). In the present study, the fast-paced nature of the performance task and the highly massed nature of the practice sessions likely did not afford individuals with adequate opportunity to explore and reflect upon the array of strategies and tactics needed to effectively adjust to the dynamic task demands. Furthermore, the 4-hour time constraint in relation to the bonus opportunities for high performance may have impacted participants' decisions to favor exploiting known strategies versus exploring new possibilities or even refining existing ones (Day, Hardy, & Arthur, 2017). In general, several characteristics of the present methodology may have created a context that magnified the distracting influence of negative emotions. One might expect different results in situations where practice is highly distributed over time, there is little pressure for immediate results, and individuals are given more time to modify and refine existing strategies or look for new strategies that are more effective. In this vein, I speculate that distributed practice allows individuals to better leverage negative-activating emotions, especially those with a more promotion focus (e.g., anger, frustration). Given the limitations of the present study, future research that examines the role of the learning context as well as different task demands is needed to further test the competing perspectives regarding how emotions might differentially relate to performance.

The present study examined the role of emotions using the suggested breakdown of emotions from the competing perspectives. Thus, I was primarily concerned with the specific emotion clusters and how they impacted performance. However, another perspective to studying emotion variability over time is by examining affect spin and pulse (Beal, Trougakos, Weiss, & Dalal, 2013; Moscowitz & Zuroff, 2004). Both affect spin and pulse suggest that emotional experiences are likely to vary within individuals (Beal et al., 2013; Moscowitz & Zuroff, 2004). Individuals who are high on affect spin are likely to experience a wider range of emotions over a given period of time, while those low on affect spin are likely to experience a smaller range of emotions. For example, individuals who are high on affect spin might experience a range of positive and negative emotions (e.g., excited, calm, angry, discouraged), whereas individuals who are low on affect spin might only experience positive emotions (e.g., excited, happy). Affect pulse refers to how often individuals differ in their intensity of emotions (Moscowitz & Zuroff, 2004). Individuals who are high on affect pulse are likely to experience variation in intensity of emotions over time, whereas those that are low on affect pulse are likely to experience less variation in intensity of emotions over time. For example, individuals who are high on affect pulse might feel extremely angry/excited at one time and then might feel slightly angry/excited a little later. In contrast, individuals who are low on affect pulse might feel extremely angry/excited across a period of time, thus exhibiting little variation in the intensity of their emotions. One could speculate that, in general, those that are high on affect spin and affect pulse might have a difficult time regulating their emotions and focusing attention to on-task thoughts. Thus, these individuals might need to exhibit greater emotional control in order to attain increases in performance. While greater emotional control has been associated with greater acquisition and adaptive performance, if individuals are constantly devoting cognitive resources to emotion control, then resources are being diverted off the task and could potentially result in lower performance, especially during the initial stages of learning a task (Jundt, Shoss, & Huang, 2014; Kanfer & Ackerman, 1989; Kanfer, Ackerman, & Heggestad, 1996; Keith & Frese, 2005). Future research should examine the role of affect spin and affect pulse in learning a complex task to determine if the variability in the range and intensity of emotions experienced over time differentially impacts performance during acquisition and adaptation to unforeseen changes in task demands.

Finally, although greater attempts were taken to establish causality by using discontinuous mixed-effects growth modeling, the direction and strength of causality could not be fully established. It was our assumption that positive and negative emotions were leading to increases and decreases in performance. However, the relationship between emotions and performance could be reversed or reciprocal in nature. For example, decreases in performance could be associated with increases in negative emotions and increases in performance could be associated with increases in positive emotions following a trial. Furthermore, these increases and decreases in positive and negative emotions could then impact performance on the following trials.

Practical Implications

One implication of the current study is that individuals who are likely to experience spikes in negative emotions should be identified prior to training, if possible. Previous research has found that individuals who are low in ability are more likely to experience negative reactions that are directed at the self when performing a complex, difficult task (Kanfer & Ackerman, 1989). Once these individuals have been identified, it is important to take steps to buffer the negative effects of negative emotions during the training. Incorporating emotion control into the training is a potential solution for this problem. Emotion control is defined as "the use of self-regulatory processes to keep performance anxiety and other negative emotional reactions (e.g., worry) at bay during task engagement" (Kanfer et al., 1996, p. 186). Emotion control is thought to be particularly important early in acquisition when the individual is likely to experience negative emotions due to challenges and mistakes (Kanfer & Ackerman, 1989; Kanfer et al., 1996; Keith & Frese, 2005). An extensive emotional control strategy was developed and used by Kanfer and Ackerman (1990), in which they told participants that they were likely to make mistakes early in training and not to worry and they were told to focus on positive thoughts and not on negative thoughts when they made mistakes. Participants were provided with emotion control training prior to completing the task and were given reminders throughout the training. One example reminder given to participants included: "Use the EMOTION CONTROL strategy while performing the task. That is, do not get upset or worry. Adopt a positive, 'CAN DO' attitude. This will improve your performance" (Kanfer & Ackerman, 1990, p. 35). When using these emotion control strategies, individuals had higher levels of performance and fewer negative self-reactions (Kanfer & Ackerman, 1990). Other examples of emotion control include encouraging individuals to use self-talk and self-encouragement statements (Bandura, 1997; Pintrich, 2000). Thus, emotion control strategies could be used as a buffer against negative spikes in emotions during training.

Furthermore, it is important to consider the context of the training when considering the impact of negative emotions. Our findings suggested that previous recommendations encouraging individuals to focus on positive thoughts (Bell & Kozlowski, 2008; Keith & Frese, 2005; Kanfer & Ackerman, 1990; Niessen & Jimmieson, 2015) and keep "negative emotions at bay" (Niessen & Jimmieson, 2015, p. 2) are extremely relevant in an active learning context as fluctuations in negative emotions were associated with decreases in performance. One implication is that it is even more beneficial to include an emotion control aspect when using an active learning context, because individuals are likely to experience negative emotions due to the lack of instruction and potential for failure throughout the training (Bell & Kozlowksi, 2008). Furthermore, their attentional resources may be diverted to off-task thoughts more often because of the increases in negative emotions (Wood, Kakebeeke, Debowski, & Frese, 2000). Previous research found that emotion control was associated with decreases in anxiety in an active learning context (Bell & Kozlowski, 2008), thus emotion control could have potential positive impacts on performance.

While emotion control may be beneficial for drawing attentional resources to task demands, previous research has recommended including error management training as a method to promote emotion control when using active learning training (Keith & Frese, 2005). Error management training involves framing the errors made in training as beneficial and encourages individuals to make errors (Keith & Frese, 2005). By encouraging individuals to make errors, it is likely that these individuals will have greater emotional control because they are less likely to experience negative emotions when they make errors (Keith & Frese, 2005). In the training, instructions regarding errors were verbally stated by the experimenter and were visually displayed on a poster. Example statements included: “Errors are a natural part of the learning process!” “There is always a way to leave the error situation!” “Errors inform you about what you still can learn!” “The more errors you make, the more you learn!” (Keith & Frese, 2005, p. 681). Error management training was associated with greater emotion control, which contributed to greater adaptive transfer (Keith & Frese, 2005). In a similar vein, Bell and Kozlowski (2008) also found error encouragement framing was associated with greater adaptive transfer. Therefore, in active learning contexts, it may be important to incorporate emotion control or error framing as a method to prompt emotion control in order to buffer the negative effects of negative emotions.

Conclusion

In summary, the present study disentangled within- and between-person effects of emotions with respect to the acquisition and adaptation of a complex skill. Results supported the hedonic tone perspective, staying calm and positive was beneficial to learning while negativity was harmful throughout acquisition and adaptation trials. The direction of emotion effects did not differ as a function of their activation potential. In addition, the results suggested that adaptation may have differing underlying processes from acquisition, because the negative effects of specific negative emotions (i.e., negative-activation, promotion-focused, negative deactivating) were weaker in adaptation versus acquisition. Thus, negative emotions may have less of an impact following an unforeseen change in task demands. Future research should examine how the effects of emotions depend on the nature of the task and practice conditions. Additionally, future research can expand upon the current findings by examining if emotions play similar roles in active learning versus proceduralized learning contexts. Lastly, future research is also needed to examine how differences in emotion variability are related to complex task learning.

Table 1

Descriptive Statistics and Correlations

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
Between-person level											
1. ACT	26.79	4.09									
2. Videogame experience	0.00	1.00	.16*	(.72)							
3. Gender[1]			-.19**	-.55**							
4. PA emotions	3.95	1.75	.22**	.40**	-.47**	(.85)					
5. PD emotions	4.17	1.60	.15*	.26**	-.30**	.45**	(.79)				
6. NAPro emotions	3.75	1.85	-.22**	-.26**	.38**	-.30**	-.53**	(.82)			
7. NAPrev emotions	3.59	1.70	-.16*	-.24**	.31**	-.14*	-.59**	.82**	(.76)		
8. ND emotions	3.47	1.88	-.25*	-.30**	.37**	-.32**	-.42**	.87**	.74**	(.87)	
9. Performance[2]	32.91	16.96	.38**	.63**	-.74**	.62**	.35**	-.48**	-.33**	-.49**	

	ICC	*M*	*SD*	1	2	3	4	5	6
Within-person level									
1. PA emotions	.56	3.95	2.28						
2. PD emotions	.53	4.17	2.14	.30**					
3. NAPro emotions	.58	3.75	2.37	-.24**	-.46**				
4. NAPre emotions	.59	3.59	2.16	-.05**	-.51**	.70**			
5. ND emotions	.60	3.47	2.37	-.27**	-.33**	.75**	.59**		
6. Performance[2]	.72	32.91	19.68	.51**	.28**	-.40**	-.24**	-.41**	

Note. Diagonal values are internal consistencies. PA = Positive Activating, PD = Positive Deactivating, NAProm = Negative-Activating, Promotion-Focused, NAPrev = Negative-Activating, Prevention-Focused, ND = Negative Deactivating.

[1]Gender is a dichotomous variable: 0 = male, 1 = female. [2]Player kills divided by the quantity of kills plus deaths plus player rank (multiplied by 100 to aid interpretability).

N between-person = 214; *N* within-person = 2996.

$^{*}p < .05$, $^{**}p < .01$

Table 2

Means, Standard Deviations, and Correlations of Average State Emotions and Performance

Variable	M_{pre}	SD_{pre}	1	2	3	4	5	6
1. PA emotions	4.39	1.84		.39**	-.24**	-.12**	-.23**	.57**
2. PD emotions	4.11	1.74	.38*		-.51**	-.55**	-.37**	.25**
3. NAPro emotions	3.76	1.91	-.30**	-.52**		.82**	.85**	-.38**
4. NAPre emotions	3.72	1.78	-.08	-.61**	.77**		.74**	-.26**
5. ND emotions	3.43	1.80	-.39**	-.43**	.84**	.67**		-.39**
6. Performance[1]	36.73	18.32	.61**	.40**	-.53**	-.33**	-.56**	
$Mean_{post}$			3.52	4.23	3.74	3.47	3.51	29.08
SD_{post}			1.86	1.71	2.08	1.90	2.15	16.44

Note. Values below the diagonal pertain to pre-change emotion intercorrelations. Values above the diagonal pertain to post-change emotion intercorrelations. PA = Positive Activating, PD = Positive Deactivating, NAProm = Negative-Activating, Promotion-Focused, NAPrev = Negative-Activating, Prevention-Focused, ND = Negative Deactivating.

[1]Player kills divided by the quantity of kills plus deaths plus player rank (multiplied by 100 to aid interpretability).

†$p < .10$, *$p < .05$, **$p < .01$.

Table 3

Coding Scheme of Change Variables in Discontinuous Mixed-Effects Growth Models

Variable	Pre-change period							Post-change period						
Measurement Occasion	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Skill acquisition (SA)	0	1	2	3	4	5	6	7	8	9	10	11	12	13
Transition adaptation (TA)	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Reacquisition adaptation (RA)	0	0	0	0	0	0	0	0	1	2	3	4	5	6
Quadratic skill acquisition (SA2)	0	1	4	9	16	25	36	36	36	36	36	36	36	36
Quadratic reacquisition adaptation (RA2)	0	0	0	0	0	0	0	0	1	4	9	16	25	36

Table 4

Discontinuous Mixed-Effects Growth Models of Performance Change

Variable	Model 1 *B*	Model 1 *SE*	Model 1 *t*	Model 2 *B*	Model 2 *SE*	Model 2 *t*
Intercept, γ_{00}	27.71	1.26	21.96**	35.79	1.10	32.44**
Skill acquisition (SA), γ_{10}	5.46	0.40	13.72**	5.65	0.42	13.39**
Transition adaptation (TA), γ_{20}	-18.85	0.93	-20.23**	-21.88	1.17	-18.66**
Reacquisition adaptation (RA), γ_{30}	-4.71	0.62	-7.62**	-4.80	0.47	-10.31**
Quadratic skill acquisition (SA2), γ_{40}	-0.57	0.06	-9.12**	-0.57	0.06	-9.13**
Quadratic reacquisition adaptation (RA2), γ_{50}	0.01	0.09	0.15			
Gender, γ_{01}				-19.42	1.82	-10.66**
SA X Gender, γ_{11}				-0.46	0.34	-1.34
TA X Gender, γ_{21}				7.19	2.01	3.58**
RA X Gender, γ_{31}				0.37	0.49	0.76
ACT, γ_{02}				0.97	0.19	5.24**
SA X ACT, γ_{12}				-0.00	0.04	-0.06
TA X ACT, γ_{22}				-0.18	0.21	-0.90
RA X ACT, γ_{32}				0.08	0.05	1.51
Videogame experience (VGE), γ_{03}				4.85	0.90	5.41**
SA X VGE, γ_{13}				0.12	0.17	0.71
TA X VGE, γ_{23}				-1.75	0.99	-1.77†
RA X VGE, γ_{33}				0.26	0.24	1.07
AIC		*20709.17*			*20484.62*	

Note. N= 214. †$p < .10$, *$p < .05$, **$p < .01$.

Table 5

Discontinuous Mixed-Effects Growth Models of Performance Change as a Function of Positive Activating Emotions (i.e., Excited, Happy)

	Model 3			**Model 4**			Model 5		
Variable	*B*	*SE*	*t*	***B***	***SE***	***t***	*B*	*SE*	*t*
Intercept, γ_{00}	34.84	1.10	31.69**	**33.21**	**1.09**	**30.60****	33.42	1.11	30.09**
Skill acquisition (SA), γ_{10}	5.55	0.42	13.09**	**5.47**	**0.40**	**13.60****	5.29	0.41	12.79**
Transition adaptation (TA), γ_{20}	-21.44	1.21	-17.79**	**-20.67**	**1.17**	**-17.65****	-20.58	1.18	-17.38**
Reacquisition adaptation (RA), γ_{30}	-4.78	0.47	-10.17**	**-4.47**	**0.45**	**-10.02****	-4.26	0.46	-9.29**
Quadratic skill acquisition (SA2), γ_{40}	-0.57	0.06	-9.13**	**-0.51**	**0.06**	**-8.67****	-0.49	0.06	-8.19**
Gender, γ_{01}	-17.15	1.86	-9.22**	**-16.47**	**1.83**	**-8.98****	-16.59	1.84	-9.04**
SA X Gender, γ_{11}	-0.21	0.36	-0.58	**-0.27**	**0.34**	**-0.78**	-0.21	0.34	-0.61
TA X Gender, γ_{21}	6.13	2.12	2.90**	**5.27**	**2.06**	**2.56***	5.14	2.06	2.49*
RA X Gender, γ_{31}	0.33	0.51	0.64	**0.40**	**0.49**	**0.82**	0.32	0.49	0.66
ACT, γ_{02}	0.87	0.18	4.77**	**0.90**	**0.18**	**5.03****	0.91	0.18	5.09**
SA X ACT, γ_{12}	-0.01	0.03	-0.39	**-0.02**	**0.03**	**-0.69**	-0.03	0.03	-0.79
TA X ACT, γ_{22}	-0.14	0.21	-0.65	**-0.12**	**0.20**	**-0.59**	-0.10	0.20	-0.48
RA X ACT, γ_{32}	0.08	0.05	1.54	**0.09**	**0.05**	**1.92†**	0.09	0.05	1.97*
Videogame experience (VGE), γ_{03}	4.25	0.88	4.82**	**3.85**	**0.87**	**4.43****	3.83	0.87	4.41**
SA X VGE, γ_{13}	0.05	0.17	0.31	**0.16**	**0.16**	**0.96**	0.17	0.16	1.04
TA X VGE, γ_{23}	-1.47	1.00	-1.46	**-1.78**	**0.97**	**-1.82†**	-1.87	0.97	-1.92†
RA X VGE, γ_{33}	0.27	0.24	1.11	**0.20**	**0.23**	**0.85**	0.19	0.23	0.81
PA Between-person emotion (PA BPE), γ_{04}	1.85	0.48	3.89**	**2.27**	**0.47**	**4.84****	2.24	0.47	4.74**
SA X PA BPE, γ_{14}	0.20	0.09	2.25*	**0.10**	**0.09**	**1.12**	0.10	0.09	1.17
TA X PA BPE, γ_{24}	-0.87	0.54	-1.60	**-0.76**	**0.53**	**-1.45**	-0.73	0.53	-1.38
RA X PA BPE, γ_{34}	-0.04	0.13	-0.29	**0.11**	**0.13**	**0.86**	0.10	0.12	0.77
PA Within-person Emotion (PA WPE), γ_{50}				**2.01**	**0.13**	**15.80****	1.80	0.31	5.82**
SA X PA WPE, γ_{60}							0.16	0.09	1.79†
TA X PA WPE, γ_{70}							-1.41	0.51	-2.74**
RA X PA WPE, γ_{80}							-0.06	0.14	-0.41
AIC		*20454.71*			***20224.87***			*20229.57*	

Note. PA = Positive Activating Emotion. Bolded results reflects those for the best-fitting model. N= 214. †p < .10, *p < .05, **p < .01.

Table 6

Discontinuous Mixed-Effects Growth Models of Performance Change as a Function of Positive Deactivating Emotions (i.e., Calm, Relaxed)

	Model 3			**Model 4**			Model 5		
Variable	*B*	*SE*	*t*	***B***	***SE***	***t***	*B*	*SE*	*t*
Intercept, γ_{00}	35.41	1.10	32.26**	**35.81**	**1.11**	**32.31****	35.92	1.12	32.11**
Skill acquisition (SA), γ_{10}	5.66	0.42	13.36**	**5.39**	**0.42**	**12.78****	5.31	0.43	12.43**
Transition adaptation (TA), γ_{20}	-21.77	1.19	-18.32**	**-21.06**	**1.18**	**-17.86****	-20.94	1.18	-17.68**
Reacquisition adaptation (RA), γ_{30}	-4.79	0.47	-10.25**	**-4.58**	**0.46**	**-9.87****	-4.48	0.47	-9.53**
Quadratic skill acquisition (SA2), γ_{40}	-0.57	0.06	-9.12	**-0.54**	**0.06**	**-8.73****	-0.53	0.06	-8.51**
Gender, γ_{01}	-18.52	1.83	-10.14**	**-18.50**	**1.84**	**-10.04****	-18.51	1.85	-10.00**
SA X Gender, γ_{11}	-0.47	0.35	-1.35	**-0.43**	**0.34**	**-1.25**	-0.40	0.34	-1.18
TA X Gender, γ_{21}	6.92	2.05	3.37**	**6.45**	**2.03**	**3.18****	6.34	2.03	3.12**
RA X Gender, γ_{31}	0.34	0.50	0.69	**0.29**	**0.49**	**0.60**	0.28	0.49	0.57
ACT, γ_{02}	0.93	0.18	5.03**	**0.93**	**0.19**	**5.01****	0.93	0.19	5.00**
SA X ACT, γ_{12}	0.00	0.03	-0.04	**0.00**	**0.03**	**-0.09**	0.00	0.03	-0.11
TA X ACT, γ_{22}	-0.17	0.21	-0.82	**-0.17**	**0.20**	**-0.81**	-0.16	0.20	-0.78
RA X ACT, γ_{32}	0.08	0.05	1.54	**0.08**	**0.05**	**1.62**	0.08	0.05	1.63
Videogame experience (VGE), γ_{03}	4.56	0.89	5.13**	**4.52**	**0.90**	**5.04****	4.51	0.90	5.01**
SA X VGE, γ_{13}	0.12	0.17	0.72	**0.11**	**0.17**	**0.68**	0.11	0.17	0.65
TA X VGE, γ_{23}	-1.66	1.00	-1.67†	**-1.49**	**0.99**	**-1.51**	-1.46	0.99	-1.47
RA X VGE, γ_{33}	0.27	0.24	1.10	**0.28**	**0.24**	**1.16**	0.28	0.24	1.15
PD Between-person emotion (PD BPE), γ_{04}	1.29	0.48	2.69*	**1.45**	**0.49**	**2.98****	1.49	0.49	3.05**
SA X PD BPE, γ_{14}	-0.02	0.09	-0.18	**-0.06**	**0.09**	**-0.71**	-0.08	0.09	-0.88
TA X PD BPE, γ_{24}	-0.39	0.54	-0.72	**-0.26**	**0.53**	**-0.49**	-0.19	0.54	-0.35
RA X PD BPE, γ_{34}	-0.04	0.13	-0.32	**0.02**	**0.13**	**0.13**	0.03	0.13	0.23
PD Within-person Emotion (PD WPE), γ_{50}				**0.76**	**0.13**	**5.92****	0.96	0.31	3.10**
SA X PD WPE, γ_{60}							0.03	0.09	0.35
TA X PD WPE, γ_{70}							-0.63	0.54	-1.16
RA X PD WPE, γ_{80}							-0.06	0.14	-0.43
AIC	*20489.75*			***20459.30***			*20466.91*		

Note. PD = Positive Deactivating Emotion. Bolded results reflects those for the best-fitting model. N= 214. †$p < .10$, *$p < .05$, **$p < .01$.

Table 7

Discontinuous Mixed-Effects Growth Models of Performance Change as a Function of Negative-Activating, Promotion-Focused Emotions (i.e., Angry, Frustrated)

	Model 3			Model 4			**Model 5**		
Variable	*B*	*SE*	*t*	*B*	*SE*	*t*	***B***	***SE***	***t***
Intercept, γ_{00}	35.03	1.10	31.83**	35.41	1.11	31.87**	**35.39**	**1.11**	**31.81****
Skill acquisition (SA), γ_{10}	5.60	0.42	13.20**	5.30	0.41	12.87**	**5.32**	**0.41**	**12.87****
Transition adaptation (TA), γ_{20}	-21.42	1.20	-17.93**	-19.85	1.13	-17.59**	**-19.55**	**1.13**	**-17.32****
Reacquisition adaptation (RA), γ_{30}	-4.77	0.47	-10.17**	-4.65	0.46	-10.14**	**-4.66**	**0.46**	**-10.14****
Quadratic skill acquisition (SA2), γ_{40}	-0.57	0.06	-9.13**	-0.54	0.06	-9.05**	**-0.56**	**0.06**	**-9.20****
Gender, γ_{01}	-17.61	1.85	-9.50**	-17.32	1.88	-9.23**	**-17.35**	**1.88**	**-9.24****
SA X Gender, γ_{11}	-0.33	0.35	-0.93	-0.30	0.35	-0.86	**-0.25**	**0.35**	**-0.73**
TA X Gender, γ_{21}	6.09	2.09	2.92**	5.04	1.96	2.57*	**4.76**	**1.96**	**2.43***
RA X Gender, γ_{31}	0.30	0.51	0.60	0.30	0.50	0.59	**0.29**	**0.50**	**0.57**
ACT, γ_{02}	0.88	0.18	4.77**	0.88	0.19	4.71**	**0.88**	**0.19**	**4.73****
SA X ACT, γ_{12}	-0.01	0.04	-0.25	-0.01	0.03	-0.32	**-0.01**	**0.03**	**-0.38**
TA X ACT, γ_{22}	-0.12	0.21	-0.60	-0.07	0.19	-0.37	**-0.07**	**0.19**	**-0.34**
RA X ACT, γ_{32}	0.08	0.05	1.57	0.07	0.05	1.36	**0.07**	**0.05**	**1.49**
Videogame experience (VGE), γ_{03}	4.70	0.88	5.37**	4.84	0.89	5.46**	**4.82**	**0.89**	**5.43****
SA X VGE, γ_{13}	0.11	0.17	0.64	0.04	0.16	0.23	**0.03**	**0.16**	**0.18**
TA X VGE, γ_{23}	-1.66	0.99	-1.68†	-1.15	0.93	-1.24	**-1.02**	**0.92**	**-1.10**
RA X VGE, γ_{33}	0.26	0.24	1.09	0.30	0.24	1.28	**0.29**	**0.24**	**1.22**
NAPro Between-person emotion (NAPro BPE), γ_{04}	-1.48	0.43	-3.46**	-1.82	0.43	-4.19**	**-1.82**	**0.44**	**-4.17****
SA X NAPro BPE, γ_{14}	-0.10	0.08	-1.28	-0.04	0.08	-0.44	**-0.04**	**0.08**	**-0.44**
TA X NAPro BPE, γ_{24}	0.90	0.48	1.87†	0.97	0.45	2.14*	**0.97**	**0.45**	**2.15***
RA X NAPro BPE, γ_{34}	0.06	0.12	0.48	-0.04	0.12	-0.35	**-0.05**	**0.12**	**-0.45**
NAPro Within-person Emotion (NAPro WPE), γ_{50}				-1.59	0.12	-13.63**	**-1.47**	**0.27**	**-5.45****
SA X NAPro WPE, γ_{60}							**-0.17**	**0.08**	**-2.10***
TA X NAPro WPE, γ_{70}							**0.92**	**0.48**	**1.90†**
RA X NAPro WPE, γ_{80}							**0.38**	**0.13**	**2.98****
AIC		*20479.96*			*20308.35*			***20304.37***	

Note. NAPro = Negative-Activating, Promotion-Focused Emotions. Bolded results reflects those for the best-fitting model. N= 214. †$p < .10$, *$p < .05$, **$p < .01$.

Table 8

Discontinuous Mixed-Effects Growth Models of Performance Change as a Function of Negative-Activating, Prevention-Focused Emotions (i.e., Anxious, Tense)

	Model 3			**Model 4**			Model 5		
Variable	*B*	*SE*	*t*	***B***	***SE***	***t***	*B*	*SE*	*t*
Intercept, γ_{00}	35.45	1.11	32.00**	**35.69**	**1.12**	**31.95****	35.54	1.12	31.59**
Skill acquisition (SA), γ_{10}	5.66	0.42	13.38**	**5.60**	**0.42**	**13.24****	5.72	0.43	13.28**
Transition adaptation (TA), γ_{20}	-21.74	1.19	-18.24**	**-21.29**	**1.19**	**-17.93****	-21.14	1.19	-17.78**
Reacquisition adaptation (RA), γ_{30}	-4.80	0.47	-10.27**	**-4.81**	**0.47**	**-10.30****	-4.90	0.47	-10.33**
Quadratic skill acquisition (SA2), γ_{40}	-0.57	0.06	-9.13**	**-0.57**	**0.06**	**-9.18****	-0.59	0.06	-9.36**
Gender, γ_{01}	-18.62	1.85	-10.06**	**-18.63**	**1.86**	**-10.00****	-18.62	1.86	-10.01**
SA X Gender, γ_{11}	-0.49	0.35	-1.40	**-0.47**	**0.35**	**-1.34**	-0.45	0.35	-1.31
TA X Gender, γ_{21}	6.85	2.06	3.32**	**6.58**	**2.05**	**3.22****	6.48	2.05	3.17**
RA X Gender, γ_{31}	0.38	0.50	0.75	**0.38**	**0.50**	**0.76**	0.36	0.50	0.73
ACT, γ_{02}	0.93	0.19	5.03**	**0.95**	**0.19**	**5.05****	0.94	0.19	5.04**
SA X ACT, γ_{12}	0.00	0.04	-0.01	**0.00**	**0.03**	**-0.11**	0.00	0.03	-0.11
TA X ACT, γ_{22}	-0.17	0.21	-0.81	**-0.14**	**0.21**	**-0.67**	-0.13	0.21	-0.64
RA X ACT, γ_{32}	0.08	0.05	1.50	**0.07**	**0.05**	**1.44**	0.07	0.05	1.46
Videogame experience (VGE), γ_{03}	4.71	0.89	5.29**	**4.74**	**0.90**	**5.28****	4.76	0.90	5.31**
SA X VGE, γ_{13}	0.12	0.17	0.73	**0.11**	**0.17**	**0.65**	0.09	0.17	0.56
TA X VGE, γ_{23}	-1.69	0.99	-1.70*	**-1.62**	**0.99**	**-1.64**	-1.51	0.99	-1.53
RA X VGE, γ_{33}	0.26	0.24	1.06	**0.28**	**0.24**	**1.16**	0.28	0.24	1.16
NAPre Between-person emotion (NAPre BPE), γ_{04}	-0.94	0.46	-2.06*	**-1.01**	**0.46**	**-2.19***	-0.97	0.46	-2.10*
SA X NAPre BPE, γ_{14}	0.04	0.09	0.43	**0.05**	**0.09**	**0.59**	0.04	0.09	0.48
TA X NAPre BPE, γ_{24}	0.40	0.51	0.78	**0.46**	**0.51**	**0.90**	0.50	0.51	0.98
RA X NAPre BPE, γ_{34}	0.00	0.12	-0.02	**-0.04**	**0.12**	**-0.33**	-0.03	0.12	-0.26
NAPre Within-person Emotion (NAPre WPE), γ_{50}				**-0.49**	**0.14**	**-3.58****	-0.18	0.33	-0.55
SA X NAPre WPE, γ_{60}							-0.17	0.10	-1.74†
TA X NAPre WPE, γ_{70}							0.69	0.57	1.20
RA X NAPre WPE, γ_{80}							0.29	0.15	1.97*
AIC		*20492.62*			***20484.20***			*20491.17*	

Note. NAPre = Negative-Activating, Prevention-Focused Emotions. Bolded results reflects those for the best-fitting model. $N = 214$. †$p < .10$, *$p < .05$, **$p < .01$.

Table 9

Discontinuous Mixed-Effects Growth Models of Performance Change as a Function of Negative Deactivating Emotions (i.e., Discouraged, Disappointed)

	Model 3			Model 4			**Model 5**		
Variable	*B*	*SE*	*t*	*B*	*SE*	*t*	***B***	***SE***	***t***
Intercept, γ_{00}	35.30	1.09	32.38**	35.45	1.08	32.71**	**35.46**	**1.09**	**32.68****
Skill acquisition (SA), γ_{10}	5.61	0.42	13.26**	5.42	0.41	13.07**	**5.42**	**0.41**	**13.05****
Transition adaptation (TA), γ_{20}	-21.53	1.18	-18.27**	-20.38	1.13	-18.09**	**-19.98**	**1.13**	**-17.66****
Reacquisition adaptation (RA), γ_{30}	-4.77	0.47	-10.22**	-4.67	0.46	-10.08**	**-4.65**	**0.46**	**-10.06****
Quadratic skill acquisition (SA2), γ_{40}	-0.57	0.06	-9.13**	-0.56	0.06	-9.15**	**-0.57**	**0.06**	**-9.28****
Gender, γ_{01}	-18.00	1.83	-9.83**	-17.80	1.82	-9.77**	**-17.84**	**1.83**	**-9.77****
SA X Gender, γ_{11}	-0.33	0.35	-0.95	-0.30	0.34	-0.89	**-0.25**	**0.34**	**-0.74**
TA X Gender, γ_{21}	6.16	2.05	3.00**	5.60	1.96	2.86**	**5.33**	**1.95**	**2.73****
RA X Gender, γ_{31}	0.29	0.50	0.59	0.21	0.51	0.42	**0.18**	**0.50**	**0.36**
ACT, γ_{02}	0.86	0.18	4.66**	0.82	0.18	4.43**	**0.81**	**0.18**	**4.38****
SA X ACT, γ_{12}	-0.01	0.04	-0.33	0.00	0.03	-0.09	**0.00**	**0.03**	**-0.04**
TA X ACT, γ_{22}	-0.10	0.21	-0.49	-0.06	0.20	-0.32	**-0.07**	**0.20**	**-0.35**
RA X ACT, γ_{32}	0.08	0.05	1.61	0.06	0.05	1.15	**0.06**	**0.05**	**1.12**
Videogame experience (VGE), γ_{03}	4.52	0.86	5.13**	4.55	0.88	5.19**	**4.54**	**0.88**	**5.18****
SA X VGE, γ_{13}	0.09	0.17	0.53	0.05	0.16	0.32	**0.04**	**0.16**	**0.24**
TA X VGE, γ_{23}	-1.51	0.99	-1.53	-1.01	0.94	-1.07	**-0.94**	**0.94**	**-1.00**
RA X VGE, γ_{33}	0.27	0.24	1.14	0.23	0.24	0.96	**0.26**	**0.24**	**1.08**
ND Between-person emotion (ND BPE), γ_{04}	-1.58	0.47	-3.35**	-1.85	0.47	-3.93**	**-1.88**	**0.47**	**-3.98****
SA X ND BPE, γ_{14}	-0.14	0.09	-1.54	-0.06	0.09	-0.71	**-0.05**	**0.09**	**-0.52**
TA X ND BPE, γ_{24}	1.15	0.53	2.17*	1.26	0.50	2.50*	**1.14**	**0.51**	**2.24***
RA X ND BPE, γ_{34}	0.09	0.13	0.68	-0.01	0.13	-0.09	**-0.05**	**0.13**	**-0.37**
ND Within-person Emotion (ND WPE), γ_{50}				-1.29	0.12	-11.13**	**-1.25**	**0.28**	**-4.43****
SA X ND WPE, γ_{60}							**-0.14**	**0.08**	**-1.77†**
TA X ND WPE, γ_{70}							**1.00**	**0.49**	**2.06***
RA X ND WPE, γ_{80}							**0.27**	**0.12**	**2.22***
AIC		*20478.57*			*20363.33*			***20361.90***	

Note. ND = Negative Deactivating Emotion. Bolded results reflects those for the best-fitting model. $N = 214$. †$p < .10$, *$p < .05$, **$p < .01$.

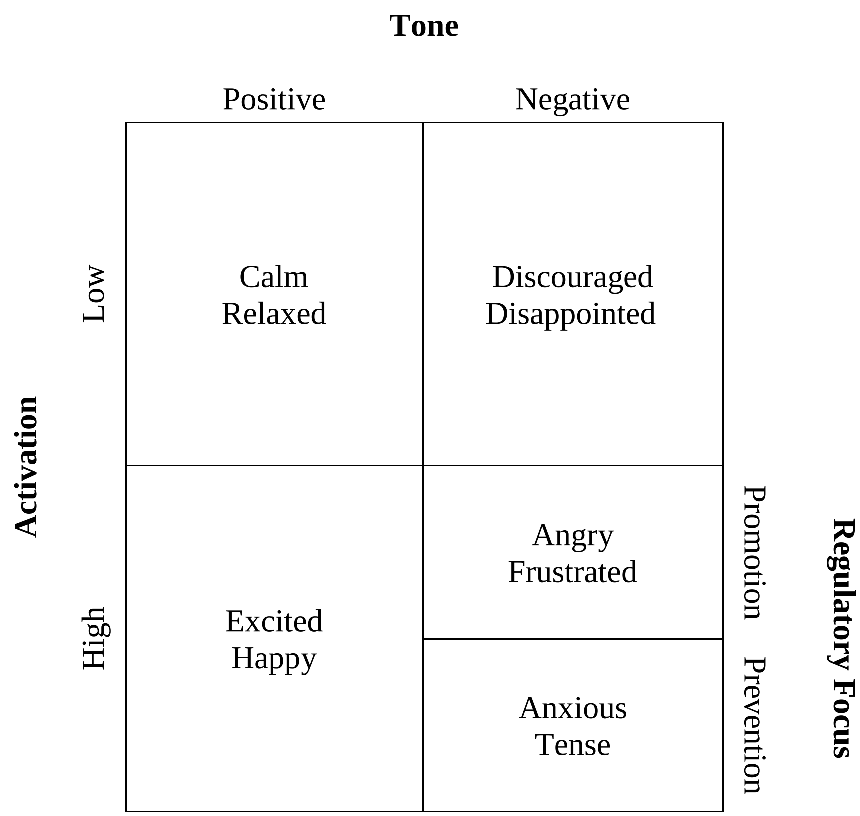

Figure 1. *Emotions measured in the present study paired into clusters based on various dimensions/scales (i.e., activation, tone, regulatory focus).*

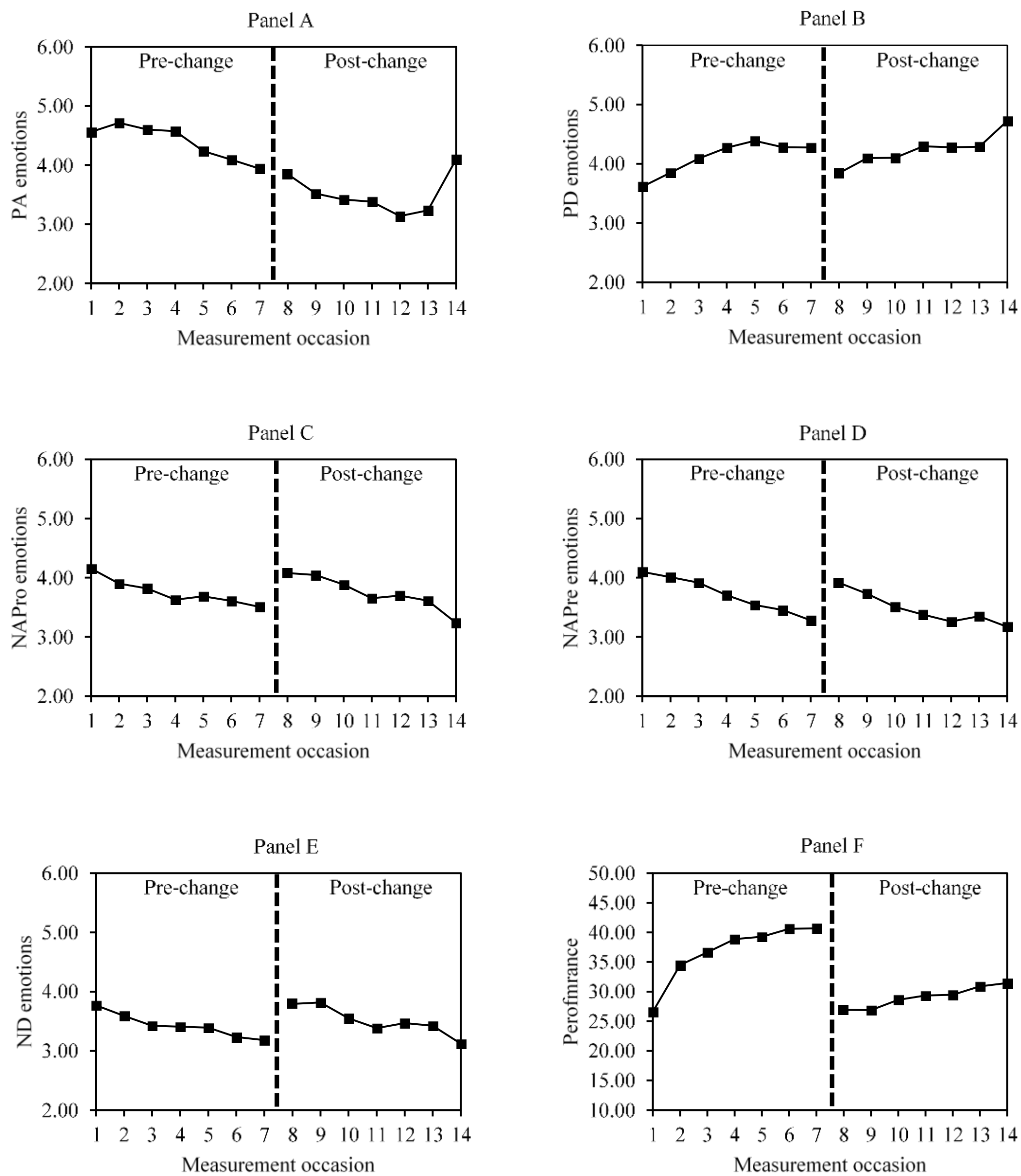

Figure 2. *Trends in study variables over the course of the 14 sessions: 1-7 = pre-change; 8-14 = post-change*

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