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AN APPLICATION OF BEHAVIOR MODELING TRAINING
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DEPARTMENT OF PSYCHOLOGY

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Abstract

Despite a preponderance of research on Behavior Modeling Training (BMT), there is a lack of research investigating BMT in complex skill acquisition contexts. This laboratory study addresses this gap in the literature by comparing the effectiveness of two forms of BMT—either using a coping model or a mastery model—with two forms of control training—either a review of the task instructions or additional unstructured practice—on a computer task that simulates the demands of a dynamic aviation environment. The results showed that BMT had a positive effect on the learning of complex skills. However, the positive effects on skill acquisition were not substantially more than a review of the task instructions. Furthermore, the effects of BMT were stronger for transfer to a related task. BMT was also associated with self-efficacy during training, enjoyment of training, perceptions of training utility, motivation, and strategy change; however, the results did not support mediation. Contrary to what was hypothesized, there were no performance-related differences between the two behavioral modeling conditions, although the coping model condition led to higher levels of self-efficacy and motivation than the mastery model. These results are discussed in terms of the need to better understand the mechanisms underlying the effectiveness of BMT.

An Application of Behavior Modeling Training to Complex Skill Acquisition

Since its inception over 30 years ago, behavior modeling training (BMT; Goldstein & Sorcher, 1974) has been a popular training intervention and subject of research (Taylor, Russ-Eft, & Chan, 2005). Behavior modeling training, which is based on Bandura's (1977) social learning theory, has been linked to positive learning outcomes in many studies (see Taylor et al., 2005 for a meta-analytic review of BMT). Examples of contexts in which the effects of BMT have been investigated include interpersonal skills (e.g., Baldwin, 1992; Latham & Saari, 1979; Manz & Sims, 1986), assertiveness skills (e.g., Decker, 1980, 1984; Mann & Decker, 1984), and computer skills (e.g., Compeau & Higgins, 1995; Davis & Yi, 2004; Gist, Rosen, & Schwoerer, 1988; Gist, Schwoerer, & Rosen, 1989; Yi & Davis, 2001, 2003).

However, despite overwhelming evidence demonstrating the effectiveness of BMT in the domains in which it has been tested, my search of the empirical literature revealed no research directly examining the effectiveness of BMT for complex skill acquisition in contexts involving human-machine interactions. Therefore, the primary purpose of the present study was to investigate the effectiveness of BMT for a complex computer-based task involving strong cognitive and psychomotor components. For this investigation, I took a naturalistic approach to BMT by having trainees observe a model performing the task while explaining his actions and strategies aloud. This approach comprehensively captures important task components while highlighting the interdependencies among task components. That is, with this approach, trainees were able to see the interplay among the various task components within the context of the whole task. This is important for complex skill acquisition because the nature of complex tasks makes it difficult to separate the task into components, consequently making it difficult to train separate components while maintaining the meaningfulness of the whole task (Gopher, Weil, & Siegel, 1989; Shebilske, Regian, Arthur, & Jordan, 1992).

Furthermore, some researchers have proposed that certain model characteristics can moderate the effects of BMT. One model characteristic that has been investigated is whether the model demonstrates immediate mastery of the task or is shown initially struggling (i.e., coping) before reaching mastery. The most common domain in which this model characteristic has been investigated is anxiety reduction (e.g., Ginther & Roberts, 1982; McMurray, Lucas, & Arbres-Duprey, 1985; Meichenbaum, 1971). Other domains include dart-throwing (e.g., Kitsantas, Zimmerman, & Cleary, 2000) and writing skill (e.g., Zimmerman & Kitsantas, 2002). However, to my knowledge, the relative effectiveness of coping and mastery models has not been examined in a complex skill acquisition context. Because complex skill acquisition is difficult and generally accompanied by initial failure, it would seem that a model coping with a low level of skill before reaching mastery would seem more similar to trainees by showing trainees that the model started with the same level of skill as them, which would then make success appear more attainable. This is a similar argument to the one used by Bandura (1977) when describing vicarious learning. Therefore, a second purpose of this study was to investigate whether coping and mastery models are differentially effective in promoting skill acquisition.

Two video-based BMT conditions exhibiting different model characteristics (i.e., coping and mastery models) were compared against two control conditions: one in which participants spent an equivalent amount of time re-watching a task instructions video and one in which participants spent an equivalent amount of time practicing the task. These conditions were compared with respect to two main criteria: skill acquisition and transfer. Furthermore, in line with the relationships suggested by previous research, I explored the mediating roles played by self-efficacy, declarative knowledge, knowledge structure coherence, and trainee reactions in the relationship between BMT and skill acquisition.

Processes in Behavior Modeling Training

Social learning theory (Bandura, 1977), also referred to as social-cognitive theory (Bandura, 1986), suggests that the learning and subsequent reproduction of observed behaviors are determined by four processes: attention, retention, reproduction, and motivation. Attentional processes refer to trainees observing a modeled stimulus. These processes are believed to underlie the transfer of the observed stimulus to short-term memory. In other words, for the learning process to begin, trainees must attend to the behaviors being modeled.

While attentional processes are responsible for the transfer of observed stimuli to short-term memory, retentional processes are considered necessary for transferring stimuli to long-term memory. That is, trainees must engage in, or be engaged in, strategies to store the learned material in memory so it can be used again. One strategy to enhance retentional processes that has been suggested by Decker (1980) is symbolic coding. Symbolic coding refers to the process by which trainees “organize and reduce the diverse elements of a modeled performance into a pattern of verbal symbols that can be easily stored, retained intact over time, quickly retrieved, and used to guide performance” (Decker, 1980, p. 628). A series of studies conducted by Decker (1980, 1982, 1984) involving assertiveness and supervisory skills training investigated techniques to promote symbolic coding. These studies demonstrated that presenting specific learning points to trainees in conjunction with modeled behaviors and encouraging trainees to extract rule codes for performance of the behavior enhances trainees' subsequent performance of the modeled behaviors. A study by Mann and Decker (1984) suggested that interspersing learning points throughout modeled performance enhances the distinctiveness of key behaviors. Furthermore, research has indicated that providing trainees with retention aids, such as cards summarizing learning points, enhances retentional processes as well (Decker & Nathan, 1985).

Reproduction processes occur when trainees practice the behaviors they learn through modeling. This practice, known as behavioral rehearsal or skill practice (Taylor et al., 2005), also includes feedback to trainees regarding their performance in using learned behaviors. An emphasis on behavioral reproduction is not unique to BMT. Rather, practice is seen as a necessary determinant of the effectiveness of any training intervention (Baldwin & Ford, 1988; Brown, 2001; Ericsson, Krampe, & Tesch-Romer, 1993). Furthermore, the training literature has shown that performance-related feedback is generally positively related to performance (see Kluger & DeNisi, 1996 for a meta-analytic review).

Motivational processes are seen as responsible for determining if trainees will continue to perform learned behaviors. That is, behaviors will not continue to be reproduced if they are not seen as useful for successful performance or if the consequences of performing these behaviors are not considered sufficiently positive. Social learning theory involves two processes believed to influence trainee motivation: enhancement of self-efficacy and vicarious reinforcement (Bandura, 1977, 1986).

Trainees experience enhanced self-efficacy during BMT by observing a model successfully performing a behavior. This observation in turn raises trainees' perceptions that they will be able to perform the behavior successfully. Additionally, trainees learn vicariously that performance of the behavior is associated with reinforcement by observing the model being reinforced for his or her behaviors. Thus, according to social learning theory, trainees will be motivated to perform the modeled behavior in order to receive similar reinforcement (Bandura, 1971).

Behavior Modeling Training and Complex Skill Acquisition

Skill Acquisition

The most commonly investigated outcome of BMT is task performance. As stated previously, BMT is thought to affect performance through its positive effects on self-efficacy and strategy formation. In general, studies investigating BMT with retention enhancers have shown positive performance effects (e.g., Decker, 1980, 1982, 1984; Latham & Saari, 1979; Yi & Davis, 2001, 2003). Furthermore, a meta-analytic review of 32 BMT studies revealed an effect size estimate of 1.18 (SD = 1.18) for BMT on skill performance compared to a no-training assessment (i.e., either a control group or a pre-training performance measure; Taylor et al., 2005). However, this does not address the comparison of BMT to less-costly, yet realistic, alternative training strategies (e.g., additional unstructured practice or a review of task instructions). Therefore, one contribution of the present study is an investigation of the effectiveness of BMT relative to practical and realistic comparison groups. I tested the following hypothesis.

Hypothesis 1: Participants undergoing BMT will exhibit higher levels of skill acquisition and transfer than those in control training conditions.

Though empirical research has largely supported the effectiveness of BMT, results have been less conclusive regarding the relative superiority of mastery vs. coping models. On one hand, research has shown that models who exhibit only positive (i.e., effective) behaviors yield better behavior reproduction than those who exhibit a combination of positive and negative behaviors (Baldwin, 1992; Becker & Englemann, 1977; Bruner, Goodnow, & Austin, 1956). On the other hand, in the context of complex tasks, initial task performance is generally so low that observation of a highly-skilled model demonstrating positive behaviors might be intimidating and less relatable to trainees, whereas observation of a model who struggles initially and then improves to a high level of skill would still demonstrate positive behaviors while at the same time appearing more similar to trainees.

This perception of similarity to an initially struggling model would likely enhance two of the four processes thought to underlie BMT. For one, trainees would likely see a similar model as more relatable. The relatability of the model, in turn, would likely influence the attention of trainees such that a highly relatable model would better hold the attention of trainees. A second process that would likely be affected by the perceived similarity of the model to trainees is motivation. According to Bandura's (1986) self-efficacy theory, the extent to which a model is seen as similar to a learner impacts the effect that the performance and subsequent reward of the model has on the learner. That is, vicarious reinforcement and the motivation derived from it are stronger if the model is perceived as more similar to the learner.

The relative superiority of models who demonstrate initial difficulty and then improve at a task (i.e., coping models) over models who only perform a task at a high level (i.e., mastery models) has also been demonstrated by previous research involving non-complex tasks such as dart-throwing (e.g., Kitsantas, Zimmerman, & Cleary, 2000), anxiety reduction (e.g., Meichenbaum, 1971), and writing skill (e.g., Zimmerman & Kitsantas, 2002). Furthermore, research investigating the effectiveness of including negative models in a BMT program (e.g., Baldwin, 1992; May & Kahnweiler, 2000) has shown that trainees exposed to both positive and negative models of behavior demonstrate better generalization of the modeled behavior. A coping model is similar to a mixed positive and negative model because the model initially demonstrates sub-optimal behaviors. For these reasons, individuals who undergo BMT with a coping model are expected to achieve higher levels of skill than those who undergo BMT with a mastery model. I tested the following hypothesis.

> Hypothesis 2: Participants undergoing BMT with a coping model will exhibit higher levels of skill acquisition and transfer than those undergoing BMT with a mastery model.

Mediators

Until relatively recently, the mediational roles played by self-efficacy and other variables in the relationship between BMT and training success were only theorized. Bandura (1978, 1982) theorized that the beneficial effects of BMT are primarily due to increased self-efficacy and the promotion of more optimal strategies for performance. Since then, only a few empirical studies (e.g., Compeau & Higgins, 1995; Johnson & Marakas, 2000; Yi & Davis, 2003) have investigated the variables that mediate the BMT – performance relationship. These studies have generally found that self-efficacy, as well as other variables (e.g., declarative knowledge; Yi & Davis, 2003) act as mediators.

However, it is still uncertain specifically which variables, if any, play significant mediational roles and which variables, if any, play the strongest mediational roles, particularly in complex skill acquisition contexts. It is possible that BMT is effective primarily because it fosters the development of more adaptive performance strategies and that the role of other variables, such as self-efficacy, in contributing to performance is negligible (Day et al., 2007). However, my review of the empirical literature suggests that other key variables do have the potential to play a mediational role. These key variables are reviewed below.

Self-Efficacy

According to social cognitive theory (Bandura, 1986), self-efficacy is one of the primary mechanisms through which behavior modeling acts because individuals experience more self-efficacious beliefs after observing a model successfully performing a task. These self-efficacious beliefs are then theorized to lead to better performance. In support of this, empirical research (e.g., Compeau & Higgins, 1995; Johnson & Marakas, 2000; Yi & Davis, 2003) has demonstrated the mediational role of self-efficacy. In order to further explore the mediational role played by self-efficacy, I investigated the relative effectiveness of BMT in elevating trainees' self-efficacy and, ultimately, the extent to which self-efficacy mediates the relationship between BMT and the training outcomes of skill acquisition and transfer.

Declarative Knowledge

Recent research has shown that BMT is positively related to declarative knowledge (e.g., Davis & Yi, 2004; Taylor et al., 2005; Yi & Davis, 2003). For example, a meta-analytic review of 14 studies comparing BMT against no-training control groups revealed an effect size estimate of 1.20 (*SD* = 1.34) for BMT on declarative knowledge. However, this research merely demonstrated a relationship between BMT and declarative knowledge; it did not examine declarative knowledge as a possible mediator in the relationship between BMT and performance. Although the literature on BMT does recommend the use of learning points during training, the primary focus of BMT is on behavioral demonstrations. Because of this, the extent to which BMT is superior or inferior, in terms of elevating trainees' declarative knowledge, to training interventions that focus on factual aspects of the task has not been empirically tested. For this reason, I investigated the relative effectiveness of BMT in elevating trainees' declarative knowledge and, ultimately, the extent to which declarative knowledge mediates the relationship between BMT and the training outcomes of skill acquisition and transfer.

Knowledge Structure

Bandura (1986, 1997) identified knowledge structures as an important mechanism in observational learning, saying that observational learning results in knowledge structures that "serve as cognitive guides for the construction of complex modes of behavior" (Bandura, 1997, p. 34). Despite this theoretical proposition, little research has explored the potential mediational role played by knowledge structure. One notable exception is a study by Davis and Yi (2004), which showed that BMT using mental rehearsal led to changes in trainees' knowledge structures, which were in turn responsible for improvements in performance and declarative knowledge. Because of this theoretical link between BMT and knowledge structure, I investigated the relative effectiveness of BMT in increasing the coherence of trainees' knowledge structures and, ultimately, the extent to which knowledge structure coherence mediates the relationship between BMT and the training outcomes of skill acquisition and transfer.

Trainee Reactions

It would seem that BMT would foster more positive trainee reactions due to the novelty of the training presentation as well as the theoretical link between BMT and self-efficacious beliefs. In support of this assertion, Latham and Saari (1979) found that supervisors who completed a BMT program responded to a series of reaction items at an average level of 4.15 (*SD* = .59) on a 5-point Likert scale (5 = strong positive reactions) indicating strong positive reactions. However, no reactions measures were given to the control group, so reasonable conclusions about the effects of BMT on trainee reactions can not be made. Beyond this study, the relationship between BMT and trainee reactions has not been widely investigated. In fact, a recent meta-analytic review (i.e., Taylor et al., 2005) explicitly excluded studies that only used reaction questionnaires on the basis that such measures are not traditional training outcomes. For this reason, I investigated the relative effectiveness of BMT in improving trainee reactions and, ultimately, the extent to which positive trainee reactions mediate the relationship between BMT and the training outcomes of skill acquisition and transfer.

Method

Participants

Participants included right-handed males enrolled in introductory psychology at the University of Oklahoma. Participants signed up for the study using a website that provided a variety of different studies to participate in. Participants were required to be right-handed due to equipment constraints and at least 18 years of age. In addition to earning course credit for their participation, participants were given a chance to earn monetary bonuses of $80, $60, $40, $20, and $10, which were paid to the top five performers after the study was completed.

A total of 151 males participated in the study. Eight participants were removed from the study for not following instructions. One participant's data were removed due to an exceptionally low (i.e., less than -4000) baseline performance score. Not only did this lead to a marked pre-manipulation performance discrepancy for his condition, but typical skill acquisition curves display much slower acquisition throughout training for those who start at low skill levels. The removal of these participants' data yielded a final sample of 142 participants.

Apparatus and Measures

Performance task. The computer-based video game Space Fortress (Mané & Donchin, 1989) was used as the performance task in this study. Space Fortress simulates important information processing and psychomotor demands that are present in aviation and other complex tasks (Gopher, Weil, & Bareket, 1994). These demands include short- and long-term memory loading, high mental workload, dynamic attention allocation, decision-making, prioritization, resource management, discrete motor responses, and difficult manual control elements (Gopher, Weil, & Siegel, 1989). The primary objective of Space Fortress is to navigate a ship around a stationary space fortress in frictionless space. The ship is navigated using a joystick and shots are fired using a trigger button on top of the joystick. The space fortress fires missiles, which must be avoided by the ship. In addition, friend and foe mines fly in the space surrounding the fortress and are identified using an indicator on the information panel at the bottom of the screen. Before destroying a foe mine, the corresponding mouse button must be double-clicked in the proper amount of time. Symbols appear on the screen just below the fortress to indicate opportunities to gain bonus points or additional missiles by pushing one of the corresponding mouse buttons. The information panel at the bottom of the screen displays information regarding the number of available missiles, the battle score, and component scores based on ship velocity, ship control, and how rapidly mines are destroyed. Each of the component scores, as well as the total score, for each game performed is stored in the computer as a record of progress. For a detailed description of Space Fortress, see Arthur et al. (1995).

General cognitive ability. To control for general cognitive ability, participants completed the 12-item short form of Raven's Advanced Progressive Matrices (APM; Raven, Raven, & Court, 1994). The APM presents participants with design problems arranged in ascending order of difficulty and is scored by summing the number of problems that are correctly answered. Participants were given a time limit of 10 minutes to complete the 12 problems. The APM was administered at the beginning of the second day of training. The Spearman-Brown split-half reliability coefficient for the APM was .56 in the present study.

Self-efficacy. The self-efficacy scale used in this study (see Appendix A) was based on sample items from scales used in several previous studies (e.g., Bell & Kozlowski, 2002; Martocchio & Judge, 1997; Nease, Mudgett, & Quinones, 1999) as well as items developed specifically for this study. The scale consists of 12 items adapted to reflect a Space Fortress context. Example items are "I can meet the challenges of Space Fortress" and "I am confident that I have what it takes to perform Space Fortress well". Participants responded using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The self-efficacy scale was administered three times: before the first condition-specific activity (i.e., training manipulation), after the first condition-specific activity, and after the second condition-specific activity. The first administration (i.e., pre-manipulation self-efficacy) was used as a control variable; an average of the second and third manipulations was used to measure self-efficacy during training. In previous research involving the same performance task, self-efficacy was moderately-to-strongly correlated ($r = .40$ to $r = .59$; Boatman, 2004; Day et al., 2007) with proximal measures of performance. Internal consistency coefficients (i.e., alphas) for the first, second, and third administrations of the self-efficacy scale in this study were .91, .94, and .95, respectively.

Declarative knowledge. To measure declarative knowledge, participants were given a 30-item multiple choice test consisting of questions about the facts and rules of the Space Fortress game. Participants were given 7 minutes to complete the test. The declarative knowledge test was administered after the first and second condition-specific activities (i.e., training manipulations). Declarative knowledge was operationalized as the average score of the two administrations. In previous research involving the same performance task, declarative knowledge was moderately-to-strongly correlated ($r = .45$ to $r = .52$; Boatman, 2004; Espejo, Day, & Scott, 2006) with proximal measures of performance.

Knowledge structure coherence. Participants' knowledge structures were elicited and analyzed using the Pathfinder (Schvanevelt, 1990; Schvanevelt, Durso, & Dearholt, 1989) procedure. Participants made similarity (i.e., relatedness) ratings for all possible pairs of 14 Space Fortress concepts (for a list of concepts, see Day, Arthur, & Gettman, 2001), which were presented at random by a computer, resulting in a total of 91 ratings. Participants were asked to indicate the extent to which each pair of concepts is related using a 9-point Likert scale (1 = not at all related; 9 = highly related). Knowledge structure coherence was measured using the Coherence score generated by Pathfinder. The Coherence score is based on a transitivity assumption in that the relationship between any two concepts should have implications for how both are seen in relation to other concepts within a network. The Coherence score is a correlation between direct relatedness ratings and a set of derived indirect ratings. Coherence is high when the actual ratings of relatedness correspond to their indirect ratings. The Pathfinder ratings were elicited after the first and second condition-specific activities (i.e., training manipulations). Knowledge structure coherence was operationalized as the average Coherence score from the two administrations. In a study relating knowledge structure to performance after computer skills training, knowledge structure analyzed using Pathfinder correlated .43 with performance (Davis & Yi, 2004). Similarly, in previous research involving Space Fortress, knowledge structure was moderately correlated (r = .34 to r = .54; Boatman, 2004; Day, Arthur, & Gettman, 2001; Espejo, 2006; Espejo, Day, & Scott, 2006) with proximal measures of performance.

Trainee reactions. A trainee reactions scale consisting of 17 items was developed specifically for this study. Three items on the scale were used to measure the extent to which participants enjoyed the manipulation (*enjoyment*; e.g., "The video was enjoyable to watch"); three items were used to measure the extent to which participants felt motivated by the manipulation (*motivation*; e.g., "I am eager to start playing Space

Fortress again"); three items were used to measure the extent to which the participants found utility in the manipulation (*utility*; e.g., "I learned new things from the video that will help me increase my Space Fortress scores"); and four items were used to measure the extent to which participants planned to change their strategies for playing Space Fortress after the activity (*strategy change*; e.g., "After having watched this video, I plan to change my strategy for playing Space Fortress").

Two versions of the trainee reactions scale were created – one for the two BMT video conditions as well as the instructions video condition and the other for the additional practice condition. The constructs measured by both scales were the same, but the items on the scale given to the video conditions were put in a video context and the items on the scale given to the practice condition were put in the context of practicing Space Fortress. However, the video condition scale included an additional four items measuring the understandability of the video (*understandability*; e.g., "The information in the video was presented in a clear manner"). The trainee reactions scales for the video conditions and practice condition are presented in Appendices B and C, respectively. Participants responded using a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). The trainee reactions scale was administered after the first and second condition-specific activities (i.e., training manipulations). Each of the trainee reaction constructs was operationalized as the average score on the relevant items from the two administrations. Internal consistency coefficients (i.e., alphas) for the first and second administrations of the understandability scale in this study were .74 and .69, respectively. For the enjoyment scale, alphas for the first and second administrations were .87 and .89 respectively. For the motivation scale, alphas for the first and second administrations were .64 and .69 respectively. For the utility scale, alphas for the first and second administrations were .73 and .74 respectively. For the strategy change scale, alphas for the first and second administrations were .66 and .78 respectively.

Procedure

Participation in the study took place for 5 hours over 2 days spread 1 week apart. Appendix D presents an ordered list of study activities. To begin the study, participants were told that the purpose of the research is to examine how different people learn novel and complex tasks. Participants then signed a consent form, after which they viewed a 17-minute Space Fortress instructions video accompanied by a seven-page training manual. Participants then performed four warm-up (i.e., baseline) games of Space Fortress. The warm-up games were followed by a 5-minute video review of the instructions. During the review of instructions, participants were given a two-page review of the Space Fortress instructions and optimal strategies, which they were able to use for the duration of the study. After the instruction review video, participants completed their first 10-game session of Space Fortress (Session 1). All 10-game sessions consisted of eight practice games followed by two test games. All games lasted 3 minutes. Immediately following each game, participants were presented with on-screen feedback about their performance. After the first 10-game session, participants completed a condition-specific practice activity.

Two groups of participants watched a 15-minute video of a highly-skilled human model performing Space Fortress. The model used in both videos demonstrated SF performance scores achieved by the 99^{th} percentile of participants in a previous study involving a comparable amount of task practice. Participants in the mastery model condition saw the model performing at a high level for two full games. Participants in the coping model condition watched two clips of the same model performing at novice and intermediate levels, followed by one full game of the model performing at a high level—the same game as the second one shown in the mastery model condition. During each game, participants were shown the game screen as the model saw it when he was playing, as well as camera footage of the model's hands using the mouse and joystick as he played. Furthermore, participants were able to hear the model explaining aloud what he was doing while he played. The modeling videos were designed to follow the general format suggested and used in previous BMT research. Before each game, a narrator described the model's experience level at the time the game was played and pointed out key learning points for participants to pay attention to. Each game began with the model explaining his plans and strategies for that game and concluded with a feedback screen showing the scores the model received and the model explaining why he received those scores. The explanations were included to expose trainees to learning points from the model as well as the narrator. Furthermore, each game concluded with a feedback screen so participants could vicariously experience the consequences of the model's behaviors. While watching the video, participants were given a sheet of paper and asked to write key facts, rules, or strategies that they learned about Space Fortress and were told that they would be able to keep these notes with them for future games of Space Fortress. This was done to facilitate the formulation of rule codes (Decker, 1980, 1982, 1984; Hogan, Hakel, & Decker, 1986) by participants. The other two groups of participants were considered control groups. Participants in the instructions condition re-watched the 17-minute instructional video. This group was also given a sheet of paper to write key facts, rules, and strategies that they learned about Space Fortress. Participants in the practice condition spent 15 minutes performing four practice games of Space Fortress.

Participants then completed a 2-game Space Fortress test session (Session 2), followed by the second 10-game session of Space Fortress (Session 3). One week later, participants completed the APM, followed by a 2-game test session of Space Fortress (Session 4). Participants then completed a 10-game session of Space Fortress (Session 5), followed by a 5-minute condition-specific review activity. Participants in the two modeling conditions watched a video of the same human model performing one game of Space Fortress at a high level. Participants in the mastery model condition were told that they would be observing the model performing at the same level as they saw in the first video; participants in the coping model condition were reminded that they observed the model performing at lower levels before they observed him performing at a high level. As before, the video included a narrator pointing out key learning points, the model explaining his plans before the game of Space Fortress, the model explaining what he is doing while performing Space Fortress, and the model explaining why he received the scores shown on his feedback screen. Participants in the instructions condition re-watched the 5-minute Space Fortress instructions review video. During the review activity, participants in both modeling conditions and the instructions condition were given the opportunity to add additional facts, rules, and strategies that they learn about Space Fortress to their notes sheet. Participants in the practice condition performed a two-game practice session of Space Fortress. After the condition-specific review activity, participants completed the trainee reactions measure, followed by the self-efficacy scale, Pathfinder, and declarative knowledge test. Participants then performed a 2-game Space

Fortress test session (Session 6) and two more 10-game sessions of Space Fortress (Sessions 7 and 8). Space Fortress session 8 performance was used to operationalize final level of skill acquisition. To conclude the study, participants completed a 2-game test of transfer in which the arrow keys on a standard keyboard were used to replace the joystick (Transfer). Monetary bonuses were based solely on test game performance.

Results

Table 1 provides the means, standard deviations, correlations, and internal consistencies for all study variables. As shown, *g*, skill before manipulation (i.e., Space Fortress session 1), and pre-manipulation self-efficacy were all positively correlated with skill acquisition and transfer. Self-efficacy during training correlated with skill acquisition and transfer, as well as understandability, enjoyment, and motivation stemming from the condition-specific activities. Declarative knowledge correlated with skill acquisition and transfer in addition to the understandability of and motivation stemming from the video-based condition-specific activities. Knowledge structure coherence correlated with skill acquisition and transfer, as well as trainees' motivation and enjoyment stemming from the condition-specific activities. Trainee reactions to the condition-specific activities were generally unrelated to skill acquisition and transfer. Two notable exceptions were that enjoyment of the activities correlated with skill acquisition, and motivation stemming from the activities correlated with both skill acquisition and transfer.

Behavior Modeling Training and Skill Acquisition

To investigate the relative effectiveness of BMT in terms of skill acquisition, I conducted a series of ANCOVA analyses treating training condition as the independent variable. I tested both Space Fortress session 8 performance (i.e., skill acquisition) and transfer performance as dependent variables. I treated *g*, Space Fortress session 1 performance, and pre-manipulation self efficacy as covariates. I chose not to use declarative knowledge and knowledge structure coherence as pre-manipulation covariates because such measures are more likely to lead to testing effects than self-efficacy. It is important to note that analyses showed no significant interactions between these variables and the training manipulation. Table 2 presents the raw means and standard deviations for the study variables for each training condition, and Table 3 presents the adjusted means and standard errors for the study variables for each condition.

Hypothesis 1. Hypothesis 1 stated that participants undergoing BMT would exhibit higher levels of skill acquisition and transfer than those in control conditions. Table 3 presents the results of a series of ANCOVAs comparing the study conditions on each of the dependent variables. A significant main effect was found for training condition for both outcome variables with the pattern of means indicating higher scores for the BMT conditions than the controls. Subsequent planned contrasts (see Table 4) revealed that the BMT conditions yielded higher scores on both skill acquisition and transfer. These results lend support to Hypothesis 1.

Hypothesis 2. Hypothesis 2 stated that participants undergoing BMT with a coping model would exhibit higher levels of skill acquisition and transfer than those undergoing BMT with a mastery model. As shown in Table 3, the results did not support this hypothesis. In fact, the results show an opposite trend with the mastery model leading to higher levels of both skill acquisition and transfer with the difference approaching traditional levels of statistical significance ($p = .06$) with respect to transfer.

A closer inspection of the adjusted means shown in Table 3 reveals that both BMT conditions led to higher levels of skill acquisition than the practice condition but not the instructions video condition. Furthermore, the practice and instructions video conditions did not differ with respect to skill acquisition. With respect to transfer performance, the mastery model condition outperformed both control conditions. The coping model condition only outperformed the practice condition with respect to transfer. Between the two control conditions, the instructions video condition led to higher levels of transfer than the practice condition.

Mediators

To investigate the roles of self-efficacy in training, declarative knowledge, knowledge structure coherence, and trainee reactions in the relationship between BMT and skill acquisition, I first conducted a series of ANCOVA analyses. I used the collapsed condition group variable (i.e., the two BMT conditions are in one condition group and the two control conditions are in the other condition group) as the independent variable and each of the outcomes as separate dependent variables. Similarly to the analyses described above, I treated g, skill before manipulation, and pre-manipulation self-efficacy as covariates.

According to Baron and Kenny (1986), three preconditions must be met before testing for mediation. To meet the first precondition, a relationship must be established between the independent variable and the dependent variable such that the independent variable affects the dependent variable in the predicted direction. The second precondition involves establishing a relationship between the independent variable and the mediator such that the independent variable affects the mediator in the predicted direction. Finally, the third precondition requires a relationship between the mediator and the dependent variable. Once these preconditions have been met, testing for mediation involves examining the relationship between the independent variable and the dependent variable when controlling for the mediator. Mediation is established if the relationship between the independent variable and the dependent variable is smaller when controlling for the mediator and the contribution of the mediator in the model is statistically significant.

To satisfy the first precondition in the context of the present study, a relationship must exist between BMT and the dependent variables skill acquisition and transfer. As shown in Table 4, BMT outperformed the control conditions on both skill acquisition and transfer. This satisfies the first precondition.

To satisfy the second precondition in the context of the present study, a relationship must exist between BMT and each of the variables being tested as mediators. As shown in Table 4, BMT outperformed the control conditions on all of the variables except declarative knowledge, knowledge structure coherence and understandability. Therefore, declarative knowledge, knowledge structure coherence and understandability will not be investigated further as possible mediators.

To satisfy the third precondition in the context of the present study, a relationship must exist between each of the variables being tested for mediation and the dependent variables skill acquisition and transfer. As shown in Table 1, self-efficacy and motivation were related to both skill acquisition and transfer, and enjoyment was related to skill acquisition. Therefore, self-efficacy, motivation, and enjoyment meet the preconditions to be tested as mediators.

To test for mediation, I conducted separate regressions for each possible mediator. For self-efficacy and motivation, I conducted two regressions—one treating skill acquisition as the dependent variable and the second treating transfer as the dependent variable. For enjoyment, I conducted only one regression treating skill acquisition as the dependent variable. I conducted each regression using two steps. In the first step, I included the training condition group, *g*, pre-manipulation self-efficacy, and skill before manipulation. In the second step, I added the variable being tested for mediation.

Table 5 displays the results of testing self-efficacy as a mediator. Self-efficacy made a statistically significant contribution in the final model, but its inclusion only reduced the regression weight for condition group from .29 to .26. Moreover, in the final model predicting transfer, the contribution of self-efficacy was not statistically significant. Overall, these results show that the inclusion of self-efficacy did not explain the relationship between BMT and performance.

Table 6 displays the results of testing motivation as a mediator. Motivation made a statistically significant contribution in the final model, and its inclusion reduced the regression weight for condition group from .29 to .22. However, in the final model predicting transfer, the contribution of motivation was not statistically significant. Overall, these results show that the inclusion of motivation only partially explained the relationship between BMT and skill acquisition and did not explain any of the relationship between BMT and transfer.

Table 7 displays the results of testing enjoyment as a mediator. Not only did the inclusion of enjoyment not reduce the relationship between condition group and skill acquisition, it also did not make a statistically significant contribution to the model.

Therefore, enjoyment is not a mediator in the relationship between BMT and skill acquisition.

Discussion

Behavior modeling training has been linked to positive training outcomes in studies across many domains (Taylor et al., 2005). However, to my knowledge the effectiveness of BMT has not been investigated with respect to complex skill acquisition in the context of human-machine interactions. Therefore, one purpose of this study was to extend the research involving BMT into the complex skill acquisition domain by comparing its effectiveness to two realistic alternative control training interventions. Furthermore, the empirical literature remains unclear regarding the mediational mechanisms by which BMT operates. Therefore, this study attempted to contribute by providing evidence for certain common variables as mediators.

Two themes emerge from this study. One is that BMT is an effective instructional methodology in the context of complex skill acquisition, even in comparison to other realistic training interventions. The second is that questions surrounding the reasons or mechanisms for the success of BMT remain unresolved.

Behavior Modeling Training

This study showed that the effectiveness of naturalistic BMT extends to the complex skill acquisition domain. Specifically, BMT outperformed the control training conditions in terms of both skill acquisition and transfer. This result is not surprising given the strong pattern of effectiveness in past studies. However, this result does provide a valuable contribution to the body of literature surrounding BMT because, by their very nature, complex skills are different from other skills such that some forms of training are less effective for complex skills than for other skills (Gopher et al., 1989). Furthermore, this study demonstrated the effectiveness of BMT relative to other realistic and less-costly training interventions.

Contrary to my hypothesis, the BMT coping model condition did not outperform the mastery model condition. Specifically, the mastery model condition yielded directionally (though not significantly) higher scores on both skill acquisition and transfer than the coping model condition. My hypothesis that the coping model condition would yield higher skill acquisition scores than the mastery model condition was based on the rationale that the coping model was shown initially struggling with the task, thereby making him potentially more relatable to the trainees. Bandura (1977) argued that vicarious learning is strengthened if learners are better able to relate to their models. This premise might have been undermined, however, by the task instructions given to both the mastery and coping model conditions. Before the condition-specific modeling videos were shown, participants were told how many games of Space Fortress the model had played prior to demonstrating his performance. This could have led participants in the mastery model condition to implicitly assume that the model had started at a lower level of performance and had improved through practice over time. If this was the case, then the model in the mastery condition might have appeared sufficiently relatable to the trainees. Future research should include a manipulation check to measure the relatability of the model as experienced by the trainees.

The hypothesis that the coping model condition would yield higher transfer scores than the mastery model was based on the relatability rationale described above as well as research showing that models demonstrating both effective and ineffective performance can lead to better generalization of skills. Past studies that have demonstrated the usefulness of including negative models as a part of BMT in terms of enhancing generalization have involved primarily interpersonal skills training (e.g., Baldwin, 1992; May & Kahnweiler, 2000) and generalization has been operationalized as making use of learned skills outside of training. In this study, generalization (i.e., transfer) was operationalized as a change in the physical input device used to perform the task. Perhaps the transfer task used in this study did not require generalization to novel task-related situations in a way that would have been helped by having seen negative performance behaviors. In other words, it is possible that this transfer task only required trainees to shift their physical, as opposed to cognitive, approach to the task thereby undermining the helpfulness of seeing a more diverse model.

Though the results of this study did not support the hypothesis that BMT using a coping model would lead to higher skill acquisition and transfer than BMT using a mastery model, it is possible that this study was not sensitive to the actual performance-related benefits of coping models. In this study, the coping model condition led to higher scores on both self-efficacy during training and motivation than the mastery model condition. These differences might have led to higher performance scores if the study had employed a more structured training design. Other than video-based introductory instructions at the beginning of the study and condition-specific training at two other points, the training in this study primarily consisted of self-directed practice during which trainees were not given specific learning points or strategies for improvement. Perhaps a more structured design would have led to a performance benefit for trainees in the coping model condition as they could have been more willing to adopt new strategies for performance that were explicitly given to them due to their higher levels of self-efficacy and motivation. That is, without structured guidance, the benefits of enhanced self-efficacy and motivation are not likely to lead to improvements in skill. Consistent with this, the benefits of self-efficacy include effort expenditure and persistence in the face of difficulty (Bandura, 1982). A second way in which this study might not have been sensitive to actual performance-related benefits resulting from the coping model involves transfer to on-the-job performance. Research (e.g., Ford, Quinones, Sego, & Sorra, 1992; Quinones, Ford, Sego, & Smith, 1996) has shown that individuals high in self-efficacy are more likely to attempt to transfer what they learn in training to the job. Had the present study included transfer back to the job as a criterion, it might have demonstrated a benefit for the coping model condition as a result of higher levels of self-efficacy.

Investigated Mediators

A major goal of this study was to contribute to the understanding of how and why BMT is effective. I investigated eight variables as potential mediators. Of the eight potential mediators, BMT contributed positively to five: self-efficacy during training, enjoyment, utility, motivation, and strategy change. Of these five, motivation partially mediated the relationship between BMT and skill acquisition, though its effect as a mediator was not strong enough to explain the relationship between BMT and skill acquisition. None of the investigated variables mediated the relationship between BMT and transfer.

Interestingly, past BMT research involving knowledge structure (e.g., Davis & Yi, 2004) has generally supported its inclusion as a mediator of the relationship between BMT and performance. Similarly, research (e.g., Davis & Yi, 2004; Taylor et al., 2005;

Yi & Davis, 2003) has demonstrated a relationship between BMT and declarative knowledge, though no relationship between declarative knowledge and performance was established. It is important to note that in the present study, scores on knowledge structure coherence were not lower for the BMT conditions. Rather, there was simply no difference between the BMT conditions and the controls. This could point to the possibility that knowledge structure coherence does play a role in the effectiveness of BMT but not differentially from the types of training interventions used in this study's control conditions.

Motivation was the only trainee reactions variable that partially mediated the relationship between BMT and skill acquisition. However, trainees who were in the BMT conditions scored higher on average on three other reactions variables: enjoyment, utility, and strategy change. It is not particularly surprising that these variables were not related to skill acquisition when controlling for *g*, skill before manipulation, and pre-manipulation self-efficacy. Past research has shown that reactions variables such as these are typically not related to performance (see Alliger & Janek, 1989 for a review). However, they are still valuable training outcomes. The results of this study suggest that the use of BMT in training complex skills will not only lead to faster skill acquisition but will also lead to more positive trainee reactions. Specifically, trainees in this study who were in one of the BMT conditions expressed higher levels of training enjoyment, motivation to continue practicing the task, perceptions of training usefulness, and intentions to modify their strategies for approaching the task. These reactions, though not directly tied to immediate skill acquisition in training, can have strong positive consequences for trainees and organizations. For instance, trainees who enjoy their training and find it useful are likely to share these perceptions with others in their organization, which could lead to higher attendance rates in future training sessions. In addition to this, positive trainee reactions to training have implications for transfer back to the job. A meta-analysis conducted by Alliger, Tannenbaum, Bennett, Traver, and Shotland (1997) found that utility-type reaction measures were even more predictive of on-the-job performance than skill acquisition or retention. This means that the extent to which training programs lead to perceptions of utility is important in determining if training will ultimately be successful. For these reasons, the usefulness of BMT as a training technique extends beyond the training environment.

Despite the fact that motivation partially mediated the relationship between BMT and skill acquisition, this study still leaves unresolved the question of exactly why BMT is effective. Perhaps the reasons for the effectiveness of BMT are difficult to measure. DeShon and Alexander (1996) discussed implicit learning in the context of learning complex tasks. Implicit learning is defined as the acquisition of knowledge learned through repeated exposure without intention or awareness. Implicit learning presents itself as improved task performance even though the individual is incapable of explicating the rules used (Berry & Broadbent, 1984; Holyoak & Spellman, 1993). In the context of complex skill acquisition, implicit learning is thought to be a determinant of performance on tasks involving numerous components with complex relationships. This description of implicit learning is consistent with the results of this study in that task performance improved with BMT but trainees in the BMT condition performed more poorly on a test of declarative (i.e., explicit) knowledge than trainees who were given a review of the task instructions. It could be that the effectiveness of BMT is due to implicit learning processes rather than those that would be detected by the measures employed in this study.

Implications

The primary implication of this study for practical purposes is that the effectiveness of BMT extends to the complex skill acquisition domain. The two BMT conditions in this study yielded higher scores on both skill acquisition and transfer than two control training conditions which were designed to mirror realistic and practical real-world alternative training interventions. Furthermore, participants in the BMT conditions expressed more positive reactions to training than those in the control conditions. Based on these results, practitioners should consider the use of BMT in complex skill acquisition contexts.

A second implication of this study is that the mechanisms underlying the success of BMT are still not fully understood. Researchers have only recently begun conducting laboratory studies attempting to identify mediators in the relationship between BMT and training success. The present study found that motivation only partially mediated the relationship between BMT and skill acquisition and played no role in the relationship between BMT and transfer. These results, taken in conjuction with those of past research, do not account for all of the success of BMT. Therefore, further research is warranted.

An implication of this study for future research pertains to the investigation of implicit learning as it relates to BMT. The empirical literature related to implicit learning suggests that it can be measured by comparing the performance of individuals who are asked to identify the rule structures dictating the interrelationships among task components with those who are given no such instructions (Berry & Broadbent, 1988;

Holyoak & Spellman, 1993; Reber, Kassin, Lewis, & Cantor, 1980). Instructing individuals to identify rule structures theoretically engages explicit processing and results in reduced performance. Such a study should be conducted in the context of BMT to attempt to shed further light on the reasons for its effectiveness.

Limitations

Despite the contributions of the present study, limitations with regard to its conclusions must be noted. A primary limitation concerns the generalization of conclusions drawn from the study sample. The participants in this study were right-handed males recruited on a university campus, and training took place in a laboratory setting. Thus, generalization of the findings of this study to a real-world training environment should be done tentatively. Future research should extend the findings of the present study to real-world training contexts. Future research should also extend these results to include both males and females.

Another limitation of this study pertains to comparisons drawn between the two BMT conditions. This study took a naturalistic approach to presenting the behavioral models. As such, some differences between the two conditions could not be controlled. The physical characteristics of the model were held constant by using the same model in both conditions. Furthermore, the model was chosen based on the fact that he employed a relatively non-affective delivery when explaining aloud. Nonetheless, the verbalizations by the model were not held constant across conditions, and thus the possibility remains that trainees could have experienced slightly different affect from the model in the two conditions. Because the affect of the model could have affected the trainee's engagement in the training, direct comparisons between the two BMT conditions should be made with caution.

Conclusion

Despite its widespread success, both in the laboratory and the classroom, BMT had not been investigated in the context of complex skill acquisition before the present study. This study supported the effectiveness of BMT in complex skill acquisition contexts when compared against other realistic and practical training interventions. However, the positive effects are only slightly more than a review of the task instructions. Furthermore, the positive effects of BMT are stronger for transfer than for skill acquisition at the end of training. Though motivation partially mediated the relationship between BMT and skill acquisition, the mechanisms underlying the effectiveness of BMT remain largely unknown. Furthermore, though no performance differences were observed, BMT using a coping model led to higher levels of self-efficacy during training and motivation than BMT using a mastery model.

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Table 1

Means, Standard Deviations, Intercorrelations, and Internal Consistencies of Study Variables

	M	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. *g*	7.83	2.32	.56											
2. Pre-manipulation SE	2.98	0.79	.21*	.91										
3. Skill before manipulation	389.14	1599.96	.29***	.44***	---									
4. SE during training	3.55	0.77	.29***	.78***	.56***	.97								
5. Declarative knowledge	26.96	2.06	.35***	.28***	.39***	.33***	---							
6. KS coherence	0.36	0.21	.32***	.22**	.24**	.25**	.40***	---						
7. Understandability	3.83	0.51	.27**	.21*	.24*	.26**	.28**	.05	.79					
8. Enjoyment	2.59	0.99	.20*	.29***	.13	.38***	.06	.23**	.11	.91				
9. Utility	2.96	0.72	.00	.06	–.09	.18*	–.08	.12	.04	.63***	.73			
10. Motivation	3.17	0.81	.24**	.45***	.33***	.64***	.20*	.28***	.14	.73***	.50***	.81		
11. Strategy change	2.75	0.70	–.03	.04	–.20*	.09	–.18*	.12	–.07	.51***	.80***	.41***	.73	
12. Skill acquisition	2314.98	2112.86	.42***	.38***	.71***	.59***	.43***	.30***	.18	.22**	.02	.42***	–.08	---
13. Transfer performance	1017.73	1728.01	.32***	.32***	.60***	.43***	.36***	.22**	.11	.12	–.04	.29***	–.07	.78***

Note. *g* = general cognitive ability. SE = self-efficacy. KS = knowledge structure. Skill before manipulation = Space Fortress session 1. Skill acquisition = Space Fortress session 8. Values along the diagonal are internal consistencies. *$p < .05$; **$p < .01$; ***$p < .001$. All tests are two-tailed. $N = 142$, except for understandability: $N = 107$.

Table 2

Raw Means and Standard Deviations of Study Variables by Training Condition

	Training Condition									
	Mastery Model $n = 37$		Coping Model $n = 34$		Practice $n = 35$		Instructions Video $n = 36$			
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	η^2
Pre-manipulation										
g	7.73	2.33	7.79	2.07	8.20	2.70	7.61	2.18	0.43	0.01
Pre-manipulation SE	3.03	0.84	2.74	0.78	3.18	0.85	2.96	0.64	1.91	0.04
Skill before manipulation	363.04	1760.64	–75.75	1535.59	584.86	1611.26	664.75	1432.41	1.51	0.03
Post-manipulation										
SE during training	3.52	0.92	3.54	0.69	3.68	0.79	3.45	0.65	0.53	0.01
Declarative knowledge	26.39^a	2.11	26.53^a	1.81	26.66^a	2.29	28.25^b	1.44	7.22***	0.14
KS coherence	0.37	0.21	0.33	0.19	0.39	0.23	0.36	0.22	0.43	0.01
Understandability	3.83	0.54	3.87	0.44	---	---	3.79	0.56	0.21	0.00
Enjoyment	2.69^a	0.95	2.81^{ab}	0.85	3.11^b	0.96	1.77^c	0.63	16.13***	0.26
Utility	3.09^a	0.72	3.24^a	0.59	3.07^a	0.66	2.47^b	0.65	9.67***	0.17
Motivation	3.24^a	0.93	3.44^a	0.71	3.27^a	0.81	2.74^b	0.63	5.40**	0.11
Strategy change	3.00^a	0.71	3.00^a	0.72	2.82^a	0.49	2.20^b	0.51	13.69***	0.23
Skill acquisition	2831.69	2254.13	1980.43	1913.79	1953.17	2304.25	2451.65	1898.85	1.43	0.03
Transfer performance	1701.41^a	1465.03	844.99^b	1646.27	321.16^b	1878.41	1155.43^{ab}	1676.59	4.30**	0.09

Note. *g* = general cognitive ability. SE = self-efficacy. KS = knowledge structure. Skill before manipulation = Space Fortress session 1. Skill acquisition = Space Fortress session 8. Pairwise differences between adjusted means were evaluated using Fisher's LSD test. Significantly different adjusted means are indicated by different superscript letters. η^2 = partial eta squared. $^{**}p < .01$; $^{***}p < .001$.

Table 3

Adjusted Means and Standard Errors for Study Variables by Training Condition

	Training Condition									
	Mastery Model $n = 37$		Coping Model $n = 34$		Practice $n = 35$		Instructions Video $n = 36$			
Variable	M_{adj}	*SE*	M_{adj}	*SE*	M_{adj}	*SE*	M_{adj}	*SE*	*F*	η^2
SE during training	3.49^{a}	0.07	3.76^{b}	0.08	3.51^{a}	0.07	3.44^{a}	0.07	3.61*	0.07
Declarative knowledge	26.41^{a}	0.28	26.76^{a}	0.29	26.44^{a}	0.29	28.23^{b}	0.28	9.24***	0.17
KS coherence	0.37	0.03	0.35	0.04	0.37	0.04	0.36	0.03	0.11	0.00
Understandability	3.82	0.08	3.90	0.09	---	---	3.78	0.08	0.55	0.01
Enjoyment	2.68^{a}	0.13	2.90^{a}	0.14	3.03^{a}	0.14	1.78^{b}	0.14	16.59***	0.27
Utility	3.09^{a}	0.11	3.25^{a}	0.12	3.06^{a}	0.11	2.48^{b}	0.11	9.05***	0.17
Motivation	3.23^{a}	0.11	3.58^{b}	0.12	3.16^{a}	0.11	2.73^{c}	0.11	9.62***	0.18
Strategy change	2.99^{a}	0.10	2.99^{a}	0.11	2.82^{a}	0.10	2.22^{b}	0.10	12.56***	0.22
Skill acquisition	2863.58^{a}	225.86	2419.82^{a}	239.20	1668.73^{b}	234.19	2280.44^{ab}	230.54	4.58**	0.09
Transfer performance	1721.14^{a}	204.95	1163.34^{ab}	217.05	123.43^{c}	212.51	1026.72^{b}	209.19	9.98***	0.18

Note. *g* = general cognitive ability. SE = self-efficacy. KS = knowledge structure. Skill acquisition = Space Fortress session 8. Pairwise differences between adjusted means were evaluated using Fisher's LSD test. Significantly different adjusted means are indicated by different superscript letters. η^2 = partial eta squared. *$p < .05$; **$p < .01$; ***$p < .001$.

Table 4

Adjusted Means and Standard Errors of Study Variables Testing the Planned Comparison BMT > Control Training

	Condition Group					
	BMT n = 71		Control n = 71			
Variable	M_{adj}	*SE*	M_{adj}	*SE*	*F*	η^2
SE during training	3.62	0.05	3.48	0.05	3.56*	0.03
Declarative knowledge	26.57	0.22	27.35	0.22	6.49*	0.05
KS coherence	0.36	0.02	0.36	0.02	0.03	0.00
Understandability	3.86	0.06	3.78[a]	0.08	0.63	0.01
Enjoyment	2.79	0.11	2.40	0.11	6.07**	0.04
Utility	3.16	0.08	2.76	0.08	11.70***	0.08
Motivation	3.40	0.08	2.94	0.08	15.18***	0.10
Strategy change	2.99	0.08	2.52	0.08	19.26***	0.12
Skill acquisition	2653.91	165.84	1976.05	165.84	8.25**	0.06
Transfer performance	1457.50	154.39	577.96	154.39	16.02***	0.11

Note. BMT = Behavior modeling training (mastery and coping conditions combined). Control = control conditions (practice and instructions video conditions combined). SE = self-efficacy. KS = knowledge structure. Skill acquisition = Space Fortress session 8. [a]instructions video condition only. η^2 = partial eta squared. *$p < .05$; **$p < .01$; ***$p < .001$. All tests are one-tailed, with the exception of declarative knowledge because the pattern of means was opposite the hypothesized direction.

Table 5

Regression Analyses Testing Self-Efficacy during Training as a Mediator

Model	β1	β2	R^2	ΔR^2
Skill acquisition				
1. Condition group	.29***	.26***		
g	.26***	.24***		
Pre-manipulation SE	.06	-.12		
Skill before manipulation	.50***	.43***	.46***	
2. Self-efficacy during training	---	.28*	.48***	.02*
Transfer				
1. Condition group	.26***	.25***		
g	.16*	.15*		
Pre-manipulation SE	.07	.03		
Skill before manipulation	.57***	.55***	.46***	
2. Self-efficacy during training	---	.06	.46***	.00

Note. Model 1 included condition group, *g*, pre-manipulation self-efficacy, and SF session 1. Model 2 included condition group, *g*, pre-manipulation self-efficacy, SF session 1, and self-efficacy during training. SE = self-efficacy. Skill before manipulation = Space Fortress session 1. Skill acquisition = Space Fortress session 8. β1 = regression weights in Model 1. β2 = regression weights in Model 2. *$p < .05$; ***$p < .001$.

Table 6

Regression Analyses Testing Motivation as a Mediator

Model	β1	β2	R^2	ΔR^2
Skill acquisition				
1. Condition group	.29***	.22**		
g	.26***	.23***		
Pre-manipulation SE	.06	-.04		
Skill before manipulation	.50***	.45***	.46***	
2. Motivation	---	.27***	.51***	.05***
Transfer				
1. Condition group	.26***	.26***		
g	.16*	.16*		
Pre-manipulation SE	.07	.08		
Skill before manipulation	.57***	.57***	.46***	
2. Motivation		-.02	.46***	.00

Note. Model 1 included condition group, *g*, pre-manipulation self-efficacy, and SF session 1. Model 2 included condition group, *g*, pre-manipulation self-efficacy, SF session 1, and Motivation. SE = self-efficacy. Skill before manipulation = Space Fortress session 1. Skill acquisition = Space Fortress session 8. β1 = regression weights in Model 1. β2 = regression weights in Model 2. **p* < .05; ***p* < .01; ****p* < .001.

Table 7

Regression Analyses Testing Enjoyment as a Mediator

Model	β1	β2	R^2	ΔR^2
Skill acquisition				
1. Condition group	.29***	.29***		
g	.26***	.25***		
Pre-manipulation SE	.06	.04		
Skill before manipulation	.50***	.50***	.46***	
2. Enjoyment	---	.06	.46***	.00

Note. Model 1 included condition group, *g*, pre-manipulation self-efficacy, and SF session 1. Model 2 included condition group, *g*, pre-manipulation self-efficacy, SF session 1, and enjoyment. SE = self-efficacy. Skill before manipulation = Space Fortress session 1. β1 = regression weights in Model 1. β2 = regression weights in Model 2. ***$p < .001$.

Appendix A

Self-Efficacy Scale Items
1. I feel confident in my ability to perform well on Space Fortress.
2. I can meet the challenges of Space Fortress.
3. I know I can achieve good scores at Space Fortress.
4. I know that I can master Space Fortress.
5. I do not think Space Fortress is something that I will become good at.
6. I am confident that I have what it takes to perform Space Fortress well.
7. I know that I am capable of improving at Space Fortress.
8. I am confident that Space Fortress will seem less challenging to me when I have completed this study.
9. I am certain that I could cope with Space Fortress if it became more complex.
10. I know I could handle Space Fortress if it became more difficult.
11. I know I could succeed at Space Fortress if aspects of the game were altered.
12. If Space Fortress got any harder, I think it would be impossible for me to get a good score.

Appendix B

Trainee Reactions Measure – Video Conditions

Enjoyment Items

1. The video was enjoyable to watch.
2. The video was interesting.
3. The video was boring.

Utility Items

1. I learned new things from the video that will help me increase my Space Fortress scores.
2. The video presented things about Space Fortress that I had not seen or thought of before.
3. Watching the video was not helpful.

Motivation Items

1. Watching the video has increased my motivation to learn Space Fortress.
2. I am eager to start playing Space Fortress again.
3. The video was discouraging.

Understandability Items

1. The material in the video could have been explained better.
2. The information in the video was confusing.
3. The information in the video was presented in a clear manner.
4. The information presented in the video was easy to understand.

Strategy Change Items

1. After having watched the video, I now have a new perspective about playing Space Fortress.
2. After having watched the video, I think differently about Space Fortress.
3. After having watched the video, I don't plan to do anything different.
4. After having watched the video, I plan to change my strategy for playing Space Fortress.

Appendix C

Trainee Reactions Measure – Practice Condition

Enjoyment Items

1. I enjoyed playing the last few practice games of Space Fortress.
2. I found the last few practice games of Space Fortress to be interesting.
3. The last few practice games of Space Fortress were boring.

Utility Items

1. I learned new things during the last few practice games that will help me increase my Space Fortress scores.
2. In the last few practice games, I learned things about Space Fortress that I had not seen or thought of before.
3. Playing the last few practice games of Space Fortress was not helpful.

Motivation Items

1. Playing the last few practice games has increased my motivation to learn Space Fortress.
2. I am eager to start playing Space Fortress again.
3. The last few practice games of Space Fortress were discouraging.

Strategy Change Items

1. After having played the last few practice games, I now have a new perspective about playing Space Fortress.
2. After having played the last few practice games, I think differently about Space Fortress.
3. After having played the last few practice games, I don't plan to do anything different.
4. After having played the last few practice games, I plan to change my strategy for playing Space Fortress.

Appendix D

Overview of Study Procedures

Mastery Model	Coping Model	Instructions	Practice
Informed consent 17-minute SF instructions video SF baseline session: 4 games 5-minute SF instruction review video Pre-manipulation self-efficacy scale SF session 1: 10 games			
15-minute modeling video showing high-level SF performance	15-minute modeling video showing progression from novice- to high-level SF performance	17-minute SF instructions video	SF practice: 4 games (approximately 15 minutes of hands-on practice)
Trainee reactions scale – Time 1 Post-manipulation self-efficacy scale – Time 1 Pathfinder – Time 1 Declarative knowledge test – Time 1 SF session 2: 2 games SF session 3: 10 games			
1-week break			
Raven's Advanced Progressive Matrices SF session 4: 2 games SF session 5: 10 games			
5-minute modeling review video showing high-level SF performance	5-minute modeling review video showing high-level SF performance	5-minute SF instructions review video	SF practice: 2 games (approximately 7 minutes of hands-on practice)
Trainee reactions scale – Time 2 Post-manipulation self-efficacy scale – Time 2 Pathfinder – Time 2 Declarative knowledge test – Time 2 SF session 6: 2 games SF session 7: 10 games SF session 8: 10 games Transfer task: 2 games			

Note: SF = Space Fortress. All 10-game sessions consist of 8 practice games followed by 2 test games. All games last 3 minutes.