

THE EFFECTS OF A BEHAVIORAL MOVEMENT-TRAINING PACKAGE
ON DANCE PERFORMANCE

by

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Abstract

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The present study examined the effects of a behavioral movement-training package on the performance of classical ballet movements by college students whose performance had not improved under conventional training. The procedures used in the behavioral movement-training package and conventional training were identical except for the following components used only in the behavioral movement-training package: (a) a lecture on a given movement; (b) the student experiencing a correct and an incorrect way of executing a movement; (c) the student labeling her own performance as correct or incorrect; (d) the student describing her own performance errors; and (e) the student receiving feedback not only on movement performance, but also on labeling and error description. Three movement categories were selected for the study: turns, jumps, and balancing. Two movements from each category were examined. One movement from each category was trained, and one served as a probe to measure generalization from training. Thus, there were 3 training movements and 3 probe movements for each participant. Throughout the study probe movements were tested only and never trained. Three female college dance students with 2 to 8 years of classical ballet training participated in the study. Each participant was exposed to two experimental conditions:

conventional training and the behavioral movement-training package. The behavioral movement-training procedure was introduced sequentially across classical ballet movements in a multiple-baseline experimental design. Behavioral movement training was taught to criterion following the baseline phase and prior the maintenance phase, both of which consisted of conventional training. The data indicate that during the baseline phase, the percentage of trials with correct classical ballet movements was below 50% on all 6 movements. For all participants, there was a systematic increase in the percentage of trials with correct classical ballet movements following the behavioral movement-training procedure. Furthermore, a similar increase in the percentage of trials with correct classical ballet movements was observed on non-trained probe trials, indicating generalization from training. The results are discussed in terms of the potential value of the behavioral movement-training package in dance, with implications for physical skill education, and movement rehabilitation.

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Introduction

Errors in motor-skill performance may arise and persist for various reasons – lack of stimulus control, insufficient reinforcement for correct performance, and improper technique (Martin, 2003). During the past several decades a number of behavior analytic studies have experimentally examined the effectiveness of different behavioral coaching procedures for athletic skill development. Behavioral procedures have been particularly effective in decreasing persistent errors in athletic skill training arising from lack of stimulus control and insufficient reinforcement for correct performance (Anderson & Kirkpatrick, 2002; Brobst & Ward, 2002; Buzas & Ayllon, 1981; Heward, 1978; Komaki & Barnett, 1977; McKenzie & Rushall, 1974; Rushall & Pettinger, 1969; Ward & Carnes, 2002). The practice of inefficient body movements is often associated with injuries (Macchi & Crossman, 1996) and, therefore, it is important to have effective error-correction procedures to improve movement performance. Although behavioral procedures have been used to address some of the issues of improper movement technique (Fitterling & Ayllon, 1983; Kladopoulos & McComas, 2001; Koop and Martin, 1983; Shapiro & Shapiro, 1985), the study of movement and movement control raises some conceptual and methodological issues for behavior analysts. In fact, the question of how to control movements has not been thoroughly studied by psychologists in general (Rosenbaum, 2005). A review of the literature examining behavioral analysis of movement is contained in Appendix A.

The study of movement in behavioral terms may require a shift in the kinds of dependent variables we study. The experimental analysis of movement requires a shift of focus from the occurrence of the operant to the manner in which it is performed,

observed, and recorded. A study by Jenkins and Moore (1973) illustrates the importance of measuring different response topographies. The authors examined the photographs of a pigeon's key pecks and identified two different topographies in beak and eyelid positioning with two different reinforcers (grain and water). When the reinforcer was grain, a pigeon's beak was opened wide and its eyelids were almost closed. In contrast, when the reinforcer was water, a pigeon's beak was almost closed and its eyelids were opened. By observing not only whether a pigeon pecked the key but also observing how it was done, Jenkins and Moore were able to demonstrate that the topography of the conditioned response depended on the properties of the reinforcer. Despite the fact that numerous behavioral studies have been conducted on response topography (e.g., Breland & Breland, 1961; Holland, 1977; Skinner, 1948; Staddon & Simmelhag, 1971; Wasserman, 1973), there have been few behavior analysis studies that have provided models of a conceptual framework for studying movement (e.g., Guthrie, 1959; Mechner, 1992a; Mechner, 1992b; Mechner, Hyten, Field, & Madden, 1997; Stokes & Balsam, 1991).

Stokes and Balsam (1991) provide a behavioral approach to examining the shaping of new forms of motor responding. They studied shaping of the topography of the rat's bar press during early and late training. The study entailed analyzing motor behavior as discrete units, not as a continuous variable. The rat's behavior was categorized and topographically defined. All responses were videotaped and analyzed frame by frame. Regarding the location, timing, and form of movement, Stokes and Balsam suggest that "...the location and timing of a behavior may be changed through shaping along continuous dimensions (Galbicka, 1988), the form of the behavior itself

may be best understood as a discrete unit composed of a sequence of subunits” (1991, p. 229). By applying this experimental model, Stokes and Balsam demonstrated that the response-reinforcer contingency can affect the topography of specific subunits of the target response both early and late in training. If the response-reinforcer contingency does not specify a particular topography, the most probable response observed prior to conditioning would predominate. This finding directly applies to the study of physical skill development. For example, a dance student may be considered the best in her class at pirouettes despite a flaw in one of its components that might persist unnoticed. Experiencing success at pirouettes the student strengthens all the components of the skill; the flawed component is also strengthened. Thus, the more the dancer practices the skill the more she practices the error and the more difficult it might be later to correct the error.

Like Stokes and Balsam, Mechner (1992a) suggests that it is important to study not just operants, but also subunits of a movement sequence. Mechner uses the term “sub-operant” for these subunits and defines them as “... physically necessary antecedents of the final effect” (p. 11). Every operant has a number of “sub-operants,” each having specific dimensions. Some of these dimensions, which he refers to as “criterial” measures, are included in the definition of the operant, but others, “noncriterial” measures, are not. For example during shaping, the sequence of movements before the rat approaches the lever might not be a part of the reinforcement contingency, but rearing over the lever before pressing the bar might be. Instead of the frame-by-frame analysis of the recorded subunits of a response, Mechner proposes a different methodological approach. He introduces the term “revealed operant,” defined as an operant that has a

specified sequence in which at least two sub-operants are automatically recorded. In addition, the initial “sub-operant” must be emitted on a separate manipulandum from the other “sub-operants” to clearly indicate the start of the operant; the completion the operant typically should be a distinct behavioral event. Mechner suggests that by using the “revealed operant” as a research tool it is possible to investigate the effects of the independent variable on properties of an operant response that have not been systematically investigated by behavior analysts. Several pilot studies with human subjects performing key-pressing response have demonstrated the feasibility of Mechner’s experimental methodology in examining (a) the long-term changes in “noncriterial” measures with number of repetitions; (b) increased stereotypy following extinction in “noncriterial” and “criterial” measures; (c) effects of fixed-ratio schedules; and (d) sensitivity of different “sub-operants” as a function of their distance from the end of the revealed operant (Mechner et al., 1997). According to Mechner, this methodology could be used also in studying the effects of reinforcer presentation on different response dimensions of well-established operant behavior.

In terms of well-established operant behavior, Mechner (1992a, 1992b) explains shaping of motor responding in terms of a “parameter shift” mechanism of reinforcement. He presents three parameters of well-established operant behavior – force, speed, and “effort flow.” The force parameter is defined as muscle contraction. According to Mechner, a general rule for the force parameter is, “... the greater the force of the muscular contraction in a motor routine, the faster the resulting movement” (p. 12). The speed parameter is defined as “... the length of the time intervals between consecutive movements (such as depression of piano keys, dance steps, or words in a sentence) that

occur in a particular sequence” (p. 21). The “effort flow” parameter is defined as the number of movements per unit of time. For example, the “effort flow” is greater when 4 dance steps, as opposed to 2, are performed in 2 seconds. Thus, the speed parameter indicates the length of interval between the consecutive movements in a given sequence, whereas the “effort flow” parameter indicates the number of movements in a specific time unit. If the force parameter is kept constant, there is a direct relation observed between the “effort flow” and speed. For example, when the overall performance of a movement sequence is slow there are fewer movements per unit of time than when the overall performance of the same sequence is fast. These three parameters alter the performance of motor responding allowing for their adaptation to the environment, which constantly fluctuates. These three parameters constitute what Mechner calls the *dynamic properties* of movement. According to Mechner, a reinforcer may produce not merely the repetition of a past topographic variation, but “ a recent topographic shift” in one or several parameters of the operant. Because reinforcement may not affect all parameters equally, some of parameters may shift in an undesirable direction.

Another important characteristic of movement is that it can produce ecological (Bijou & Baer, 1961) or automatic reinforcers (Catania, 1998, Vaughan & Michael, 1982) not mediated by another person. Such reinforcers are the natural product of the movement itself. Kinesthetic stimuli or sensory feedback represent one type of the putative “ecological” or “automatic” reinforcers. These stimuli are produced by movements of the body and by gravity (Mechner, 1992b). Regarding well-established operants, Guthrie (1935) suggested that movement-produced kinesthetic stimuli are among the basic elements of skilled performance. According to Guthrie, skills themselves

represent “habits” consisting of small units, each of which is typically learned at full strength in a single trial. Although Guthrie (1959) argued that movement-produced stimuli and serial responses could be experimentally controlled, he did not provide the needed methodology.

For the behavior analyst movement-related sensory feedback is a phenomenon that may be difficult to measure and, therefore, may be rarely investigated. Nevertheless, if one considers that a complex gross-motor skill consists of series of movements and each movement might produce sensory feedback, then together they might be conceptualized as a behavioral chain. Skinner recognized this problem in stating that, “...events which are, for the moment at least, accessible only to the individual himself often occur as links in chains of otherwise public events and they must then be considered” (Skinner, 1953, p. 229). These chains may have a functional unity, that is, the entire chain may be affected by a single consequence.

There are several approaches proposed on how private events may be conceptualized within a behavior-analytic framework. First, Moore (1980) suggests that the covert form of the response may involve the same musculature as its overt form. For example, in straightening the knee one may feel the upper thigh tightening (a covert form of the response) and the observer may see the muscles tightening in the upper thigh (an overt form of the response). This suggests that, at least in movement, it is possible to observe the action of musculature and infer the private kinesthetic event. Of course, for the person who is experiencing this covert event it is not an inference. Second, in discrimination training, labeling private events may be established in situations in which the discriminative control of the labeling response is initially exerted by public stimuli,

but later the private stimuli, occurring at the same time as the public stimuli, also acquire discriminative control.

In summary, well-learned motor behavior may be analyzed in terms of (a) topography, (b) dynamic properties of movement, and (c) the discrimination of private kinesthetic events. Empirical studies investigating error-correction as a procedure for modifying well-learned athletic skills have addressed response topography (Anderson & Kirkpatrick, 2002; Buzas & Ayllon, 1981; Brobst & Ward, 2002; Kladopoulos & McComas, 2001; Shapiro & Shapiro, 1985; Ward & Carnes, 2002), and response topography and discrimination between correct and incorrect movement (Allison & Ayllon, 1980; Fitterling & Ayllon, 1983; Koop and Martin, 1983). Nevertheless, the dynamic properties of movement have not been fully investigated. Because movement-produced kinesthetic stimuli are among the basic elements of skilled performance (Guthrie, 1935), the procedures of the studies addressing both topography and the discrimination of private kinesthetic events will be examined next.

Allison and Ayllon examined the functional relation between behavioral coaching combined with a “freeze” technique and skill development in football, gymnastics, and tennis. The procedure for behavioral coaching consisted of five steps: (a) the execution of the skill by the athlete; (b) the judgment of the correct execution of the skill by the coach; (c) the description of the incorrect execution of the skill by the coach; (d) modeling of the correct execution of the skill by the coach; and (e) the imitation of the correct execution of the skill by the athlete. During the first step of the procedure, the coach instructed the athlete on the specific skill and the consequences for correctly or incorrectly executed skills. The athlete then was asked to execute the skill. During the

second step, the coach judged whether the skill was executed in the correct or incorrect way. The correct execution of the skill was praised. When the coach judged the execution of the skill being incorrect the coach shouted, “freeze,” and the athlete had to stop immediately in the position that he or she was at that moment. The third step of the procedure consisted of the coach commenting on the athlete’s errors while he or she remained in the frozen position. For example, “It’s no wonder you’re not getting any power behind that block. Your feet are so close together you don’t have a stable base from which to spring” (p. 300). During the fourth step of the procedure, the athlete remained in the frozen position while the coach modeled and described the correct position and commented how his position differed from that of the athlete’s. During the fifth step of the procedure, the coach asked the athlete to assume the correct position and then directed the athlete’s attention to its topography. For example in football, the coach could comment on the proper blocking positions, “Try to feel the patterns in your muscles. Notice how you have a stable base, your weight is forward, your knees are bent for driving, and your elbows are parallel to the ground. Now that’s a good position that will help you to keep your opponent from throwing your block” (p. 300). Compared to the standard coaching procedures, this five-step behavior coaching procedure was effective in quickly increasing the correct execution of athletic skills in football, gymnastics, and tennis. Fitterling and Ayllon (1983) reported similar findings of rapid skill increase with classical ballet skills using a similar procedure combined with a “freeze” technique.

Koop and Martin (1983) observed several methodological and procedural limitations in the Allison and Ayllon study. First, the response definitions consisted of

many behavioral components and their evaluation during a brief trial might have been problematic for the coaches. For example, in the football skill there were 8 behavioral components and in one of the tennis skills there were 11 behavioral components. Second, it appears that there were no observational data taken on the standard coaching procedure making the comparison problematic. Third, once the standard coaching procedure was reestablished many athletes performed the trained skills poorly. Fourth, because the data were collected only in the presence of the coach, it is possible that errors increased during experimental phases when the athlete continued to practice the skills and perhaps practice errors while the coach worked with other athletes. Fifth, in many athletic skills it may be nearly impossible to “freeze” at the moment when the error occurs. Finally, according to anecdotal reports provided by Allison and Ayllon, for some athletes the procedure was aversive. Considering these limitations, Koop and Martin developed their error-correction procedure.

In their study, Koop and Martin examined the functional relation between the behavioral coaching and the decrease in errors in swimming strokes. The identification of the target behavior proceeded in three parts. First, preliminary lists of possible errors for each swimming stroke (freestyle, backstroke, and breaststroke) were compiled. Second, the lists were given to coaches to independently rank-order the errors according to their relative importance. Finally, the errors on which the coaches strongly disagreed or considered not important were deleted from the lists. The final target behavior list was compiled for each swimmer providing a description for each error and identifying the rank-order of the error. Standard coaching was the baseline procedure that was compared with the behavioral coaching procedure. The standard coaching procedure consisted of

(a) positive feedback for desirable behavior – general and specific; (b) negative feedback for undesirable behavior – general and specific; and (c) any other type of general instruction. The behavioral coaching procedure consisted of two phases: training and maintenance. The training phase was conducted in a small training pool, whereas the maintenance phase was conducted in a large practice pool.

The training phase procedure consisted of (a) preliminary description of a correctly performed steps of a behavioral chain; (b) out-of-pool intervention for incorrect steps of a behavioral chain; (c) in-pool practice of correct steps of a behavioral chain; (c) in-pool consequences of incorrect performance; and (d) in-pool consequences of correct performance. During the training phase, a large checklist describing and illustrating the correct behavior was placed near the training pool. During training sessions, before a swimmer entered the pool, the trainer referred to this checklist and identified the swimmer's recently emitted correct behavior and praised it. Next, the trainer identified the errors and provided instruction on how to perform the skill correctly, modeled the incorrect behavior and then the correct behavior accompanied with self-prompts. The swimmer then executed both the incorrect and correct behavior and was asked by the trainer whether he or she felt the difference. If the swimmer replied with "no," additional instruction and modeling were provided. If the swimmer replied with "yes," he or she practiced the correct behavior with self-prompts several times until the trainer approved the swimmer's performance. Following out-of-pool practice, the swimmer started the in-pool practice in which the swimmer was required to swim six consecutive laps. He or she was informed about the consequences of both correct and incorrect performance of the skill. During the six-lap swim, the trainer walked beside the swimmer. If an error

occurred, the trainer tapped the swimmer on the shoulder. The occurrence of three errors during one lap resulted in additional instructions from the trainer before resuming the next lap. The failure to complete six laps in 15 minutes resulted in the termination of the training session. Upon completion of each lap, the correct performance, two or fewer errors per lap, was positively commented by the trainer. Upon completion of six laps, verbal approval and feedback was provided regarding the swimmer's performance. Training was terminated once the percentage of errors was 20% or less over three consecutive sessions in the training pool.

The maintenance condition consisted of two phases. During the first maintenance phase, the trainer would provide the initial instruction at the start of the practice and provide descriptive feedback during practice. During the second maintenance phase, only the initial instruction at the start of practice was provided for three sessions. Compared to the standard coaching procedure, which showed little or no decrease in errors over time, the behavioral coaching procedure produced a decrease in errors on swimming strokes during the training phase, and there was stimulus generalization to regular practice. The authors mentioned two procedural limitations. The first was of an organizational issue – the need of an additional person to supervise the swimmers in the big pool while the coach conducts the training sessions in the small pool. The second issue pertained to the need to educate and train the coach in the behavioral coaching. During the maintenance phase, the experimenter had to remind the coach to administer the programmed feedback prompts.

The two studies, Allison and Ayllon (1980) and Koop and Martin (1983), demonstrate the effectiveness of behavioral coaching. One of the issues not explored by

these two studies concerns such movement properties as force and speed. In the Allison and Ayllon study, the athletes were asked to “freeze” when the coach observed an error. It is possible that the athlete was not able to stop at that instance and the “freeze” position was not the consequence of an incorrect move, but that of a sudden stop. The authors themselves reported one of the gymnastics coaches saying that the freezing strained the muscles. For example in working on front handsprings the coach said, “I’m going to try to see what you’re doing wrong so I can help you to learn front handsprings better. If you land off balance and fall, freeze like that” (p. 304). Similarly, in the Koop and Martin (1983) study, the athletes practiced swimming strokes out of the swimming pool. It could be argued that water affects several parameters of movement (e.g., water provides resistance, thus changing the parameter of force). The other issue that was not addressed by the two studies was the athlete’s response in a discrimination procedure of contrasting the correct and incorrect patterns of muscle work. In the Allison and Ayllon study the coach described the incorrect and correct movement patterns. It appears that the athlete’s verbal report of the private kinesthetic event was not measured. In the Koop and Martin (1983) study the athletes were required to role play both incorrect and correct response, and then they were asked whether they could feel the difference between the two. Because the consequence for the negative reply was additional instruction and modeling, it is conceivable that some of the athletes gave the positive reply to avoid repeated instruction and modeling. The athletes in both studies did not label the events. Perhaps the athletes learning to do both label and respond appropriately to instances and noninstances of a class could further improve the athletic skill performance.

Considering these two issues, the present study investigated an alternative error-correction procedure that addresses (a) the speed and force of movement and (b) the education of the physical skill performer in appropriate responding to the correct and incorrect movement, labeling one's own performance as correct or incorrect, and describing one's own performance errors. As mentioned earlier, there have been numerous empirical studies investigating error-correction procedures in sports (e.g., Allison & Ayllon, 1980; Koop & Martin, 1983; Shapiro & Shapiro, 1985). In contrast, we have been able to locate only one empirical study investigating error correction in classical ballet with 7- and 8-year-old participants (Fitterling & Ayllon, 1983). According to Kerr, Krasnow, and Mainwaring (1992), injury among university dance majors is pervasive. Of their 39 participants, 97% had some type of dance-related injury over a period of 8 months. While there could be many reasons for the high rate of injury among dance students, improper technique may be one of the contributors. In addition, several dance educators have pointed out some shortcomings in the approach to teaching classical ballet. One such shortcoming is lack of specificity in the instructions and procedures used (Messerer, 1967). Messerer notes that many classical ballet teachers provide conflicting rationales for the manner in which a given movement is performed. The training manuals provide a description of the specific topography, but they do not mention the dynamic properties of movement (Morris, 2003). Another notable shortcoming of many approaches to teaching is that the teacher leads the student without evoking sufficient responding by the student (Morris, 2003; Warburton, 2004). It appears that a behavioral approach using an error-correction procedure may provide a model for

dance educators. This model addresses not only topography, but also the speed and force of movement and educates the learner in the analysis of his or her own performance.

The present study examined the effects of a behavioral movement-training package on the performance of classical ballet movements by college dance majors whose performance on specific movements had not improved under conventional training. The behavioral movement-training procedure was provided for 3 training movements, and generalization from training on those 3 movements to 3 other non-trained probe movements was assessed. The generalization probe movements used in this study involved movements that were in some ways similar and in some ways opposite of the training movements. The probe movements differed in their topography in one or two elements from the training movements. These elements were positioning of the arms, positioning of the head, or the direction of a turn. A detailed description of these elements will be provided in the Method section. The probe movements were similar to the training movements in the force and speed requirements. Because in classical ballet training, movements such as *en dehors pirouette* and *1st arabesque* are introduced prior to *en dedans pirouette* and *2nd arabesque*, it was expected that such movements might have been practiced more. Thus, for all participants the 3 training movements were: *en dehors pirouette from 5th position*; *grand fouetté sauté in 1st arabesque*; and *piqué in 1st arabesque*. The 3 probe movements were: *en dedans pirouette from 5th position*; *grand fouetté with the arms in 3rd position*; and *piqué in 2nd arabesque*.

Method

Participants

At the start of the study, there were 4 participants (3 women and 1 man). They all were Nassau Community College students enrolled in Dance Technique courses. All participants were 21-years old. Anna was a second-year student and she had studied classical ballet for 2 years. Beth was also a second-year student, but she had studied classical ballet for 6 years. Carol was a first-year student who had studied classical ballet for 8 years. Don was a first-year student who had studied classical ballet for 11 years.

As judged by the experimenter, the students had difficulty with technique. Although conventional movement training is effective for most students, for some it may not produce improvement in performance. The experimenter had over 25 years of experience as both classical ballet instructor and choreographer. She is a professionally trained ballet artist educated in the Vaganova technique. She is a graduate of the Riga Ballet School in Latvia.

The techniques on which the students had difficulty (50% or fewer trials correct) were on three classical ballet movements (*en dehors pirouette from 5th position*, *grand fouetté sauté in 1st arabesque*, and *piqué in 1st arabesque*) and they were asked to participate in the study. All the experimental sessions were conducted outside the regular-class time. Three of the participants completed the study. One participant (Don) experienced only the baseline phase of the study. Because of time constraints he was not able to complete the study. Thus, the data on the 3 participants who completed the study are presented.

Materials

For ease in obtaining data from video taped sessions and for informative feedback to the participants, trial numbers were displayed. Five white panels (76 cm high and 51 cm wide) made of a foam board were used to indicate the number of each trial. One number (40 cm high) from 1 to 10 was written in black marker on each side of each panel.

Apparatus

A SONY® TRV62 video camera was used to capture visual images. A wireless system SAMSON® - VM1, connected to the video camera and consisting of a body-pack transmitter, a receiver, and a lavalier microphone was used in capturing and conducting high quality live sound.

Setting and General Procedure

The study was conducted at the Department of Theatre and Dance of Nassau Community College. All sessions were conducted in a dance studio (25 m by 30 m) with full-length mirrors covering one of the walls and with ballet barres and a piano. All sessions were videotaped using a SONY® TRV62A video camera. The behavior of the participants and the instructor was videotaped for later assessment.

The experimental sessions were held two days a week for 45 minutes each. They were conducted with each student individually. A session consisted of 3 to 6 sets of 10 training trials. In each set of 10 training trials, only one movement was trained. There were two types of movements: trained and probe, as described below. The training movements were: *en dehors pirouette from 5th position*, *grand fouetté sauté in 1st arabesque*, and *piqué in 1st arabesque*. Modeling, physical guidance, corrective feedback, a request to repeat the given movement, or praise was provided for these

movements during both conventional and behavioral movement training. In addition to the above components, the behavioral movement-training procedure contained a lecture on a given movement, a request to perform correct and incorrect forms of that movement, a request for the student to label her own performance as correct or incorrect, a request for the student to describe her own performance errors, and feedback on the student's responses. These procedures will be more fully described under experimenter responses. The probe movements were: *en dedans pirouette from 5th position*; *grand fouetté with the arms in 3rd position*; and *piqué in 2nd arabesque*. No feedback was provided for the probe movements.

Prior to the introduction of the behavioral movement-training package, the order of the movements to be practiced was determined at random. Typically, there were 6 sets of 10 training trials in each session in which each trained movement was presented at least once. Upon the introduction of the behavioral movement-training package, the movement presentation order was also determined at random, however, the trained movement was practiced for 2 consecutive sets. Typically, behavioral movement training required more time than conventional training and therefore, only 3 sessions were conducted.

At the beginning of each trial, a stack of 5 foam-board panels was placed against a stool behind the student. It served as a display indicating the number of the current trial. Each trial was initiated by the experimenter. The experimenter placing the panel with the number 1 written on it and asking the student to perform a given named movement indicated the start of the first trial. The experimenter turning the panel to the other side displaying the number 2 indicated the end of the first trial. The start of each successive

trial was indicated by the experimenter displaying the panel with the next number. The experimenter changing the just displayed side of the panel to the following number indicated the end of each trial.

Both training and probe trials were thus initiated by the experimenter who allowed 5 seconds for the student to perform the movement. Training trials were ended by experimenter feedback on movement performance. Probe trials were ended after movement performance or 5 seconds had passed.

Dependent Measures

Three movement categories were selected for the study: turns, jumps, and balancing. Two movements from each category were examined. One movement from each category was trained, and one served as a probe to measure generalization from training. In the figures and tables, the turns are indicated with a letter *A*, the jumps with a letter *B*, and balancing with a letter *C*. The training movements were indicated with the number 1 and the probe movements with the number 2. The six classical ballet movements under study were as follows: *A1 (en dehors pirouette from 5th position)*; *B1 (grand fouetté sauté in 1st arabesque)*; *C1 (piqué in 1st arabesque)*; *A2 (en dedans pirouette from 5th position)*; *B2 (grand fouetté with the arms in 3rd position)*; and *C2 (piqué in 2nd arabesque)*. Each movement was scored as correct or incorrect according to the definitions provided in Table 1. Additionally, during the behavioral movement-training procedure, when the experimenter requested the student to execute movements both correctly and incorrectly, the participant's response was scored as matching or not matching the instruction. For example, when the student was asked to perform the *en dehors pirouette from 5th position (A1)* the incorrect way, "Make a half pirouette," and

Table 1

Operational Definitions of Classical Ballet Movements

Code	Definition
A1	<i>En Dehors Pirouette from 5th Position</i>
C – correct	<p data-bbox="537 695 987 722">A full turn of the body on one foot.</p> <p data-bbox="537 768 1409 1682">The starting position is standing in <i>5th position</i> with the right foot in front, arms in a preparation position. The movement starts with both knees bending while heels remain on the floor; the right arm moves to <i>1st position</i> and the left arm moves to <i>2nd position</i>. The right arm opens to the side and then, simultaneously, as the right leg slides up touching the front of the left leg with the pointed toes and stopping at the base of the calf of the left leg, the left arm joins the right arm in first position, the knee of the left leg straightens and the left heel pushes off the floor producing a full turn on the ball of the foot to the right. At the end of the turn, the body returns to the starting position, both knees bend while heels remain on the floor with feet in <i>5th position</i> with the right foot in front and both arms open to <i>2nd position</i>. The ending position is kept for at least 1 s</p>
1 – incorrect	The same steps as in the correct, but a full turn is not accomplished;

the body does not return to the starting position or the dancer finishes the turn on *demi-pointes* or in *4th position*, instead of the *5th position*.

- 2 – incorrect The same steps as in the correct, but the turn goes further than a full turn; the body does not return to the starting position.
- 3 – incorrect The same steps as in the correct, but there is a hop or a step and traveling forward, backward, or sideways while ending the turn.
- 4 – incorrect The same steps as in the correct, but while ending the turn the supporting leg heel goes down on the floor before the working foot or the supporting leg knee is bent during the turn.

A2

En Dedans Pirouette from 5th Position

C – correct

A full turn of the body on one foot.

The starting position is standing in *5th position* with the left foot in front, arms in a *preparation position*. The movement starts with both knees bending while heels remain on the floor; the left arm moves to *1st position* and the right arm moves to *2nd position*. The left arm opens to the side and then, simultaneously, as the right leg slides up touching the front of the left leg with the pointed toes and

stopping at the base of the calf of the left leg, the left arm joins the right arm in first position, the knee of the left leg straightens and the left heel pushes off the floor producing a full turn on the ball of the foot to the left. At the end of the turn, the body returns to the starting position, both knees bend while heels remain on the floor with feet in *5th position* with the left foot in front and both arms open to *2nd position*. The ending position is kept for at least 1 s

- 1 – incorrect The same steps as in the correct, but a full turn is not accomplished; the body does not return to the starting position or the dancer finishes the turn on *demi-pointes* or in *4th position*, instead of the *5th position*.
- 2 – incorrect The same steps as in the correct, but the turn goes further than a full turn; the body does not return to the starting position.
- 3 – incorrect The same steps as in the correct, but there is a hop or a step and traveling forward, backward, or sideways while ending the turn.
- 4 – incorrect The same steps as in the correct, but while ending the turn the supporting leg heel goes down on the floor before the working foot or the supporting leg knee is bent during the turn.

B1

Grand Fouetté Sauté in 1st Arabesque

C – correct

A half-turn jump.

The starting position is standing on the left foot in 3rd *arabesque* with the right foot pointed in the back, the right arm reaching forward and the left arm extending out to the side. The movement starts with the body turning to the right, arms opening to the sides, and making a step with the right foot, followed with a small jump in which the left foot chases the right foot, followed by landing on the left foot, a step on the right foot while bringing the arms down, kicking of the left leg in front, jumping up so that the right foot would be off the ground and pointed, making a half-turn in the air turning away from the left leg while arms move up over the head, and landing on the right foot with the right knee bent, left leg extended in the back, right arm reaching forward, and the left arm extending out to the side. The balance is kept in the ending position for at least 3 s.

1 – incorrect

The same steps as in the correct, but the jump is not high enough for the right foot to be off the ground and pointed.

2 – incorrect

The same steps as in the correct, but the body continues to travel in the direction of the starting step and failing to land in the required

position or a hop is made or the foot of the supporting leg moves.

- 3 – incorrect The same steps as in the correct, but the body falls forward or sideways and a hop is made upon landing failing to maintain the required position.
- 4 – incorrect The same steps as in the correct, but the balance is maintained for less than 3 s.

B2

Grand Fouetté Sauté in 3rd Position

C – correct

A half-turn jump.

The starting position is standing on the left foot in *3rd arabesque* with the right foot pointed in the back, the right arm reaching forward and the left arm extending out to the side. The movement starts with the body turning to the right, arms opening to the sides, and making a step with the right foot, followed with a small jump in which the left foot chases the right foot, followed by landing on the left foot, a step on the right foot while bringing the arms down, kicking of the left leg in front, jumping up so that the right foot would be off the ground and pointed, making a half-turn in the air turning away from the left leg while arms move up over the head, and landing on the right foot with the right knee bent, left leg

extended in the back, and both arms in over the head in 3rd position.

The balance is kept in the ending position for at least 3 s.

- 1 – incorrect The same steps as in the correct, but the jump is not high enough for the right foot to be off the ground and pointed.
- 2 – incorrect The same steps as in the correct, but the body continues to travel in the direction of the starting step and failing to land in the required position or a hop is made or the foot of the supporting leg moves.
- 3 – incorrect The same steps as in the correct, but the body falls forward or sideways and a hop is made upon landing failing to maintain the required position.
- 4 – incorrect The same steps as in the correct, but the balance is maintained for less than 3 s

C1

Piqué in 1st Arabesque

- C – correct A step on the ball of the foot into a position of the body supported on one leg and with other leg extended in the back.
- The starting position is standing on the left foot with the knee straight, right leg is lightly bent with the pointed foot touching the

floor in the back, and arms in a preparation position. The movement starts with the left knee bending while the right leg moves off the floor extending with pointed foot forward, arms move to first position. Then, a forward step is made on the ball of the right foot while raising the left leg approximately to the 90-degree level in the back with the foot being pointed. The right arm reaches forward while the left arm extends to the side. The head is kept straight. The balance is kept for at least 4 s before coming down on the left foot stepping forward and finishing in the starting position.

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|---------------|--|
| 1 – incorrect | The same steps as in the correct, but the body falls backward while stepping on the right foot. |
| 2 – incorrect | The same steps as in the correct, but the body falls forward while stepping on the right foot. |
| 3 – incorrect | The same steps as in the correct, but the body falls sideways while stepping on the right foot. |
| 4 – incorrect | The same steps as in the correct, but the balance is maintained for less than 4 s before stepping down on the left foot. |
| 5 – incorrect | The same steps as in the correct, but the supporting foot heel goes |

stepping on the right foot.

- 2 – incorrect The same steps as in the correct, but the body falls forward while stepping on the right foot.
- 3 – incorrect The same steps as in the correct, but the body falls sideways while stepping on the right foot.
- 4 – incorrect The same steps as in the correct, but the balance is maintained for less than 4 s before stepping down on the left foot.
- 5 – incorrect The same steps as in the correct, but the supporting foot heel goes down while balancing or the working leg knee bends while in the arabesque, or the working leg is not reaching the 90-degree level.
- 6 – incorrect The same steps as in the correct, but upon stepping down, a step backward is made instead of forward, or a hop is made.

she accomplished the outcome requested, the student response was scored as matching. The response was scored not matching if the student's behavior did not accomplish the outcome requested by the experimenter. For example, if the experimenter asked the student to perform the *en dehors pirouette from 5th position* (A1) the correct way and the student failed to perform it correctly, as defined in Table 1, the response was scored as not matching.

Verbal labeling of movements was scored as correct if the student appropriately labeled her own movement performance that met the defined criteria for either correct or incorrect performance (see Table 1). For example, if the student labeled her own movement as "incorrect" when it was indeed incorrect, the labeling response was scored as correct. When the student labeled her own movement performance as "correct" when it did not meet the defined criteria or if the student said, "I don't know," the verbal response was scored as incorrect.

Correct verbal description of performance errors was scored for the trial if the student identified at least one of the specific errors from the potential error list associated with the given type of error (see Table 2). Furthermore, when errors occurred the type of error was scored according the descriptions of potential errors provided in Table 2. If the errors described by the student did not correspond with the given type of error, the verbal response was scored as incorrect.

Data obtained from the videotapes included the following: (a) the percentage of training and probe trials with correct classical ballet movements; (b) the number of specific type of errors; (c) the percentage of training trials with the movements matching the experimenter's request for a correct or an incorrect movement; (d) the percentage of

Table 2

Potential Errors Associated with Three Classical Ballet Movements

Type of Error	Specific Errors
<i>Al</i>	
<i>En Dehors Pirouette from 5th Position</i>	
<p>I. A full turn is not accomplished; the body does not return to the starting position or the dancer finishes the turn on <i>demi-pointe</i> or in <i>4th position</i>, instead of the <i>5th position</i>.</p>	<ol style="list-style-type: none"> <li data-bbox="680 789 1357 898">1. Not enough force is exerted against the floor when bending the knees in a <i>demi-plié</i> just before the turn. <li data-bbox="680 1010 1386 1119">2. The heels do not stay on the floor during a <i>demi-plié</i> just before the movement. <li data-bbox="680 1230 1365 1339">3. The rising and pivoting backward on the ball of the foot is too slow. <li data-bbox="680 1451 1395 1629">4. Timing of the movement series – rising and pivoting backward on the ball of the foot and closing of the arms in <i>1st position</i> – is not synchronized. <li data-bbox="680 1740 1411 1845">5. The muscles in the upper back are not fully engaged at the end of the turn.

6. The knees are not bent and the heels are not down on the floor at the end of the turn.

II. The turn goes further than a full turn; the body does not return to the starting position.

1. The opening of the right arm creates too much force at the beginning of the turn.

2. The rising and pivoting backward on the ball of the foot is too fast.

3. The right hip moves with the knee at the start of a turn.

4. The arms open to the 2nd position too late.

III. There is a hop or a step and traveling forward, backward, or sideways while ending the turn.

1. The muscles are not fully engaged in the upper back during the turn or at the end of the turn.

2. The abdominal muscles are not fully engaged during the turn or at the end of the turn.

3. As the right foot moves down, the body tips to the left at the end of the turn.

4. As the right foot moves down, the body tips to the right at the end of the turn.

5. Arms are lower than the *1st position* during the turn.

6. Arms are higher than *1st position* during the turn.

7. The thigh muscles of the supporting leg are not fully engaged during the turn.

8. A *demi-plié* is not deep enough at the end of the turn.

9. Too much force is created at the beginning of the turn.

<p>IV. While ending the turn the supporting leg heel goes down on the floor before the working foot or the supporting leg knee is bent during the turn.</p>	<p>1. The thigh muscles of the left leg are not fully engaged at the end of the turn.</p> <p>2. The muscles of the left ankle are not fully engaged at the end of the turn.</p>
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*BI**Grand Fouetté in 1st Arabesque*

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| <p>I. The jump is not high enough for the right foot to be off the ground and pointed.</p> | <ol style="list-style-type: none"> 1. The <i>chassé</i> is too big and slow before the jump. 2. Timing of the movement sequence – the jump and movement of the arms to the 3rd <i>position</i> – is not synchronized. |
| <p>II. The body continues to travel in the direction of the starting step and failing to land in the required position or a hop is made or the foot of the supporting leg moves.</p> | <ol style="list-style-type: none"> 1. While kicking the leg forward the body travels in the direction of the kick. 2. The outward rotators are not fully engaged during the jump allowing the pelvis to move backward. 3. Upon landing, the <i>demi-plié</i> is not deep enough. 4. Upon landing, the muscles of the upper back are not fully engaged and the left leg is not lifted up in the back. 5. Abdominal muscles are not fully engaged during the jump or upon landing, or both. |

III. The body falls forward or sideways and a hop is made upon landing failing to maintain the required position.

1. Upon landing, the muscles of the upper back are not fully engaged.

2. Upon landing, the body tips to the right.

3. Upon landing, the body tips to the left.

4. Upon landing, the outward rotators are not fully engaged and the left leg moves to the left.

IV. The balance is maintained for less than 3 s.

1. Upon landing, the left leg is not lifted up in the back.

2. Upon landing, the muscles in the upper back are not fully engaged.

3. The *demi-plié* is not deep enough.

C1

Piqué in 1st Arabesque

I. The body falls backward while stepping on the right foot.

1. The left leg is lifted up too slowly.

2. Timing of the movement sequence – lifting of the leg

and shifting the weight over the right foot – is not synchronized.

3. While stepping forward over the right foot, the abdominal muscles are not fully engaged.

4. The step forward is too small.

II. The body falls forward while stepping on the right foot.

1. The left leg is lifted up too fast.

2. The muscles of the upper back are not fully engaged.

3. The step forward is too small.

III. The body falls sideways while stepping on the right foot.

1. The muscles of the right ankle are not fully engaged.

2. The outward rotators are not fully engaged allowing the pelvis to move to the left.

3. The abdominal muscles are not fully engaged.

IV. Balance is maintained

1. The thigh muscles of the right leg are not fully

for less than 4 s before stepping down on the left foot.

engaged.

2. The adjustment is not being made in the upper back muscles at the moment when the body starts tipping forward.

3. The adjustment is not being made in lifting the left leg up at the moment when the body starts tipping backward.

4. The abdominal muscles are not fully engaged.

V. The supporting foot heel moves down while balancing or the working leg knee bends while in the arabesque, or the working leg is not reaching the 90-degree level.

1. The thigh muscles of the right leg are not fully engaged.

2. The thigh muscles of the left leg are not fully engaged.

3. The weight of the body moves backward.

4. The muscles of the right ankle are not fully engaged.

5. The body is not aligned over the right leg, the muscles of the upper back are not fully engaged, and the left leg is not being lifted up.

- VI. Upon stepping down, a step backward is made instead of forward, or a hop is made upon.
1. The weight of the body is not pushed forward.
 2. The abdominal muscles are not fully engaged upon stepping down.

training trials with correct verbal labeling of movements; and (e) the percentage of training trials with correct verbal description of performance errors.

An event recording (occurrence or nonoccurrence) procedure was used. Behavior during a set of 10 trials was video recorded and then later analyzed. One data point represents 10 consecutive trials.

Experimenter Responses

Nine experimenter responses (a) instruction to perform a given named movement being trained; (b) a lecture on the techniques of performing the classical ballet movement; (c) a request for a specific movement outcome; (d) a request for the student to describe her own performance errors; (e) a praise statement; (f) modeling; (g) physical guidance, (h) corrective feedback; and (i) a request to repeat the given movement were recorded as being present or absent. The specific experimenter responses that were recorded are shown in Table 3. The same observers scored both student and experimenter responding from videotapes.

Experimental Procedures

Conventional training

The conventional training procedures were those typically used by ballet instructors. Students perform movement and the instructor then provides praise, corrective feedback, demonstration of correct and, occasionally, incorrect movement patterns, or physical guidance. During the conventional training procedure, the students were asked to perform the 6 classical ballet movements. For the 3 training movements (A1, B1, and C1), the experimenter provided praise for the correctly performed movements and feedback in a form of modeling, physical guidance, and verbal

Table 3
Scoring of Experimenter Responses

Experimenter Response	Description
Instruction to Perform a Given Named Movement	A response was scored as being present for the trial whenever the experimenter gave the instruction to participants to perform a given named movement (e.g., “Please get ready for the <i>en dehors pirouette</i> from 5 th position” or “Show me please the <i>grand fouetté sauté in 1st arabesque</i> ”).
A Lecture on Technique of Performing the Classical Ballet Movement Being Trained	A response was scored as present for the trial when it occurred. A lecture was comprised of the task analysis of a given classical ballet (see Table 4) and a description of specific consequences, muscle groups involved in correct and faulty movement patterns, and potential errors associated with a given movement (see Table 2). Appendix B contains the 3 lectures.
A Request for a Specific Movement Outcome	A response was scored for the trial whenever the experimenter asked the participant to perform the movement in a correct or an incorrect way.

A Request for Student to Describe Her Own Performance Errors	A response was scored as present when the experimenter asked the participant to identify the errors in the components of his or her movement.
A Praise Statement	A response was scored when the experimenter provided a positive comment on the participant's performance of a given movement, "This was a great pirouette!" or "Yes, this is a correct arabesque."
Modeling	A response was scored when the experimenter demonstrated either a correct or an incorrect way of performing the entire movement or one of its individual components.
Physical Guidance	A response was scored when the experimenter physically guided the participant's body part or parts through the proper motion. For example, in <i>CI (piqué in 1st arabesque)</i> , the experimenter held the participant's arm to provide a balanced position over the supporting leg while adjusting the position of the participant's upper back.
Corrective Feedback	A response was scored when the experimenter provided

either a negative comment and an explanation or a correction on the participant's performance of a given movement, "You did not engage the upper back this time and that is why you fell forward" or "No, this was not a correct performance of an *arabesque*; your step has to be bigger;" or both positive and negative comments on several features of participant's movement performance, "Now, you did hold your upper back well, but the step was too small."

A Request to Repeat the
Given Movement

A response was scored when the experimenter asked the participant to repeat the entire movement.

Table 4

Task Analysis of Three Classical Ballet Movements

Steps	Responses
<i>Al</i>	
<i>En Dehors Pirouette from 5th Position</i>	
1	Standing in <i>5th position</i> with the right foot in front, bend both knees and push both heels down into the floor; at the same time, the right arm moves to <i>1st position</i> and the left arm moves to <i>2nd position</i> .
2	The right arm opens to the side and then, simultaneously, rising and pivoting backward on the ball of the left foot, straightening the knee of the left leg, sliding the right foot with pointed toes up to the base of the left calf and closing both arms in <i>1st position</i> and making a 360-degree turn.
3	Finish the turn by moving the right foot down, bending both knees, returning the feet in that starting position and opening both arms in <i>2nd position</i> . Hold this position for at least 1 s.

*B1**Grand Fouetté in 1st Arabesque*

- 1 Standing in the 3rd arabesque, with the right foot pointed in the back, turn the body to the right while moving both arms to the sides, make a sliding step sideways with the right foot followed by a small and quick jump pulling both feet together and landing on the left foot.
- 2 Immediately, step on the right foot and kicking the left leg in front, moving both arms down and jumping up so high that the right foot could point in the air, at the same time moving both arms up over the head and making a half-turn in the air turning away from the left leg.
- 3 Finish the jump by landing on the right foot with the right knee bent, left leg extended in the back, right arm reaching forward and the left arm out to the side. Hold this position for at least 3 seconds.

*C1**Piqué in 1st Arabesque*

- 1 Standing the left leg with the knee straight and the right leg slightly bent

with the pointed toes touching the floor in the back, arms in down; bend the left knee while right leg moves off the floor extending with pointed foot in front while both arms move to *1st position*.

- 2 Make a step forward on the right ball of the foot while raising the left leg approximately at the 90-degree level in the back pointing the foot, the right arm reaches forward and the left reaches out to the side, the head is kept straight. The balance in this position is held for at least 4 seconds.

- 3 Step down on the left foot with the right foot pointed in the back and the right knee slightly bent.

corrections. For example, if the student performed the training movement incorrectly, the student was asked to repeat the movement while the experimenter physically adjusted the positioning of the arms and provided corrective feedback. This was followed by a new trial. For the probe movements (A2, B2, and C2), the experimenter did not provide any feedback.

Behavioral movement training

The behavioral movement-training procedure, like the conventional training procedure, consisted of modeling, physical guidance, and corrective feedback on movement performance. In addition to the above training components, the behavioral movement-training procedure also contained (a) a lecture on a given movement; (b) the student experiencing both a correct and an incorrect way of executing a movement; (c) the student labeling her own performance as correct or incorrect; and (d) the student describing her own performance errors; and (e) the student receiving feedback not only on movement performance, but also on labeling and error description.

During the behavioral movement-training procedure, only the training movements were presented. The training trials were comprised of pairs of trials: correct and incorrect movements. The initial trial of behavioral movement training was comprised of two parts – a brief lecture followed by practice sessions. First, the experimenter delivered a brief lecture that was comprised of the analysis of technique of a given movement by identifying the steps, and she described the natural consequences for each of the steps. The experimenter introduced the distinction between correct and faulty movement patterns and she identified muscle groups involved in each movement. The experimenter defined the correct and incorrect way of performing the given movement as defined in

Table 1. Next, the student was given a handout describing the potential errors associated with each movement (see Table 2). The lecture was concluded by a brief summary of the performance errors of the participant. The lecture was delivered only once on the first trial of the first set of 10 trials. The students then underwent behavioral movement-training trials, alternating trials of a correct movement first, followed by an incorrect movement. The incorrect-movement trials were based on the individual errors of each student. Behavioral movement training was taught to criterion: the student performing 8 out of 10 trials correctly or for the same number of sets of ten trials as in the baseline phase for a given movement, whichever came first, as follows. To allow the student to get accustomed to the new training procedure, the first set of 10 trials for each trained movement was excluded from the number of sets of 10 trials counted toward the criterion. For example, if the student had 17 sets of 10 training trials in the baseline phase, the movement discrimination condition for this student could not exceed 18 sets of 10 trials.

The correct-movement trials

The correct-movement trials started by the experimenter requesting the student to perform the movement correctly (e.g., “Show me please the *en dehors pirouette* from 5th position the correct way”). Upon a completion of the movement, the experimenter asked the student to label her own performance as being correct or incorrect (e.g., “Was this a correct or incorrect response?”). If the student performed the movement correctly and labeled her performance as such, the experimenter provided praise for both the movement (e.g., “Good, it was correct!”) and the correct labeling of the movement (“You are correct in your performance identification”). This was followed by an incorrect-movement trial.

If the student performed the movement incorrectly and labeled her performance as such, the experimenter provided praise for correct labeling (e.g., “Yes, you correctly identified your performance”) and the experimenter then asked the student to describe her performance errors. If the student correctly described her performance errors, the experimenter provided praise (e.g., “Yes, that is exactly the error that you made”). If the student incorrectly described her performance errors, the experimenter provided corrective feedback (e.g., “No, that is not what was wrong there. Your upper back muscles were not fully engaged and that is why you fell forward”). Next, the student was asked to repeat the movement and the experimenter provided feedback in a form of modeling, physical guidance, and corrective feedback. This practice was followed by an incorrect-movement trial.

If the student performed the movement incorrectly and labeled her performance as correct, the experimenter provided corrective feedback for both labeling of the performance (e.g., “No, it was incorrect”) and movement (e.g., “You bent your supporting leg knee before stepping into the 1st arabesque”). The student was asked to repeat the movement and the experimenter provided feedback in a form of modeling, physical guidance, and corrective feedback. This was followed by an incorrect-movement trial.

If the student performed the movement correctly and labeled her performance as incorrect, the experimenter provided corrective feedback on both labeling of the performance (e.g., “No, it was correct”) and movement (e.g., “All steps were correctly performed”). This was followed by an incorrect-movement trial.

The incorrect-movement trials

The incorrect-movement trials were based on the individual errors of each student and they started by the experimenter requesting the participant to perform the movement committing a specific error (e.g., “Make a pirouette the incorrect way by finishing it without bending the knees”). Upon a completion of the movement, the experimenter asked the student to label the performance as being correct or incorrect (e.g., “Was this a correct or incorrect response?”) and asked whether she committed the requested error. If the student performed the movement reaching the outcome requested by the experimenter and correctly labeled her performance as incorrect, the experimenter provided praise for correct labeling (“Yes, it was incorrect”) and the movement and the description of the error (e.g., “Good, you kept your knees straight! Yes, you did commit the error”). This was followed by a correct-movement trial.

If the student performed the movement correctly and labeled her performance as correct, the experimenter provided praise for correct labeling (e.g., “Yes, it was correct”) and provided corrective feedback for the performance (e.g., “I asked you to bend your knees instead of keeping them straight”). The student was asked to repeat the movement and the experimenter provided feedback in a form of modeling, physical guidance, and corrective feedback. This was followed by a correct-movement trial.

If the student performed the movement correctly and identified her performance as incorrect and said that she committed the specified error, the experimenter provided corrective feedback on labeling of the movement (e.g., “You performed the movement correctly”) and performance outcome and error specification (e.g., “You finished the pirouette with your knees bent; you did not commit the error that I requested”). The

student then was asked to perform the movement again and the experimenter provided feedback in a form of modeling, physical guidance, and corrective feedback. This was followed by a correct-movement trial.

If the student performed the movement reaching the outcome requested by the experimenter and incorrectly labeled her performance as correct, the experimenter provided praise for the performance (e.g., “Good, you kept your knees straight!”) and corrective feedback on labeling of the movement (e.g., “Your mistakenly identified your performance as correct”). The participant then was asked to perform the movement again and the experimenter provided feedback in a form of modeling, physical guidance, and corrective feedback. This was followed by a correct-movement trial.

Upon completing the experiment, each participant was asked to complete a questionnaire (see Appendix C) and to comment on the experience during the study.

Experimental Design

A within-subject multiple-baseline experimental design across classical ballet movements was used. There were 2 experimental conditions: conventional training and the behavioral movement-training package. Conventional training was presented during 2 phases: baseline and maintenance. The behavioral movement-training package was introduced sequentially across classical ballet movements between the baseline and maintenance phases. To partially control for order effects, each participant had a different treatment administration order. For Anna treatment was introduced first to turns (A), then to balancing (C), and finally to jumps (B). Thus, for Anna the treatment-administration order was ACB. For Beth the treatment order was BAC and for Carol it was BCA. The

actual sequence of conditions to which each of the participants was exposed is shown in Table 5.

Interobserver Agreement

Two observers viewed and scored the videotapes independently. One observer was the experimenter. The other observer was a graduate student who was not familiar with classical ballet training. The experimenter trained the second observer in the data collection by (a) having the second observer become acquainted with the movement definitions and specific classical ballet terminology (e. g., *1st position* of the arms, *5th position* of the feet, and *demi pointe*); and (b) teaching the second observer to use the definition tables (Tables 1 and 2) as a checklist for determining the correct and incorrect movement performance. Prior to scoring data, there were practice sessions conducted until interobserver agreement scores were 90% or better on each movement. On occasions, when there was a disagreement on responses, definitions were reviewed and the set was scored again, with a maximum of 5 scorings of any ten-trial set. Interobserver agreement was calculated by dividing the total number of agreements by the sum of agreements and disagreements and then multiplying by 100%.

Interobserver agreement observations were obtained for 31% of 672 sets of 10 trials for the 6 classical ballet movements and 3 participants. For all participants, overall agreement across experimental conditions and 6 classical ballet movements for the percentage of training and probe trials with correct classical ballet movements was 99%, for the number of specific type of errors 94%, for the percentage of training trials with the movements matching the experimenter's request for a correct or an incorrect movement 99%, for the percentage of training trials with correct verbal labeling of

Table 5

The Sequence of Treatment Conditions for the Three Participants

Participant	Sequence of Treatment Introduction		
	First	Second	Third
Carol	B	C	A
Beth	B	A	C
Anna	A	C	B

movements 99%, and for the percentage of trials with correct verbal description of performance errors 99% (see Appendix D).

Procedural reliability measures were obtained for 31% of 672 sets of 10 trials. The number of agreements was divided by the sum of agreements and disagreements and then multiplied by 100%. For all movements and participants, overall interobserver agreement on procedural reliability of the experimenter's responding was 100% for instruction to perform a given named movement, 100% for a lecture on the techniques of performing the classical ballet movement, 100% for a request for a specific movement outcome, 99% for a request for the participant to describe her own performance errors, 98% for a praise statement, 99% for modeling, 99% for physical guidance, and 99% for a request to repeat the given movement (see Appendix E).

Information on procedural validity of the experimenter feedback delivery across experimental conditions for all responses and participants is contained in Appendix F.

Results and Conclusions

Figures 1 through 3 show the percentage of trials with correct classical ballet movements during baseline and maintenance phases for Carol, Beth, and Anna. Baseline and maintenance consisted of the same procedure: conventional ballet training. For all participants, there was a systematic increase in the percentage of training trials with correct classical ballet movements following the behavioral movement-training procedure. Furthermore, there was a systematic increase in the probe trials.

Figure 1 represents the percentage of trials with correct classical ballet movements for sets of 10 trials for Carol across the baseline and maintenance phases. The percentage of trials with correct classical ballet movements is plotted on the ordinate

Figure Caption

Figure 1. Percentage of trials with correct classical ballet movements per set of ten trials for Carol. Horizontal lines with arrows represent sets of ten trials when training of movements B1 and C1 took place.

Carol

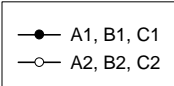
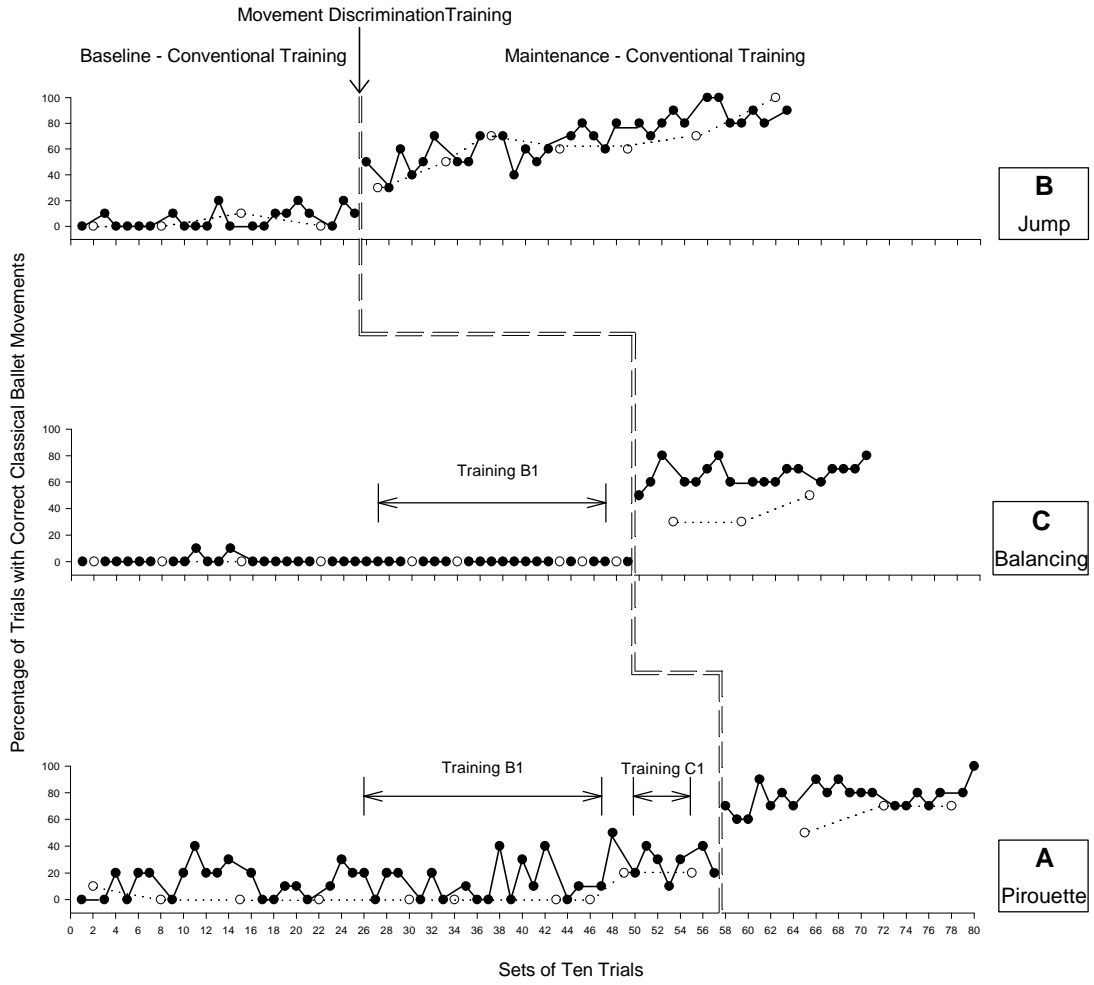


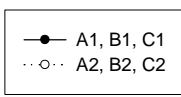
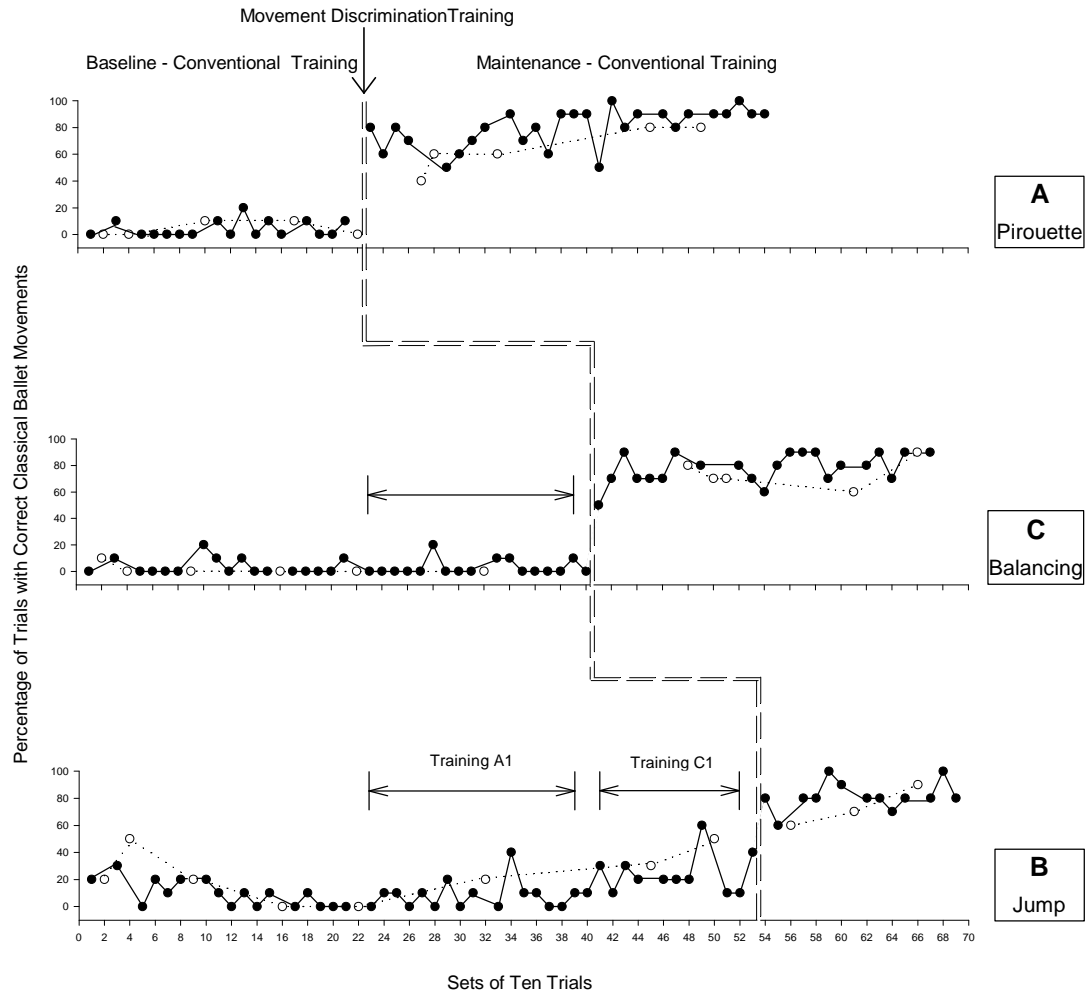
Figure Caption

Figure 2. Percentage of trials with correct classical ballet movements per set of ten trials for Beth. Horizontal lines with arrows represent sets of ten trials when training of movements B1 and A1 took place.

Figure Caption

Figure 3. Percentage of trials with correct classical ballet movements per set of ten trials for Anna. Horizontal lines with arrows represent sets of ten trials when training of movements A1 and C1 took place.

Anna



and sets of ten trials are plotted on the abscissa. The filled circles represent the training movements and the open circles represent the probe movements. For Carol the intervention was first introduced for the movement B1 (the jump), next for the movement C1 (balancing), and then for the movement A1 (the pirouette).

Following behavioral movement training (not shown in Figure 1), during the maintenance phase, there was a systematic increase over baseline in the percentage of training trials with correct classical ballet movements. For B1 (jumps-filled circles) there was a change from 10% during set 25 in baseline to 50% during set 26 in maintenance. During the subsequent 30 sets of maintenance there was a gradual increase from 50% to 100% correct responding during training trials. For C1 (balancing) there was an increase from 0% correct during set 49 of baseline to 50% during set 50 of maintenance. This was followed by a further increase to 80% correct over subsequent 17 sets. On the pirouette (A1) the data had a range of 0-to-40% correct during the first 42 sets of 10 trials and then showed a small increasing trend from 0-to-50% between sets 44 and 57. Following behavioral movement training, there was an increase from 20% during set 57 in baseline to 70% during set 58 in maintenance. Over the next 19 sets there was a gradual increase from 70% to 100% correct.

Because there was a systematic increase in the percentage of training trials with correct classical movements from baseline to maintenance phases following the introduction of the behavioral movement-training procedure, and not in control movements, one may conclude that it was this procedure that caused the increase in correct responding. Performance during training trials increased slightly for A1 between sets 44 and 57 of baseline, but there was a more pronounced increase following

behavioral movement training. This finding suggests that although conventional training might have contributed to the increase during baseline, its effectiveness was enhanced following the behavioral movement-training procedure.

In addition to the above findings, there was a systematic increase in the percentage of non-trained probe trials (open circles) across the 3 movement types following the introduction of the behavioral movement-training procedure for the training trials for Carol. This indicates that there was generalization from training during the training trials to the non-trained probe trials. As described in the Method section, the probe trials consisted of *en dedans pirouette from 5th position* (A2), *grand fouetté with the arms in 3rd position* (B2), and *piqué in 2nd arabesque* (C2). No feedback was provided for these movements.

Beth, as shown in Figure 2, experienced treatment on the ballet movements in a different order from that experienced by Carol and Anna. Nevertheless, for Beth there was also a systematic increase in the percentage of training trials correct following the introduction of the behavioral movement-training procedure. Therefore, one may conclude that the intervention procedure caused that increasingly correct performance. Beth's data also show a systematic increase in the percentage of correct probe movements with the introduction of the movement-discrimination training procedure on the training trials. Thus, correct performance on the training trials generalized to correct performance on the probe trials.

The data for Anna (Figure 3) showed similar patterns for the training and probe movements to those of Carol and Beth for the pirouettes (A) and balancing (C). For the jumps (B), performance during training trials increased slightly for B1 between sets 34

and 53 of baseline, but that increase was much more pronounced following behavioral movement training. Although there was a clear change from baseline to maintenance for the probe movements A2 and C2, the change might have been already taking place for B2 during baseline. The slope in baseline on sets 45 to 50 is similar to that in maintenance on sets 56 through 67.

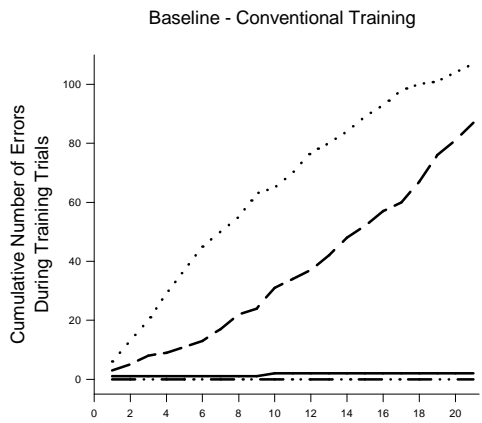
Figures 4 through 12 track the different error patterns exhibited by the students. They show the cumulative number of errors on the 6 classical ballet movements during the baseline (left-hand column) and maintenance (right-hand column) phases for Carol, Beth, and Anna. The cumulative number of errors is plotted on the ordinate and sets of ten trials are plotted on the abscissa. The types of errors are shown with different lines. As indicated in the Method section, the description of the potential errors for each of the 6 movements is provided in Table 2. The two left-hand graphs show the error patterns during the baseline – conventional training phase for the training movements (the top graph) and the probe movements (the bottom graph). The two right-hand graphs show the error patterns during the maintenance – conventional training phase for the training movements (the top graph) and the probe movements (the bottom graph). For all participants, the functions for each error pattern showed a reduction in the slope following the behavioral movement-training procedure during the maintenance phase when compared with the baseline phase.

Figure 4 represents the cumulative number of errors for all sets of 10 trials (as in Figure 1) on the training movement B1 and the probe movement B2 during the baseline and maintenance phases for Carol. During the baseline phase, for both B1 and B2 prior to behavioral movement training there was a differentiated error pattern observed. For B1

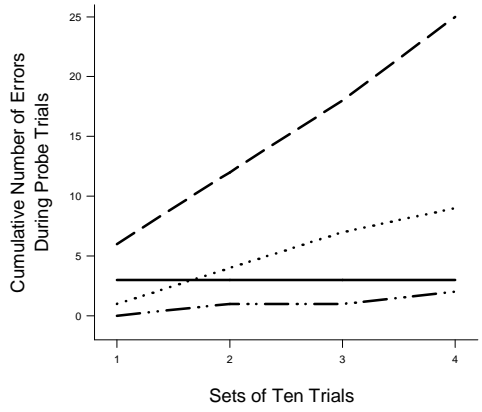
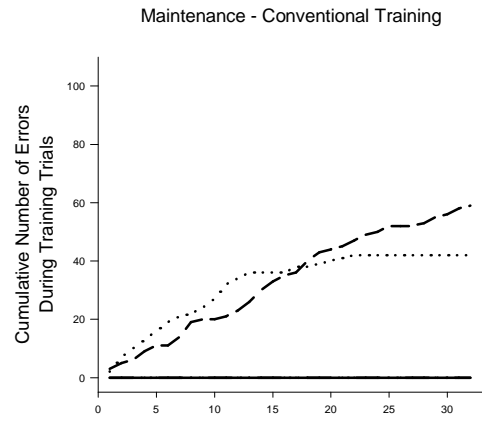
Figure Caption

Figure 4. Cumulative number of errors per set of ten trials on the training movement B1 and the probe movement B2 during baseline and maintenance phases for Carol.

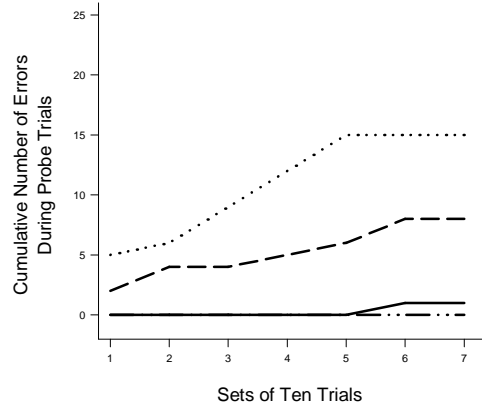
Carol



B1
Jump



B2
Jump

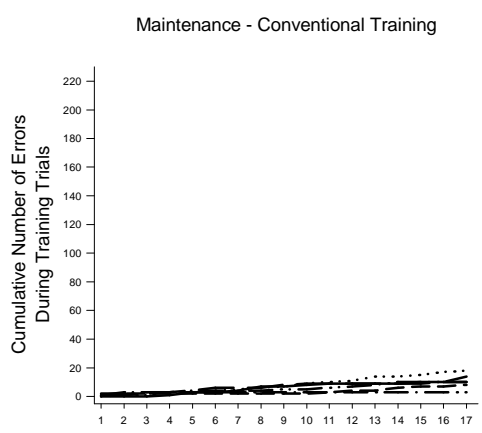
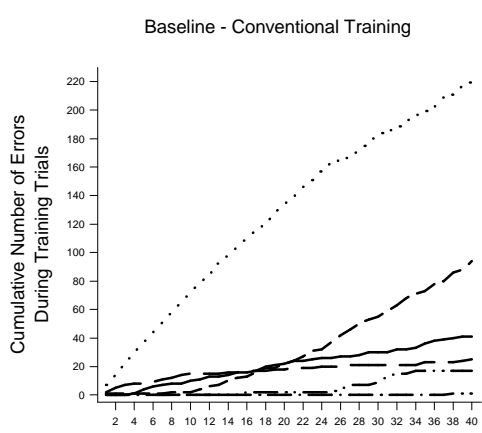


— Error 1 - Low jump
..... Error 2 - Traveling backward upon landing
- - - Error 3 - Body falling forward or sideways
- . - . Error 4 - Position held for less than 3s

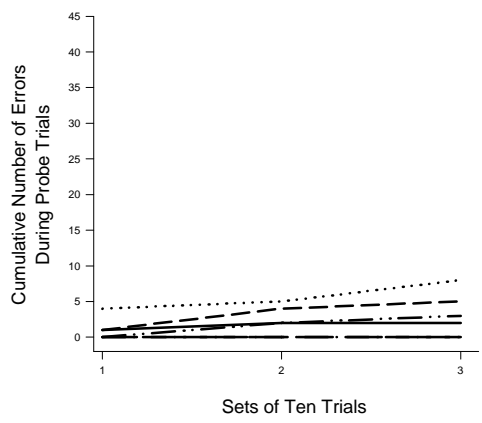
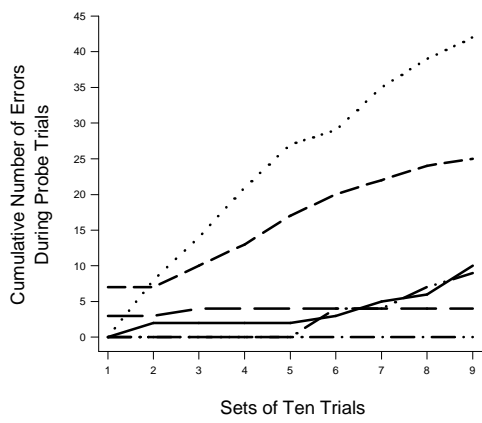
Figure Caption

Figure 5. Cumulative number of errors per set of ten trials on the training movement C1 and the probe movement C2 during baseline and maintenance phases for Carol.

Carol



C1
Balancing



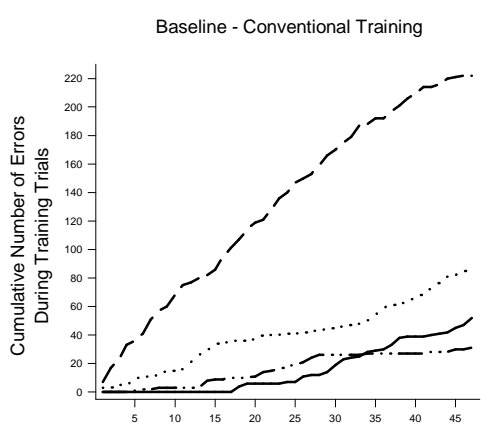
C2
Balancing

- Error 1 - Body falling backward
- Error 2 - Body falling forward
- - - Error 3 - Body falling sideways
- · - · Error 4 - Balancing for less than 4s
- - - · Error 5 - Heel going down/knee bending
- · - - Error 6 - Failure on stepping down

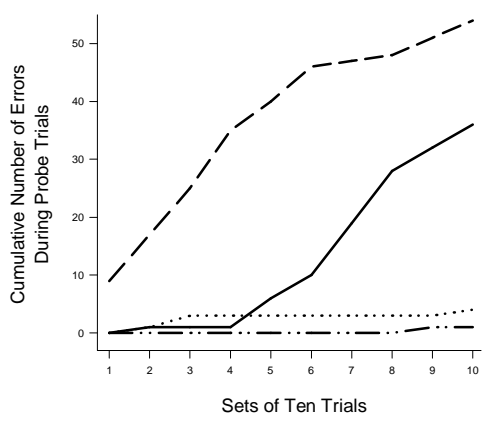
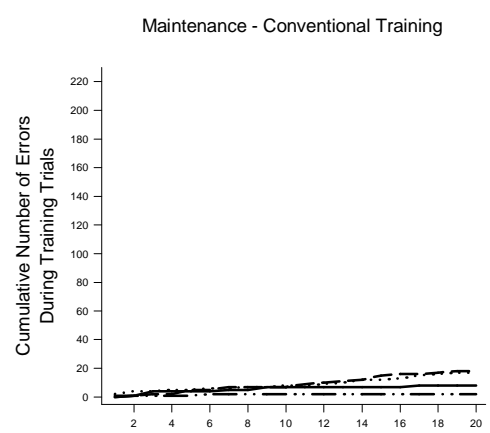
Figure Caption

Figure 6. Cumulative number of errors per set of ten trials on the training movement A1 and the probe movement A2 during baseline and maintenance phases for Carol.

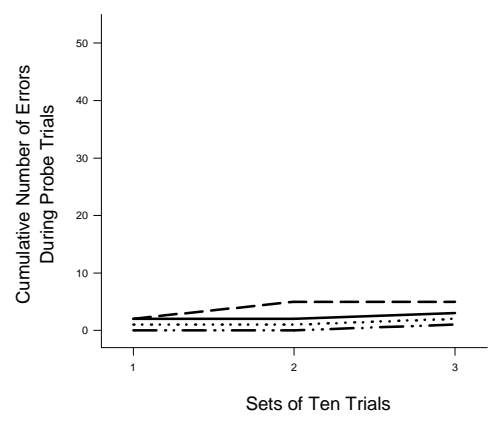
Carol



A1
Pirouette



A2
Pirouette



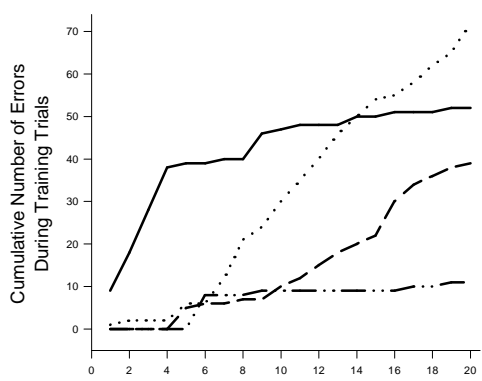
— Error 1 - Not a full turn
..... Error 2 - More than a full turn
- - - Error 3 - A hop or a step at the end of the turn
- · - · Error 4 - Heel going down/knee bending prior to ending the turn

Figure Caption

Figure 7. Cumulative number of errors per set of ten trials on the training movement B1 and the probe movement B2 during baseline and maintenance phases for Beth.

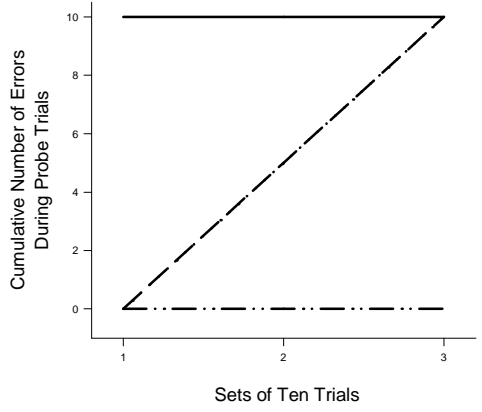
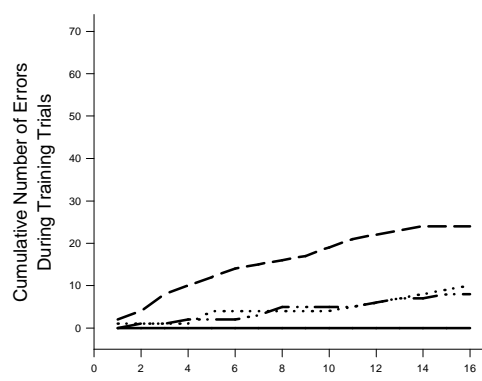
Beth

Baseline - Conventional Training

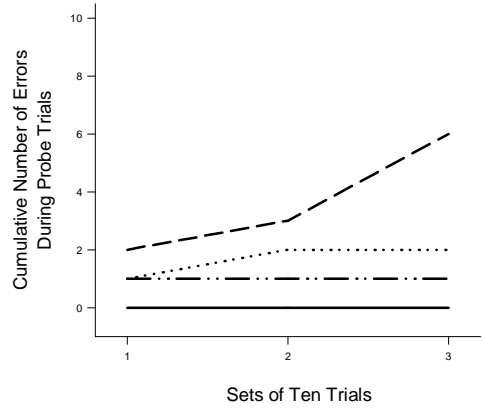


B1
Jump

Maintenance - Conventional Training



B2
Jump

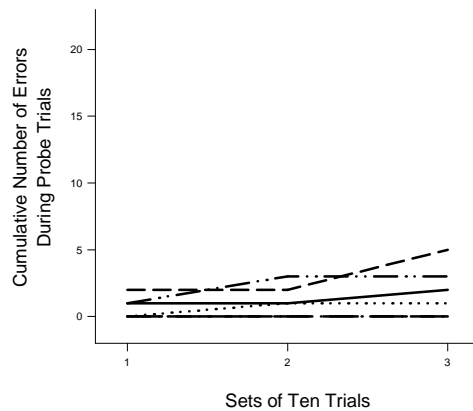
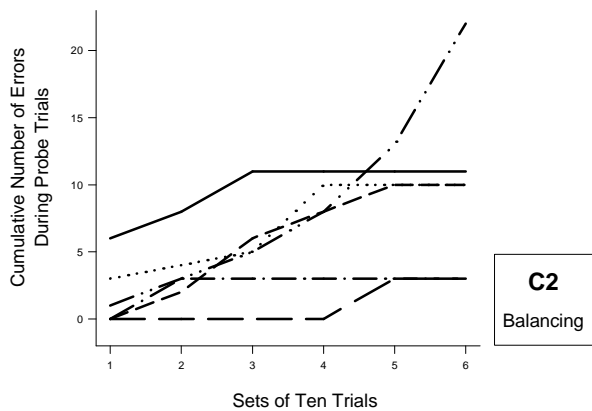
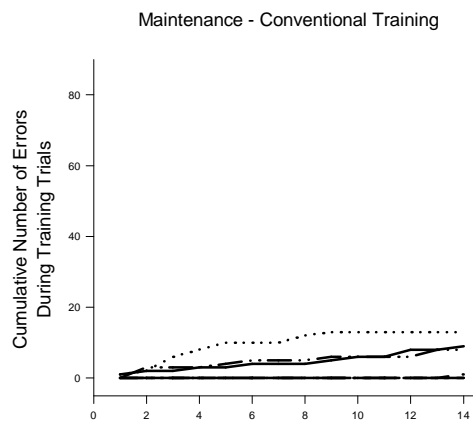
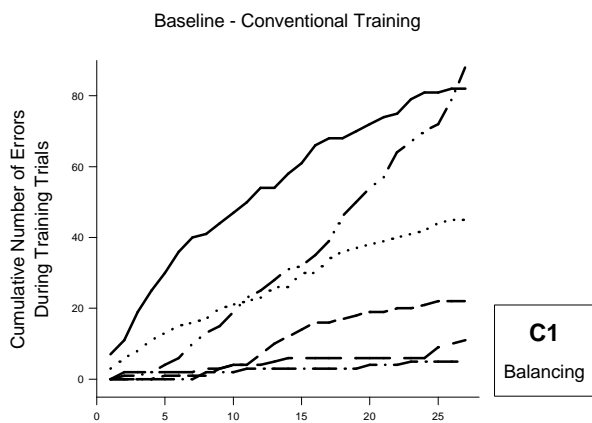


- Error 1 - Low jump
- Error 2 - Traveling backwards upon landing
- - - Error 3 - Body falling forward or sideways
- · - · Error 4 - Position held for less than 3s

Figure Caption

Figure 8. Cumulative number of errors per set of ten trials on the training movement C1 and the probe movement C2 during baseline and maintenance phases for Beth.

Beth

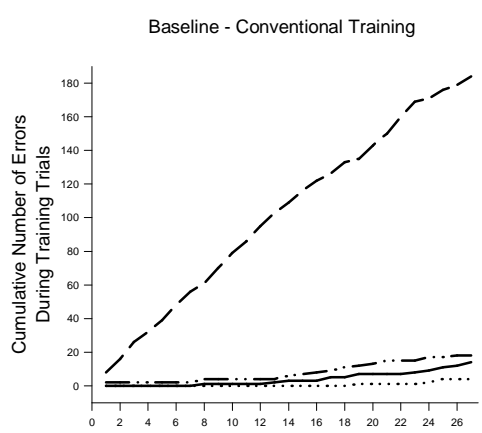


- Error 1 - Body falling backward
- Error 2 - Body falling forward
- - - Error 3 - Body falling sideways
- · - · Error 4 - Balancing for less than 4s
- - - · Error 5 - Heel going down/knee bending
- · - - Error 6 - Failure on stepping down

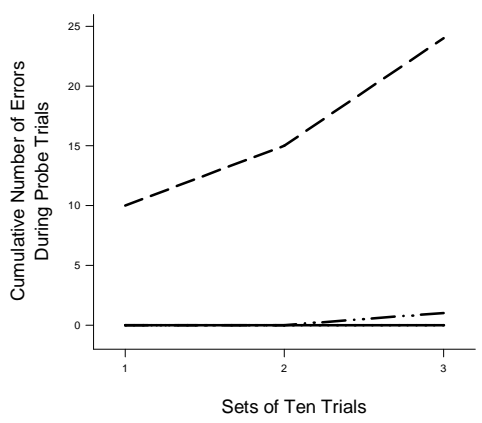
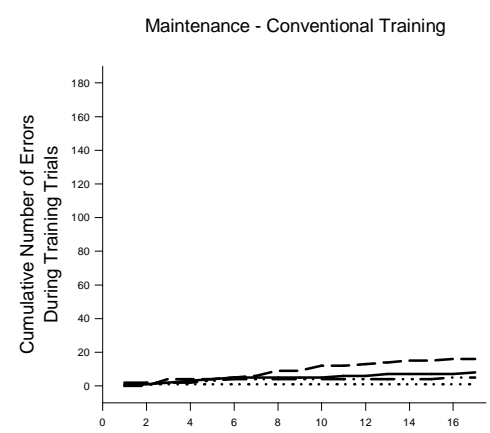
Figure Caption

Figure 9. Cumulative number of errors per set of ten trials on the training movement A1 and the probe movement A2 during baseline and maintenance phases for Beth.

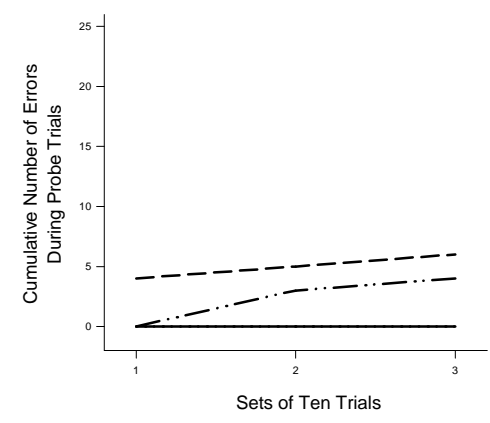
Beth



A1
Pirouette



A2
Pirouette

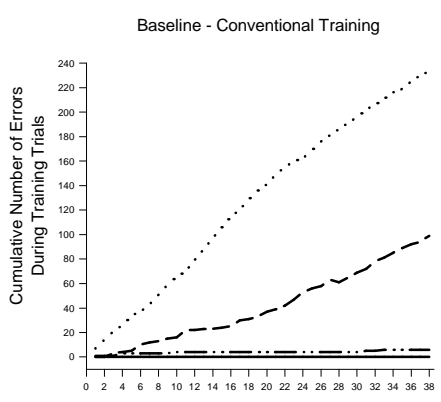


- Error 1 - Not a full turn
- Error 2 - More than a full turn
- - - Error 3 - A hop or a step at the end of the turn
- . - . Error 4 - Heel going down/knee bending prior to ending the turn

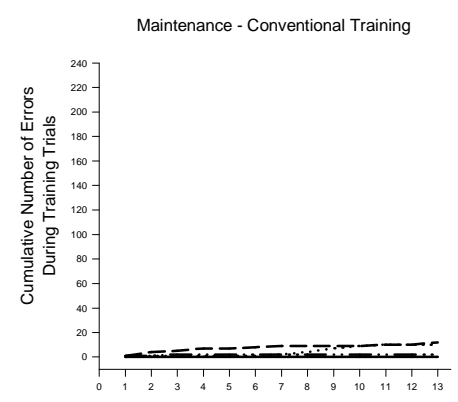
Figure Caption

Figure 10. Cumulative number of errors per set of ten trials on the training movement B1 and the probe movement B2 during baseline and maintenance phases for Anna.

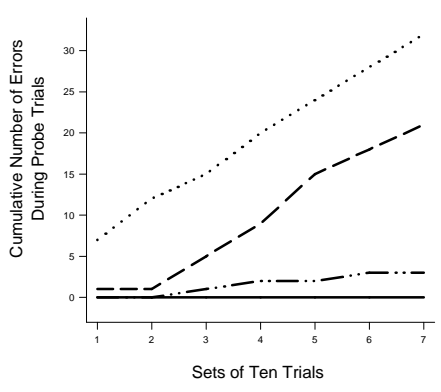
Anna



B1
Jump



Error 4 - Position held for less than 3s



B2
Jump

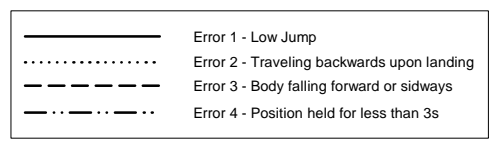
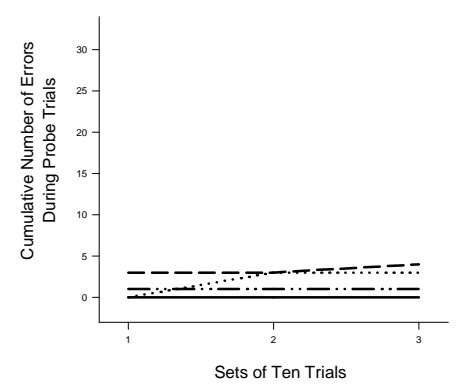
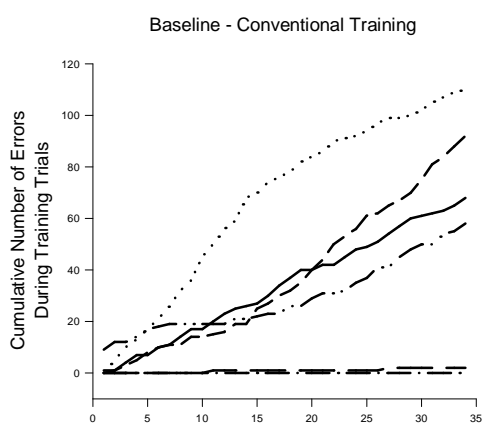


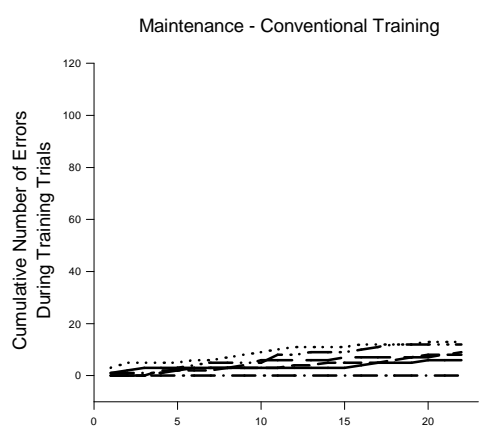
Figure Caption

Figure 11. Cumulative number of errors per set of ten trials on the training movement C1 and the probe movement C2 during baseline and maintenance phases for Anna.

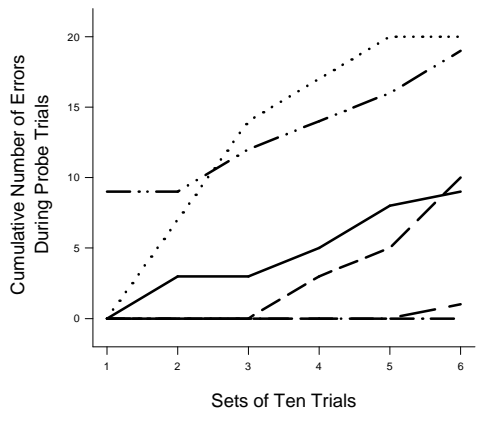
Anna



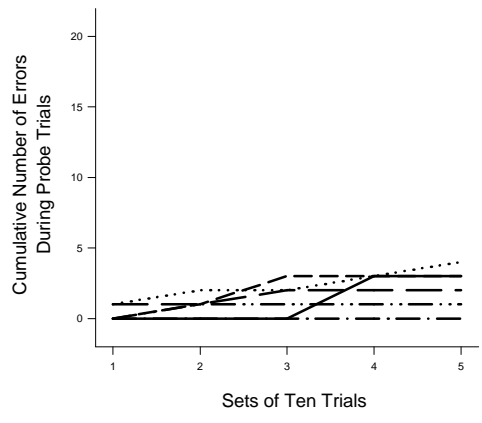
C1
Balancing



Error 6 - Failure on stepping down



C2
Balancing

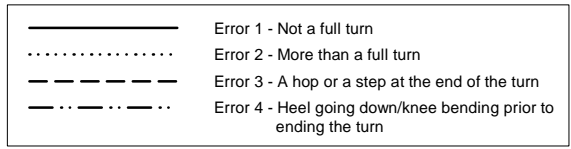
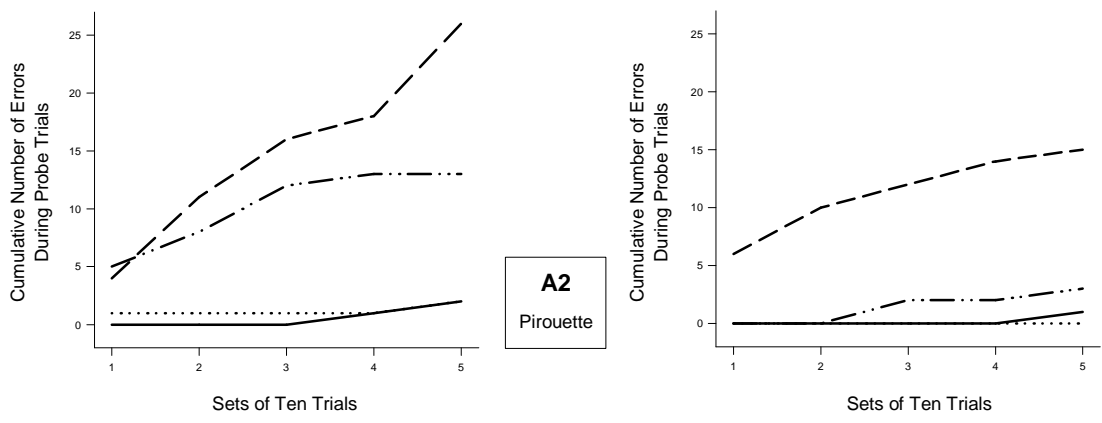
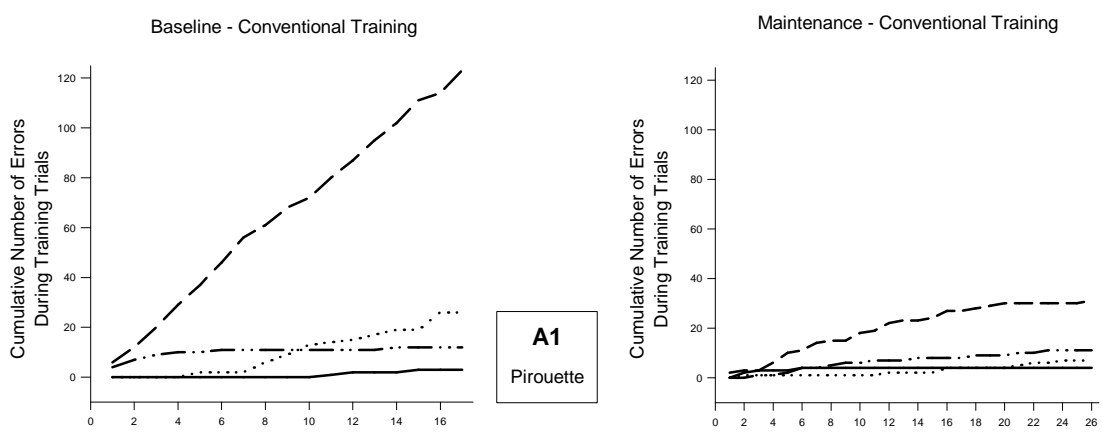


- Error 1 - Body falling backward
- Error 2 - Body falling forward
- - - Error 3 - Body falling sideways
- · - · - Error 4 - Balancing for less than 4s
- · - - Error 5 - Heel going down/knee bending
- · - · - Error 6 - Failure on stepping down

Figure Caption

Figure 12. Cumulative number of errors per set of ten trials on the training movement A1 and the probe movement A2 during baseline and maintenance phases for Anna.

Anna



error functions showed non-zero slopes for Error 2 (traveling backwards upon landing) and Error 3 (body falling forward or sideways). For B2 the slope was steeper for Error 3 (body falling forward or sideways). When compared to the baseline phase, the two errors were less differentiated and the slopes of these error functions were less steep for B1 following behavioral movement training. For the probe movement (B2), the slope of the error function was less steep than in baseline for Error 3, but Error 2 showed an increasing error function.

As with the jumps (B – Figure 4), the data on balancing (C – Figure 5) for Carol showed similar patterns. For the training movement (C1) during baseline Error 2 (body falling forward) showed an increasing error function. During maintenance, there was not only a decrease in the slope of the error function for Error 2; it was indistinguishable from the other types of errors. For the probe movement (C2) Error 2 (body falling forward) and Error 3 (body falling sideways) showed steady increasing error functions during baseline. During maintenance, the slopes of all error functions were nearly flat and undifferentiated.

The error patterns displayed by pirouettes (A) for Carol were similar to those of jumps (B) and balancing (A), as shown in Figure 6. For the training movement (A1) during the baseline phase, the steepest error function was observed in Error 3 (a hop or a step at the end of the turn). During maintenance, the slopes of all error functions were nearly flat and indistinguishable among the 4 types of errors. For the probe movement (A2), two types of errors showed increasing error functions – Error 3 (a hop or a step at the end of the turn) and Error 1 (a heel going down or a knee bending prior to ending the

turn). As with the training movement, the slopes of all error functions were nearly flat and indistinguishable among the 4 types of errors during maintenance.

For both Beth (Figures 7, 8, and 9) and Anna (Figures 10, 11, and 12) the data showed similar patterns to those of Carol – a differentiation and steady increasing error functions in specific types of errors during the baseline phase and, during the maintenance phase, the error functions were undifferentiated and their slopes were reduced. The types of errors observed in both Beth and Anna were the same as for Carol on the trained movements: for B1 Errors 2 and 3 and for A1 Error 3. On the non-trained probe movement (B2), for both Beth and Carol Error 2 and 3 were the most common.

Because the performance patterns, measured by the cumulative number of errors, showed a decrease in errors in the trained movements following the behavioral movement-training procedure, one may conclude that procedure caused this change. In addition, a similar decrease in errors was observed in non-trained probe movements. In contrast, none of the control movements showed a decrease in errors during the baseline phase. Thus, the behavioral movement-training procedure implemented during the training trials generalized to movement patterns on the probe movements.

Figures 13 through 15 show the percentage of correct verbal and nonverbal responses for pairs of ten-trial sets during the behavioral movement-training procedure on 3 movements (A1, B1, and C1) for Carol, Beth, and Anna, respectively. The percentage of correct responses is plotted on the ordinate and pairs of ten-trial sets are plotted on the abscissa. The filled circles represent movements matching the experimenter's request. The open triangle represents verbal labeling of movements. The filled square represents verbal description of performance errors. The graphs on the left hand-side show

Figure Caption

Figure 13. Percentage of correct verbal and nonverbal responses per pair of ten-trial set during the behavioral movement-training procedure on the jump (B1), balancing (C1), and the pirouette (A1) for Carol.

Carol

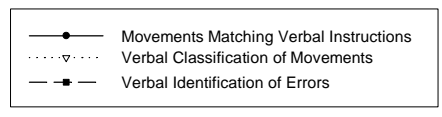
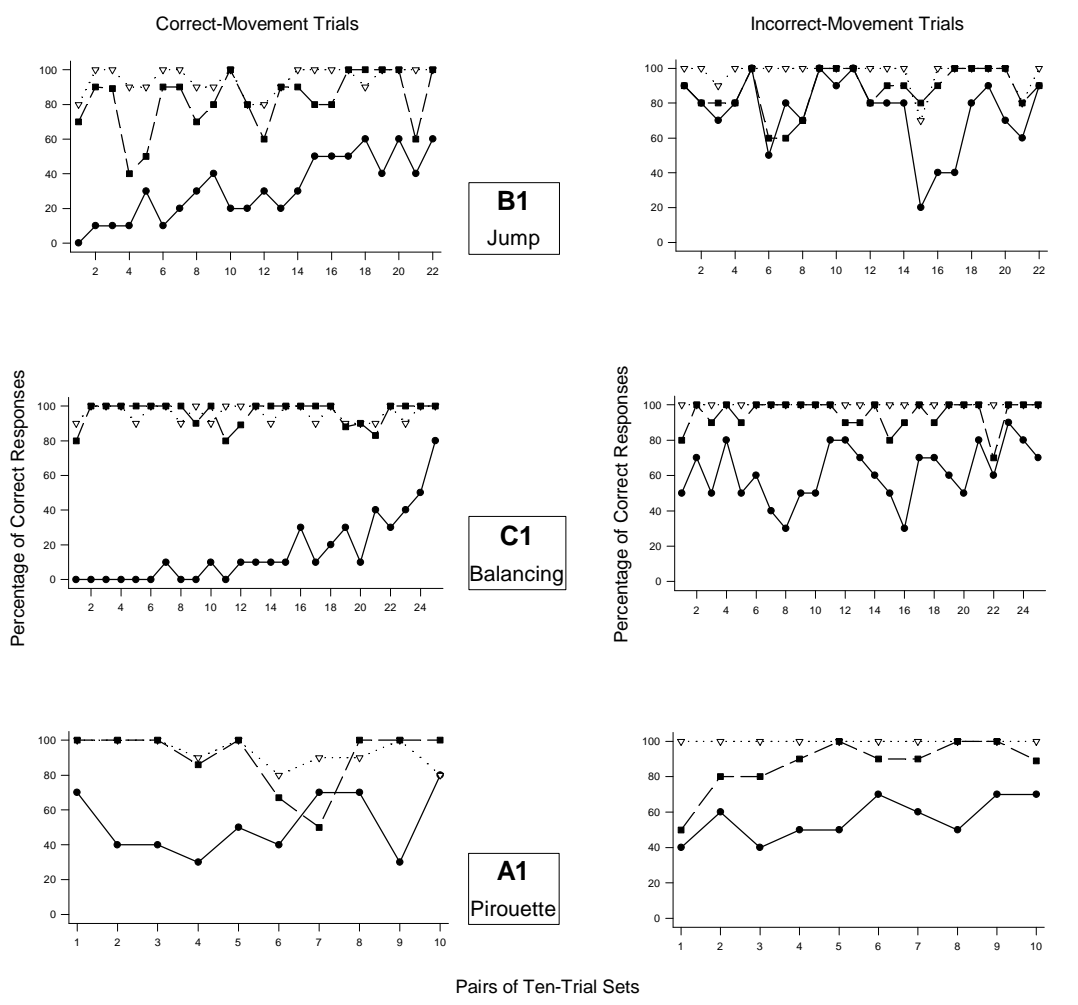


Figure Caption

Figure 14. Percentage of correct verbal and nonverbal responses per pair of ten-trial set during the behavioral movement-training procedure on the jump (B1), the pirouette (A1), and balancing (C1) for Beth.

Beth

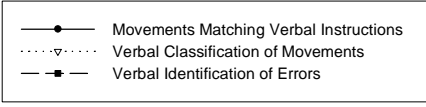
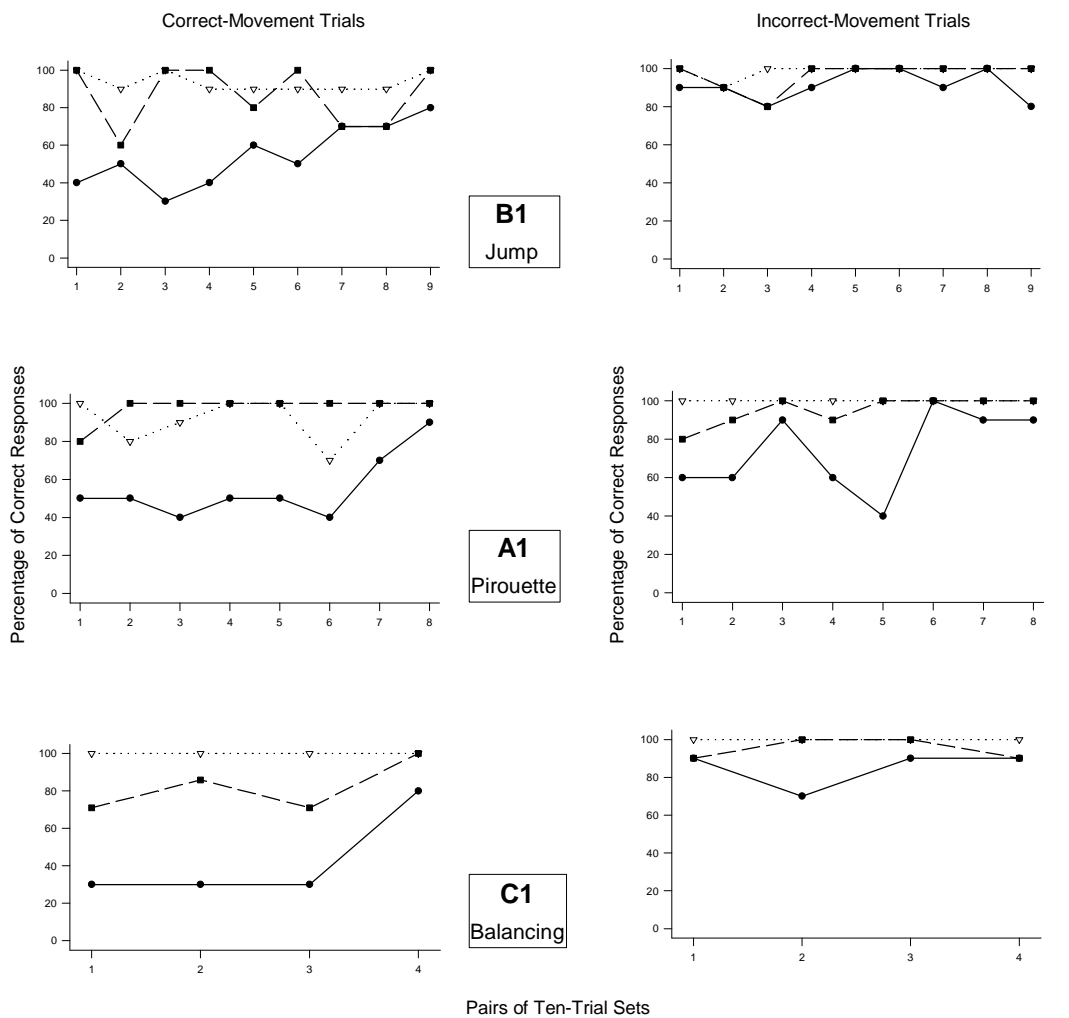
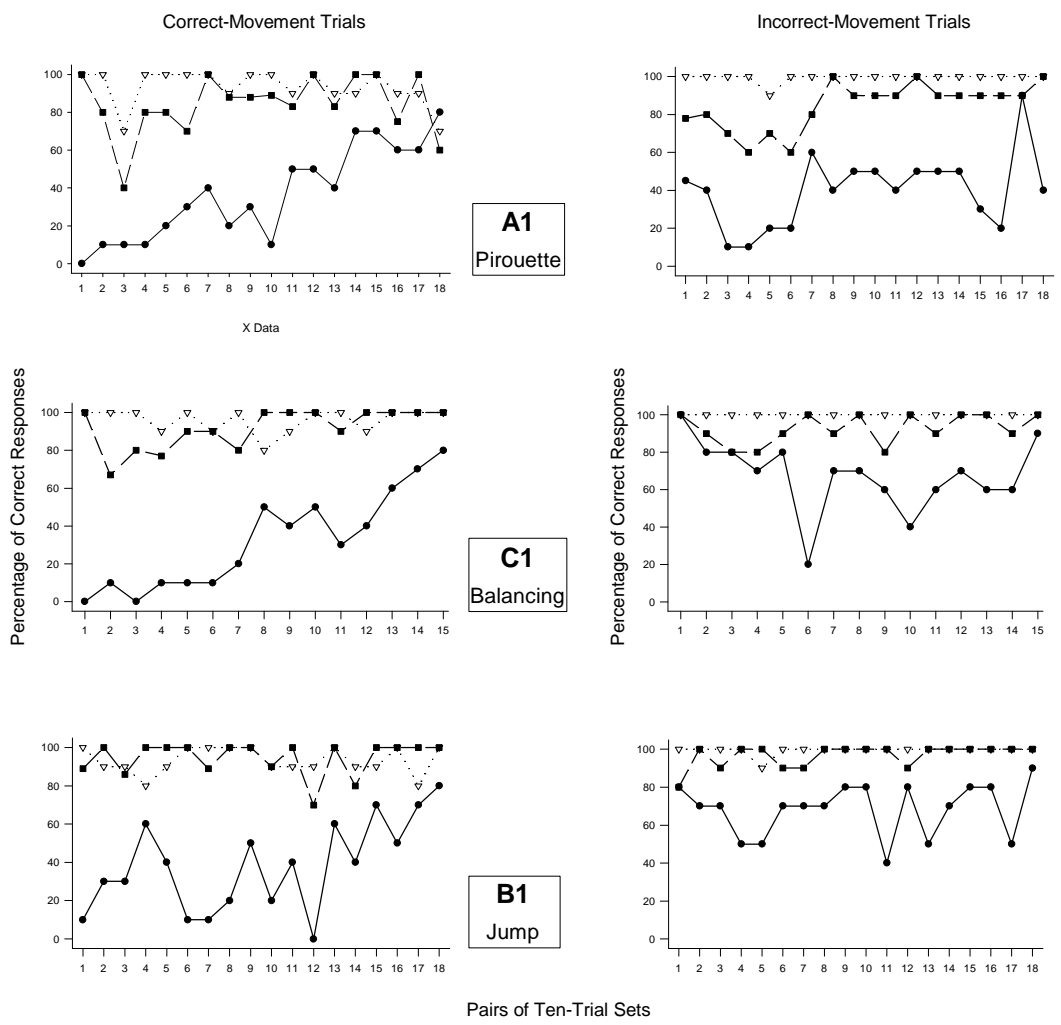


Figure Caption

Figure 15. Percentage of correct verbal and nonverbal responses per pair of ten-trial set during the behavioral movement-training procedure on the pirouette (A1), balancing (C1), and the jump (B1) for Anna.

Anna



Pairs of Ten-Trial Sets

responding during the correct-movement trials. The graphs on the right hand-side show responding during the incorrect-movement trials.

For all participants, a high level of correct responding was observed on the two verbal responses – labeling of movements and description of performance errors – during both correct- and incorrect-movement trials for the 3 movements. The movements matching the experimenter’s request for a correct movement showed an increasing trend and the movements matching the experimenter’s request for an incorrect movement showed a varied level of responding on the 3 training movements for 2 participants. For 1 participant the movement that was trained last showed a varied level of responding on the movements matching the experimenter’s request for a correct movement and an increasing trend on the movements matching the experimenter’s request for an incorrect movement.

Figure 13 represents percentage of correct verbal and nonverbal responding for pairs of ten-trial sets during behavioral movement training on 3 training movements for Carol. The behavioral movement-training package was introduced first to the jump (B1), then to balancing (C1), and lastly to the pirouette (A1).

The top left-hand graph shows responding during the correct-movement trials and the top right-hand graph shows responding during the incorrect-movement trials on the jump (B1). As shown with the filled circles, movements matching the experimenter’s request displayed an increasing trend in percentage of correct responding observed over 22 pairs of ten-set trials with 0% on set 1 to 60% on set 22 (top left-hand graph). Carol did not reach the criterion, 8 out of 10 trials correct on B1 within the set limit of the number of ten-trial sets of baseline (21 sets). Her behavioral movement training was

discontinued upon reaching the set 22 with 6 out of 10 trials correct. For movements matching the experimenter's request for an incorrect movement (top right-hand graph) the level of responding varied from 90% on set 1, dropping to 20% on set 15 and reaching 100% on sets 5, 9, and 11. As shown with open triangles on B1, verbal labeling of movements had a high percentage of correct responding, with high of 100% and low of 80%, during the correct-movement trials. The corresponding incorrect-movement trials had a high of 100% and a low of 70%. A similar pattern, but with a wider range, was observed for the correct verbal description of performance errors (filled squares) for the correct-movement trials, with high of 100% and low of 40%. The corresponding incorrect-movement trials had a high of 100% and a low of 60%.

Similar patterns of responding were observed in Carol's performance on behavioral movement training for C1 (balancing), shown on the graph below B1. There was an increasing trend in percentage of correct responding observed over 25 pairs of ten-trial sets on movements matching the experimenter's request for a correct movement from 0% on sets 1 through 6 to 80% on set 25. The criterion of performing the movement correctly in 8 out of 10 trials was reached on set 25. As with B1, for movements matching experimenter's request for an incorrect movement the level of responding varied from 50% on set 1, dropping to 30% on sets 8 and 16, and reaching 90% on set 23. Also on C1, a high percentage of correct responding was observed on verbal labeling of movements during the correct-movement trials with high of 100% and low of 90%. The incorrect-movement trials had 100% for all trials. The verbal description of performance errors showed a high percentage of correct responding during the correct-movement trials with high of 100% and low of 80%. For the incorrect-movement trials a high percentage

of correct responding was observed for the verbal description of performance errors, with a high of 100% and a low of 70%.

Behavioral movement training trials for A1 (pirouette) are shown below the graph for C1. Unlike with B1 and C1, the level of responding varied on movements matching the experimenter's request for a correct movement from 70% in set 1, dropping to 30% in sets 4 and 9, and reaching 80% in set 10. The criterion of performing the movement correctly in 8 out of 10 trials during the correct-movement trials was reached on set 10. There was an increasing trend observed over 10 pairs of ten-trial sets on movements matching the experimenter's request for an incorrect movement from 40% on set 1 to 70% on set 10. A high percentage of correct responding was observed over 10 pairs of ten-trial sets during the correct-movement trials on both verbal labeling of movements, with a high of 100% and a low of 80%, and verbal description of performance errors, with a high of 100% and a low of 50%. Similarly, a high level of correct responding was observed during the incorrect-movement trials on verbal labeling of movements, with all responses at 100% level. Verbal description of performance errors showed an increasing trend from 50% on set 1 to 100% on set 5, and on the remaining sets 6 through 10 responding varied, with a high of 100% and a low of 90%.

There was an increasing trend in percentage of correct responding observed on movements matching the experimenter's request for a correct movement on jump (B1) and balancing (C1). In contrast, the data on the same movements were variable on movements matching the experimenter's request for an incorrect movement. This disparity in responding may be attributed to the difference in the specification of the experimenter's request. For each of the correct-movement trials the request was the same

– to perform the named movement correctly; whereas for each of the incorrect-movement trials the request to perform movement incorrectly also specified the error that the student had to commit, and those errors varied from trial to trial. Nevertheless, the pattern of responding for the movement that was trained the last (A1) was reversed from the pattern displayed on the movements that were trained first (B1 – jump and C1 – balancing) during the correct- and incorrect-movement trials. For the pirouette (A1) the data on percentage of correct responding were variable on movements matching the experimenter’s request for a correct movement. In contrast, an increasing trend was observed on movements matching the experimenter’s request for incorrect movement.

For both verbal labeling of movements and verbal description of performance errors, a high percentage of correct responding was observed during the correct- and incorrect-movement trials. Overall, response acquisition was observed on movements matching the experimenter’s request for a correct movement. It is possible that verbal responding during the correct- and incorrect-movement trial pairs and movements matching the experimenter’s request for an incorrect movement enhanced responding on movements matching the experimenter’s request for a correct movement.

For Beth and Anna (see Figures 14 and 15) the behavioral movement training data showed similar patterns to those of Carol (Figure 13). For both Beth and Anna a high percentage of correct responding was observed during the correct-movement as well as the incorrect-movement trials on both verbal labeling of movements and verbal description of performance errors. Unlike Carol’s data, the data for both Beth and Anna showed an increasing trend in percentage of correct responding on movements matching the experimenter’s request for a correct movement not only on the jump (B1) and

balancing (C1), but also on the pirouette (A1) irrespective of their training order.

Likewise, for both Beth and Anna the data on the experimenter's request for an incorrect movement were variable on all 3 movements. Unlike Carol, both Beth and Anna reached criterion on all 3 movements. Beth reached the criterion, 8 out of 10 trials correct, in 9, 8, and 4 pairs of ten-trial sets on B1, A1, and C1, respectively. Anna reached the criterion, in 18, 15, and 18 pairs of ten-trial sets on A1, C1, and B1, respectively.

The social validity measures obtained from the questionnaire revealed that, in terms of the usefulness in working on technique development, 1 student found the behavioral movement-training procedure more useful than the conventional training procedure and 2 students found both procedures equally useful. In terms of the movements being practiced the most prior to the study, 1 student reported the *en dehors pirouette from 5th position* (A1) and 2 students reported the *grand frotté sauté in 1st arabesque*. The social validity measures are summarized in Table 6.

Discussion

Because there was a systematic increase over baseline in the percentage of ballet movement trials correct with the introduction of the behavioral movement-training package, one may conclude that the training procedures were effective in producing the increase. Because the baseline and maintenance phases preceding and following the introduction of treatment were, themselves, conventional training procedures, one may further conclude that the behavioral movement-training procedure enhanced the conventional training procedure. Indeed, during the maintenance phase following treatment, there was an increasing trend in correct ballet movements through the end of the study. The generalization probe data consistently mirrored the data obtained during

Table 6

Students' Responses to the Questionnaire on the Usefulness of the Conventional and Behavioral Movement Training on 3 Classical Ballet Movements: En Dehors Pirouette from 5th Position (A1), Grand Fouetté Sauté in 1st Arabesque (B1), and Piqué in 1st Arabesque (C1)

Questions	Responses		
	Anna	Beth	Carol
One the scale 1-10, rating the usefulness of the conventional training	6	10	9
One the scale 1-10, rating the usefulness of the behavioral movement training	10	10	9
Classical ballet movements practiced the most prior to the study	B1	A1	B1
Classical ballet movements that presented the greatest difficulty during the conventional training	B1	B1	C1
Classical ballet movements that presented the greatest difficulty during the behavioral movement training	C1	C1	C1

Classical ballet movements that presented the least difficulty

during the behavioral movement training

A1

A1

A1

the training trials, which allows one to conclude that the behavioral movement-training procedure applied during the training trials produced generalization to the probe trials.

Previous research examining discrimination between correct and incorrect movements in physical skill training of young athletes has demonstrated the effectiveness of a behavior analytic approach (Allison & Ayllon, 1980; Fitterling & Ayllon, 1983; Koop & Martin, 1983). Nevertheless, these studies also reported limitations in response generalization from no response generalization (Fitterling & Ayllon, 1983) to limited generalization of some components of the skill (Allison & Ayllon, 1980; Koop & Martin, 1983). In addition, treatment effects were not always enduring. In contrast, the present study demonstrated that the behavioral movement-training package effects were enduring, as shown by increasingly correct responding under the maintenance phase. Furthermore, there was response generalization observed from training to probe movements. It is possible that the stronger findings in the present study may be attributed to methodological and procedural differences, as described below.

Movements in the present study were evaluated as being correct or incorrect with respect to movement components. Such components have been evaluated in the previous studies. This study went further and also evaluated faulty movement patterns. Faulty movement patterns were defined as persistent errors. Because cumulative data have been proven to be useful in pattern detection (Kazdin, 1982), this study used cumulative data to detect faulty movement patterns. This type of data analysis allowed the evaluation of error patterns for each student. These data revealed error patterns that were unique to each student. With the introduction of the behavioral movement-training procedure, the errors of each student decreased during the maintenance phase.

The steady increasing error function during the baseline phase is puzzling. The experimenter was careful to withhold reinforcement following errors. Nevertheless, Stokes and Balsam (1991) have demonstrated that movement patterns reinforced during shaping remain in the repertoire despite the absence of reinforcement. In the present study, the students were all experienced in ballet movements, and presumably all training and probe movements were in the students' repertoire. Thus, the steady increasing error function during baseline suggests that the students might have learned faulty movement patterns earlier. Furthermore, for all students, the type of persistent errors made was related to such properties of movement as speed and force (e.g., body falling forward or sideways; not making a full turn). As mentioned in the introduction, it is possible that not all movement properties are sufficiently addressed in conventional classical ballet training. The findings of the present study show that change in movement patterns was observed following behavioral movement training. For example, for Anna, prior to the behavioral movement-training procedure, the most frequent error on the jumps (B1 and B2) was Error 2 (traveling backwards upon landing). Following behavioral movement training, this error was occurring at very low rates. Similar change in faulty movement patterns was observed for all 3 students not only on training movements, but also on probe movements. Thus, one may assume that the behavioral movement-training procedure had an impact on such properties of movement as speed and force on all 3 movement categories – pirouettes (A), jumps (B), and balancing (C).

The method used to teach movement discrimination in the present study was based on the assumption that a deliberate commitment of an error may allow the student to experience movement properties contributing to this error. Bernstein (2004), a Russian

physiological psychologist who studied motor control extensively, has argued that intentional exaggeration of errors during motor skill development allows the learner to “feel” the movement better. Kinesthetic stimuli represent private events that are associated with movement performance. The behavior analysis literature indicates that in discrimination training private stimuli may acquire discriminative control when the private event is labeled (Mechner, 1992b; Moore, 1980). In fact, Mechner suggests that by labeling his or her own errors as such and receiving immediate feedback a learner may be forming conceptual classes. Furthermore, Mechner states that by classifying and responding appropriately to instances and non-instances of a class, the learner demonstrates concept learning. The Koop and Martin (1983) study provide experimental evidence for this interpretation. In their behavioral coaching procedure during a training phase, swimmers were trained to discriminate between correct and incorrect forms of behavior. The swimmers were asked to role play both forms of behavior and then report whether they felt the difference. The specific movement properties addressed by Mechner were speed and force, and these are the properties of movement assumed to be controlling stimuli in the present behavioral movement-training procedure.

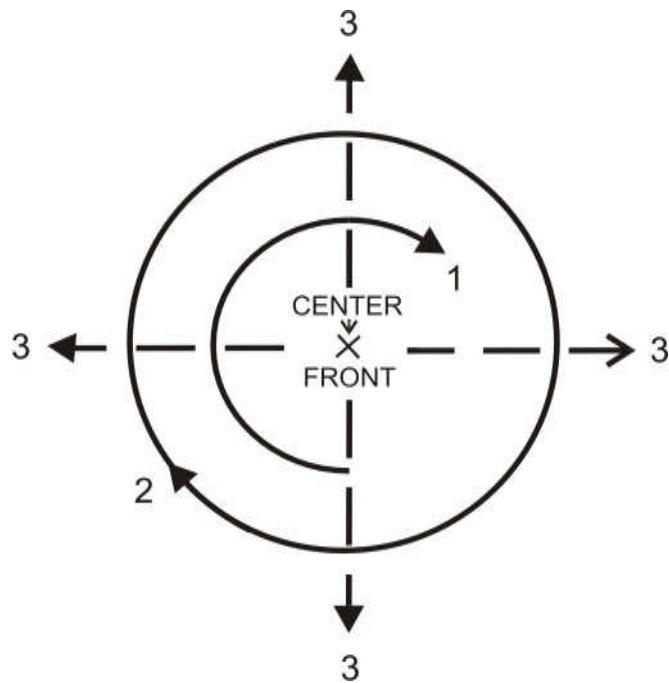
The training condition in the present study consisted of pairs of correct- and incorrect-movement trials. The aim of the behavioral movement-training procedure was to make the speed and force of a given movement salient during the movements that were rarely performed correctly by the student. During the correct-movement trials the request was to perform the movement correctly, and for the incorrect-movement trials the request was to commit a specific error. For example, during the correct-movement trial the experimenter requested, “ Show me please the *en dehors pirouette* the correct way.” By

contrast, during the incorrect-movement trial the request was “Show me please the *en dehors pirouette* the incorrect way, disengaging the muscles of the upper back when finishing the turn.” Such disengagement changes the speed and force of the movement. On the following pair of trials the request on the correct-movement trial remained the same, but the request on the incorrect-movement trial often differed, “Show me please the *en dehors pirouette* the incorrect way disengaging the abdominal muscles during the turn.” Thus, the aim was to improve the student’s muscle control to such extent that the correct and incorrect movement performance would differ only in the level of engagement of the named muscle groups. For both types of trials reinforcement was provided for a response matching the request. The data show variability in the percentage of movements correctly matching the experimenter’s request during the incorrect-movement trials, and an increasing trend during the correct-movement trials.

One of the reasons for this effect of the behavioral movement-training procedure may be the narrowing of the range of viable parameters of force and speed for the correct movement performance by sampling the extreme parameters that fall outside the range of reinforcement. Response force often corresponds to muscle engagement and speed of the movement. In the pirouette (A1), for example, if we look at the rotational force (see Figure 16), two types of errors are possible: not completing a full turn (Error 1) and making more than a full turn (Error 2). By practicing to make more than a full turn or to make a three quarters of a turn, or a half a turn during the incorrect-movement trials and receiving praise for committing the specific error, the students may have learned how to generate enough force for each. Because the rotational force parameter for a full turn lies between those two types of errors (Error 1 and Error 2), students sample a narrowed

Figure Caption

Figure 16. Depiction of potential faulty outcomes for 3 types of errors in the pirouette (A1).



- 1 – Not a full turn
- 2 – More than a full turn
- 3 – A hop or a step and traveling forward, backward, or sideways while ending the turn

range of possible force parameters. With a narrowed range of parameters, there are more opportunities to reinforce a specific (correct) response that falls within that range. A similar approach to narrowing the range of the force parameter was used with Error 3. This type of error comprises four possible outcomes where a hop or a step is made and there is traveling forward, backward, to the right, or to the left while ending the turn. Typically when the upper back is not fully engaged the body tends to fall forward. When a student tries to correct this error, another error may occur. Abdominal muscles may become slightly disengaged and the body then tends to fall backward. The body falling sideways may indicate that the weight may not be fully shifted over the supporting leg. In all four situations, the center is not maintained. By deliberately committing each of the specific errors separately during the incorrect-movement trials, the student may have learned something about shifting and maintaining body weight over a variety of parameters. Some of these parameters are those associated with the correct response. That response may become more frequently available for reinforcement. The data show an increase in praise being delivered for the 3 training movements for all 3 participants.

Another factor contributing to the effectiveness of the behavioral movement-training procedure may be the type of movements examined. In the present study, students were required to perform movements in a controlled manner and to maintain a given position by adjusting muscular force. The motor control literature indicates that this type of movement "...can be continuously modified on the basis of the feedback arising from the action itself and on the basis of changes observed to occur in the environment" (Rose, 1997, p. 112). The behavioral movement-training procedure might not be as effective with movements that cannot be modified while in progress (e.g.,

throwing a ball). Such ballistic movements are less dependent on kinesthetic feedback. By contrast, classical ballet movements produce continuous kinesthetic stimulation and therefore may benefit from behavioral movement training.

One of the problems with kinesthetic stimuli mentioned by Skinner (1965) is that the learner is experiencing them in combination with the stimuli from his or her environment and, as a result, the learner may not "... correctly identify the source of stimulation" (p. 262). For example, an instructor's verbal description intended to evoke specific characteristics of movement may not have the intended effect. A dancer may be asked to perform a *piqué*, picking up the foot as if the floor were very hot. This instruction does not address the speed and force of the required movement but instead a simple reflex to a painful stimulus. Therefore such a metaphor may mislead the learner.

The generalization probes used in this study are interesting because they involved movements that were in some ways the opposite of the training movements. For example, both types of pirouettes (A1 and A2) were performed on the same leg and the positioning during the turn was the same; however, the direction of the turn differed. Because the starting and ending position of the turn was the same (the 5th position) for both types of pirouettes and a completion of a single turn was required for both, one may assume that such characteristics as speed and force were similar. Because the training and probe pirouettes shared these characteristics, the strengthening of correct responding on the trained movement (A1) may have lead to the strengthening of correct responding on the probe movement (A2). In the same way, for both the jumps (B) and balancing (C) the training and probe movements shared most of their properties. The probe and training jumps differed in the positioning of the arms upon landing. During balancing the probe

and training responses differed in the positioning of the head and the arms during the balance. Thus, generalization of correct responding observed during the maintenance phase in the present study may be attributed to the movement properties that the responses have in common.

Finally, verbal behavior may have contributed to the effectiveness of the behavioral movement-training procedure. According to Keller and Schoenfeld (1950/1995) language may serve a discriminative function in learning a task by reducing the acquisition time and error rate. For example, Vintere, Hemmes, Brown, and Poulson (2004) found that self-instruction could increase the acquisition rate of new complex gross-motor chains in preschool dance students. Because in the present study the behavioral movement training procedure contained verbal behavior and there was a reduction in performance errors, it could be argued that the verbal behavior was functional in improving classical ballet movement performance. First, a lecture on the movement being trained, instructed the student on specific contingencies for correct and incorrect movement performance technique and potential errors associated with incorrect performance. Second, unlike previous studies in which a coach or a trainer labeled an athlete's performance as being correct or incorrect, the students in the present study were required to label their own performance and received immediate feedback. Thus, each student actually experienced specific contingencies introduced in the lecture and was measured on both verbal and nonverbal performance. This may have helped students in the classification of movements based on their properties. Finally, verbal description of performance errors by the students may have further helped them to recognize specific properties or sub-classification of incorrect movements that contribute to a specific type

of error. Overall, verbal responding may have provided additional properties to movement, facilitated distinctiveness of physical cues, and added discriminability. Because students' verbal responding showed that they generalized among the stimuli belonging to a specific class (correct movement or incorrect movement) and discriminated between the two classes, it is conceivable that verbal responding may have enhanced concept learning.

Because the behavioral movement-training procedure differed from the conventional movement training procedure by having four additional components, one may conclude that one or more of these additional components enhanced the effectiveness of training. The five components unique to the movement-discrimination training procedure were: (a) a lecture on a given movement; (b) the student experiencing a correct and an incorrect way of executing a movement; (c) the student labeling her own performance as correct or incorrect; (d) the student describing her own performance errors; and (e) the student receiving feedback not only on movement performance, but also on labeling and error description. The four training components in conjunction with conventional training (praise, modeling, physical guidance, corrective feedback, and practice) were used to develop discrimination between correct and incorrect movement performance. Nevertheless, the extent to which each component of each training procedure contributed to the effectiveness of training cannot be determined without an experimental component analysis of both the conventional movement training and behavioral movement-training procedures.

Although the present study examined the effects of the behavioral movement-training package on classical ballet technique in college students, this procedure could

potentially be relevant to pedagogical practices in other performance disciplines such as music, acting, and athletics. Also, it could potentially be beneficial in movement rehabilitation. Naturally occurring contingencies for correct and incorrect movements, especially as they relate to speed and force parameters of movement, may not always be clear to a learner. In addition, when metaphor is used in physical skill training, it may not convey the critical characteristics of the movement being trained. Faulty movement patterns often persist and may lead to various kinds of injuries. The findings of the present study suggest that the behavioral movement-training procedure may help a learner to correct persistent errors in physical skill performance by increasing control by the relevant characteristics of this skill. In addition, in terms of usefulness of the procedure, participants of the present study reported that the behavioral movement-training procedure was more useful or equally useful as the conventional-movement training in classical ballet technique development.

Appendix A

A review of the literature examining behavioral analysis of movement.

Abstract

Behavioral Analysis of Movement

by

Parsla Vintere

Adviser: Professor Claire L. Poulson

Movement has rarely been a central focus in the field of behavior analysis. While movement is a part of all behavior, it may become the main focus in the context of motor development, health, and various forms of physical activity. This paper defines movement in behavioral terms and examines behavioral measures that might be used to uncover learning process underlying movement. The purpose of this paper is to review the behavior analysis literature on movement and that of subdisciplines of kinesiology pertaining to movement as a dependent variable and environmental control of movement by antecedents and consequences. It is concluded that movement, when defined in behavioral terms, is an important and appropriate, albeit not well defined, area of behavior analysis. The study of movement is relevant in terms of acquisition, maintenance, and training of various motor skills.

Introduction

Behavior is a primary characteristic of living things.

We almost identify it with life itself. Anything which moves is likely to be called alive – especially when the movement has direction or acts to alter the environment. Movement adds verisimilitude to any model of an organism.

(B. F. Skinner, 1953/1965, p. 45)

All behavior of an organism is under control of environmental stimuli that may be acting upon the organism from within or without (Dinsmoor, 1995). Movement is behavior that can be understood and analyzed on different levels because it is the product of many subsystems. Movement depends on the interaction of perception, motivation, physiological condition and a mechanical system consisting of muscles, bones, and joints. When studying human movement, it is important to consider these contributing elements (Thelen, 1989). Because of the complexity of the phenomenon of movement there are many academic disciplines related to kinesiology, the study of human movement, such as psychology, biology, physiology, biomechanics, and physical education. In psychology, three subdisciplines, sport psychology, motor behavior, and motor learning, have contributed to the body of knowledge of kinesiology. Exercise and sport science researchers are calling for more collaborative work with psychology researchers in the “movement domains” (Singer, 2003; Gill, 2003).

In the field of behavior analysis there are relatively few empirical studies conducted examining movement itself. Perhaps one of the reasons for this paucity is Skinner's (1938/1991) definition of behavior in terms of response classes:

By behavior, then, I mean simply the movement of an organism or of its parts in a frame of reference provided by the organism itself or by various external objects or fields of force. It is convenient to speak of this as the action of the organism upon the outside world, and it is often desirable to deal with an effect rather than with the movement itself, as in the case of the production of sounds. (p. 6)

Behavior, thus, is described in terms of its consequences in the environment and the description indicates movements of an organism. Thus, according to Skinner, behavior and movement are synonymous in that they serve a specific function. Furthermore, movements that serve the same function can form functionally defined classes and thus serve as the basic units of analysis of behavior.

Behavioral analysis in terms of functional response classes obviates the direct study of movement. Nevertheless, there are situations in which behavior is defined in terms of both topography and function. Presumably, in these situations, principles of behavior control can be applied to movement. For example, particular reasons for analyzing human movement may arise in the context of motor development, health, sport, exercise, and physical activity. The purpose of this paper is to examine the behavioral analysis literature pertaining to movement. Nevertheless, pertinent literature from subdisciplines of kinesiology will be discussed in the behavioral terms as it relates to definitions, classification, theory and measurements of movement.

Talking about Movement in Behavioral Terms

Defining Movement

At the beginning of the 20th century there were two distinct approaches dominating the early research in movement: (a) physiological: examining neural mechanisms of movement and (b) behavioral: examining environmental determinants of movement. The human movement research of the second half of the 20th century, however, has been dominated by a cognitive approach (Mazur, 1994).

Despite the interest in human movement there has not been a clear definition of the term “movement.” Typically such terms as “response,” “motor behavior,” “movement,” “action,” and “motor skill” have been used interchangeably. In its broadest sense, the term “response” denotes “any reaction of an organism to, or in the presence of, a stimulus” (Reber, 1985, p.643). For the behavior analyst, the term “response” indicates the single case of a class of behavioral events that may be functionally and topographically defined (Johnston & Pennypacker, 1980). Thus, one could define movement as motor response or motor behavior, however, Ioffe (1992) points out that the term “motor behavior” denotes external manifestation of muscular movement of any activity of an organism. Bernstein (1967) proposed a more restricted definition of human movement. According to his definition movement is a process of coordination and interaction of many parts of the body to produce a unified outcome. The Bernstein’s conceptualization of movement has two important implications. First, the process of coordination and interaction of different parts of the body is achieved by skeletal muscles. The main function of these muscles is body movement and support of posture (Rasch, 1989). Second, according to Bernstein, coordination is the control of moving

segments of the body to produce a unified outcome. In addition, muscular movement may have different consequences depending on the specific context in which movement occurs. Bernstein suggested that movement be classified “according to the dependence of the actions of an organism on the stimuli which provoke them, or on the input in general” (p. 149). Thus, according to Bernstein, movements could be put on a continuum from “passive acts” to “active movement.” “Passive acts” consist of unconditioned reflexes that can be explained by the stimuli activating them. “Active movement” consists of “voluntary” movement that cannot be explained by the activating stimuli alone.

The behavior analysis approach argues that “voluntary” movement or “voluntary” behavior is behavior selected by the environment, that is, operant behavior. In addition, a distinction is made between “movement” and “action.” That is, “movements” are “responses defined by their form or the musculature used, and ‘actions,’ responses defined by their relations to the environment” (Catania, 1998, p.10). This formulation of movement does not preclude behavior analytic investigation of movement; rather it sets limits for this type of investigation. Movement that is studied by the behavior analyst has to be defined by its form and function. Furthermore, movement as operant behavior can be classified in two broad structural categories: body control and manual control (Bijou & Baer, 1961; Schlinger, 1995). Body control is comprised of postural control and locomotion. Manual control or prehension is comprised of reaching and grasping. The term “control” refers to coordination of behavior in the environment (Schlinger, 1995). Reflexes and rhythmic stereotypies are stereotypical responses to sensory stimuli. Many developmental psychologists suggest that reflexes are fundamental muscle combinations or the building blocks of coordinated movement (Thelen & Fisher, 1983). Rhythmic

stereotypies are “intrinsic oscillations of functionally related muscle groups” (p. 130). Therefore, reflexes and rhythmic stereotypies may be viewed as “fundamental structures” of behavior.

Thus, in behavioral terms, human movement may be defined as a process of control of moving segments of the body to produce a unified outcome that serves a function and is topographically and functionally defined. The outcome can be classified as reflexes, postural, locomotive, and prehensile movements. Furthermore, different movements could form a continuum. On one end of this continuum are reflexes, stimulus-response relations in which a stimulus elicits the response. On the other end of this continuum are movements selected by the environment, three-term (stimulus-response-consequence) relations in which the response is emitted in the presence of an antecedent stimulus that signals the availability of the consequence.

General Categories of Motor Skills

The term “motor skill” is typically used in the motor learning literature for any movement that must be learned in order to be accomplished (Magill, 1980). For example, standing and walking are considered motor skills. They are relatively simple skills or actions that require movement, and they require learning. Motor skills are often classified into broad categories based on their characteristics that form a continuum. According to the motor learning approach, some of the principal characteristics of motor skills are (a) the magnitude of the movement: gross motor and fine motor; (b) the distinctiveness of beginning and end points of the movement: discrete and continuous; (c) the dependence on environmental stability: closed and open; (d) the sensory feedback they provide: closed-loop and open-loop; and (e) the level of familiarity: novel and familiar (Magill,

1980; Mazur, 1994; Oxendine, 1984). To examine the relationship between the motor learning literature terms and those of behavior analysis, each of the above-mentioned characteristics is investigated separately.

The magnitude of movement is typically categorized into gross-motor or fine-motor skills. Gross-motor skills usually involve coordination of large muscle groups in which force is important. Such skills as diving and jumping are examples of gross-motor skills. Fine-motor skills involve coordination of small muscle groups in which precision is important. Some of the examples of fine-motor skills are piano playing and drawing. This categorization of skills does not represent mutually exclusive groups, but rather a continuum from a barely visible movement of a finger to a high leap in the air. For the behavior analyst the categorization of movement into gross-motor and fine-motor skills may be relevant in terms of qualitative and quantitative analysis of movement patterns or topography and response generalization. In terms of qualitative analysis, functional anatomy provides information on anatomical contributions to the movement. For example the movement pattern of kicking forms a basic component of several gross-motor skills such as a goal kick in soccer, a front kick in Tae Kwon Do, and kicking a field goal in football. Thus, the movement pattern of kicking trained in soccer most likely will generalize to Tae Kwon Do and football (Magill, 1980).

When movements are grouped based on the distinctiveness of beginning and end points, the two categories formed are discrete and continuous skills (Magill, 1980). The discrete skills have distinct beginning and end points. A discrete skill is a simple response, such as catching a ball or hitting a keyboard key. The performer has to adhere to defined beginning and end points of the task to succeed in it. In contrast to discrete

skills, continuous skills do not have distinct beginning and end points defined by the task as, for example, in skiing, skating, and walking. The performer determines the beginning and end points for these skills. In the behavior analysis literature this kind of classification of movement represent temporal properties of responding that included frequency, duration, and latency (Catania, 1998; Johnston & Pennypacker, 1980; Sulzer-Azaroff & Mayer, 1991).

The classification of motor skills based on their dependence on environmental stability as “open” and “closed” skills has been frequently used in the motor learning literature (Magill, 1980; Marteniuk, 1976; Oxendine, 1984; Poulton, 1957; Rose, 1997). Skills that are performed in variable environments in which change in responding is needed are categorized as “open” skills. Typically, “open” skills can be found in ice hockey, tennis, soccer, and basketball. Skills that are performed in stable environments in which consistent movement patterns can be observed from trial to trial are categorized as “closed” skills. “Closed” skills can be encountered in gymnastics, dance, and figure skating. This classification often has created much confusion because many skills cannot be classified as “open” or “closed” and the environment is rarely unchanging. Consider, for example, figure skating. Although this skill is performed in relatively stable environments, such parameters as the quality of ice, lighting, and temperature may be changes requiring some variation in the performance of the skill. The behavior analyst might use the term “context” to address this issue. Both “closed” and “open” skills serve a function and therefore can be functionally defined. Despite some variations in the performance of a given skill (e.g., figure skating) similar consequences are produced and,

thus, form a functionally defined class of behavior. Finally, the context is defined by the function it has for the performer of the given skill (Leslie, 2002).

The classification of motor skills based on the sensory feedback they provide form two categories of “closed-loop” and “open-loop” skills (Magill, 1980). In the “closed-loop” skills sensory feedback information may be used to make the adjustments to the movement. The individual performing these skills relies essentially on proprioceptive control. Some examples of the “closed-loop” skills are balancing, downhill skiing, and bicycling. In contrast, in the “open-loop” skills sensory feedback cannot be used to make the adjustments to the movement because these skills must be performed very quickly. Some of the examples of the “open-loop” skills are hitting a baseball, throwing a ball, and piano playing. The major difficulty with this categorization of movement is that many of the skills may start out in one category and move to the other. For example, a novice piano player may depend on the environmental cues provided by sheet music and such proprioceptive cues as the positioning of the fingers, a “closed-loop skill,” but with practice he or she may no longer depend on the sensory feedback and thus, it may become an “open-loop skill.” The current approach to this classification is that the mode of the sensory feedback control used depends on “ the type of environment in which we are moving and the goal of the action we have chosen to solve a given motor problem” (Rose, 1997, pp. 10-11). The current approach to sensory feedback control agrees with the behavior analysis approach to operant conditioning, that is, the process of selection by consequences that “consists of a three-term relationship between the context, the behaviour and its consequences” (Leslie, 2002, p. 11).

Finally, motor skills are categorized based on the level of familiarity of movement into novel and familiar skills (Magill, 1980; Oxendine, 1984). Novel skills are those movements that are presumed to be absent from one's repertoire. In contrast, familiar skills are those skills that have been performed by the individual. In the behavior analysis literature, it is argued that novelty cannot be a property of individual responses, rather a property of several responses in the context of other responses. The given response might be novel in "the context of one sequence of past responses and stereotyped in the context of another" (Catania, 1998, p. 127). In addition, the categorization of behavior as novel depends on several factors: the behavior of the organism being observed, the level of analysis of the observer, and knowledge of the history of the organism being observed (Shahan & Chase, 2002). Thus, for the behavior analyst the classification of motor skills into familiar and novel may be relevant in terms of quantitative analysis, such as response rate, duration, and accuracy, and qualitative analysis, such as level of response stereotypy in the context of other responses.

Measuring Movement

As indicated by the brief review above of general categories of motor skills, movement may vary across a number of dimensions such as, movement patterns, response accuracy, and temporal properties of responding. When studying psychological aspects of movement, researchers have pondered the movement characteristics that should be measured (Smith & Haggard, 1999). With the technological development of three-dimensional recording of movement the issue of relevant measures has intensified. Because movement measures do not correspond directly to underlying psychological processes, some researchers measure a number of relevant variables believed to covary

with underlying psychological processes. It appears that "... the study of movement and action continues to develop the ways in which theoretical questions are related to issues in measurement" (Smith & Haggard, 1999, p. 243).

For behaviorists, the question is what behavioral measures may be used to uncover learning processes underlying movement. According to Skinner (1938/1991), the main quantitative dimension of behavior is the rate of responding. Nevertheless, he suggested that other measures could be "interesting or even valuable" (p. 58). Indeed, Johnston and Pennypacker (1980) state that, in addition to rate of responding, latency and duration are fundamental quantitative dimensions of behavior. Other measures of behavior often used in the behavior analysis literature are response accuracy, intensity, and topography (Sulzer-Azaroff & Mayer, 1991). Because movement is behavior that can be analyzed on different levels from large units of complex responses to fine-grained topography of moment-to-moment quantitative and qualitative changes, behavioral analysis of movement may be divided into two approaches – molar and molecular.

The molar analysis of movement typically examines large units of behavior or behavior chains. The temporal properties of movement, such as frequency, latency, and duration, and outcome accuracy or performance errors are used in the molar analysis of movement. For example, many behavior analysis research studies of movement have examined (a) frequency of complex responses (Azrin, Rubin, O'Brien, Ayllon, & Roll, 1968; Gruber, Reeser, & Reid, 1979; Hardiman, Goetz, Reuter, & LeBlanc, 1975); (b) duration of movement sequence (Taub, Crago, Burgio, Groomes, Cook, III, DeLuca, & Miller, 1994; Vintere, Hemmes, Brown, & Poulson, 2004); (c) response accuracy measured as percentage of correct responding (Allison & Ayllon, 1980; Anderson &

Kirkpatrick, 2002; Correa, Poulson, & Salzberg, 1984; Kladopoulos & McComas, 2001; Komaki & Barnett, 1977); (d) number of correct responses (Fitterling & Ayllon, 1983; Kirby & Hoborn, 1986; Shapiro & Shapiro, 1985); (e) number of performance errors (Mosk & Bucher, 1984); and (f) percentage of errors (Koop & Martin, 1983). The molar analysis of movement may provide information on the speed and accuracy of movement, however, it is possible and sometimes desirable, to further analyze behavioral chains into constituent, smaller, more molecular units.

The molecular analysis of movement provides information on small units of behavior or fine-grained topography. In the behavior analysis literature, the molecular analysis of movement tends to be merely descriptive; that is, specific patterns of body position and movements are described. For example, Young et al. (1994) describe pantomime model of eating as “one hand scoops to open palm of other, then comes to lips” (p. 688) or Poppen (1998) describes a relaxed body positioning as “the torso, hips, and legs are symmetrical around midline, resting against the chair, with no movement” (p. 43). By contrast, the motor-control literature, molecular analysis tends to be quantitative, with reliance on biomechanical measures. These measures comprise kinematic (topography related) and kinetic (force related) analyses. Kinematic analysis is used to identify important components of movement. Measurement of topography is based on dimensional quantities that are descriptive of motion, such as Newtonian mechanics (Johnston & Pennypacker, 1980). Two of the most frequently used measurement techniques of topography are kinematic analysis and electromyography (EMG).

The first kinematic analysis that combined computer technology with biomechanics to analyze sports skills was conducted by Gideon Ariel (Moore, 1977). This technique allows one simultaneously study limb position, acceleration, and velocity. Today, advanced film equipment and computer software packages that contain mathematical and statistical programs are used in many movement-related studies (e.g., Smits-Engelsman, Wilson, Westenberg, & Duysens, 2003; Thelen, 1994; Winold, Thelen, & Ulrich, 1994). For example, Winold, Thelen, and Ulrich (1994) examined patterns of arm movements of highly skilled cellists. The bow arm movements of ten cellists were recorded using an optoelectronic motion analysis system (WATSMART). Infrared light-emitting diodes were attached to the cellists' arms. Two infrared sensitive cameras tracked and recorded the movement of these pulsating diodes. Two-dimensional data from the cameras were converted into three-dimensional coordinates using a mathematical software package. The analysis of relative timing and velocity patterns of arm joints and the bow was conducted. The study demonstrated that both strict task constraints and substantial flexibility characterize the bow arm movements in skilled cello players. The implication for cello performance and practice is that there are different movement solutions for slow and fast movement patterns. This means that the common practice strategy of playing musical passages slowly for accuracy and then building up the tempo may not always be the most effective practice.

Another approach to measuring topography of movement is electromyography (EMG). EMG gathers information on the activity of muscles during movement. Electrodes that record muscle activity are typically placed on the surface of the skin on top of the muscles being measured. The raw EMG signal then is amplified and filtered.

The output allows one to identify spatial and temporal characteristics of the given movement, such as the amplitude and duration of muscle contraction and the temporal coordination of muscle groups (Rose, 1997). This type of measurement is often one of several physiological measures used in studies examining muscle stress (e.g., Budzynski & Stoyva, 1969; Lundberg et al., 1999; Lundberg et al., 2002). For example, Budzynski and Stoyva (1969) used the EMG measures to provide the participants with feedback on deep muscle relaxation. Lundberg et al. (1999) used the EMG measures to demonstrate that elevated stress levels of workers with repetitive tasks increased the risk of developing neck and shoulder pain. Similarly, the EMG measures allowed Lundberg et al. (2002) to reveal that, under stress, muscle units may stay active even in the absence of physical demands and, thus, present a risk factor for the development of muscle pain.

An account of fine-grained topography measures of movement would not be complete without kinetic movement analysis that considers internal and external forces acting on the body. These forces can be measured using different types of equipment, such as force platforms and force transducers. Measures of the amount of force applied during movement are graphically presented and analyzed. Researchers then are able to determine how one can achieve a similar movement using different levels of force (Rose, 1997). Kinetic analysis of movement may provide information on the forces produced during movement, may identify important parts of a skill, and may identify aspects of a skill or movement that predisposes the performer to injury (Hamill, Dahnert, & Knutzen, 2003). Wulf, Shea, and Whitacre (1998), for example, used kinetic analysis to determine the effects of physical guidance, provided by an apparatus, on efficiency (measured in relative force onset of the feet) of slalom-type movements. The apparatus used for this

study was a ski-simulator with one pressure transducer mounted on each side of the platform. These transducers allowed measurement of the immediate values of the forces exerted on the platform by the participants' feet. The kinetic analysis of coordination patterns allowed the authors to conclude that physical guidance enabled participants to learn movement patterns similar to those of advanced performers.

The two approaches of behavioral analysis of movement (molar and molecular) often use different measurement techniques. While techniques used in the molar analysis of movement are routinely used in behavior analysis research on movement, the quantitative techniques (kinematics and kinetics) of molecular analysis tend not to be. Nevertheless, the quantitative techniques of molecular analysis of movement may be valuable and informative in uncovering learning processes underlying movement.

Others in the field of psychology have recognized some of the problems of studying movement and note that "... psychologists have not studied movement as much as they have studied perception, language, or memory" (Smyth & Haggard, 1999, p. 243). Nevertheless, they do not take a behavioral perspective. Therefore, the following literature review highlights some unique aspects to be considered with respect to the three-term contingency when studying movement: (a) movement as a dependent variable, (b) consequences of movement, and (c) antecedents of movement.

Movement as a Dependent Variable

As discussed at the beginning of the introduction of this paper, Skinner's operant analysis of behavior emphasized the function of behavior, rather than its form. Because of this focus on the function of behavior, rather than on its topography, there have been relatively few operant analyses of the topography of movement itself. The study of

movement in behavioral terms requires a shift in the kind of dependent variables we study. Thus, in behavior analysis, what makes movement different as a dependent variable is that not only the occurrence of the operant is observed and recorded, but also the manner in which it is performed is observed and recorded. When movement is used as a dependent variable, several issues should be considered: (a) response specificity and (b) mechanisms of response differentiation and induction.

Response Specificity

Leonardo da Vinci said that human movements "... performed on one single occasion or for one single purpose are infinitely varied in themselves" (Richter, 1985, p. 158). In terms of behavioral analysis this means that topographical response classes of movement are not fixed. Topography of movement may change as a result of practice and general condition of the organism. In kinesiology, one of the principles of training and development of physical skills is the principle of specificity (Garhammer, 1989). It states that a specific demand will produce a specific response by the body and this response will depend on the performer's condition (e.g., level of motor skill development) and situation. Thus, movement is a function of a combination of processes and restrictions in the organism and in the environment (Thelen, 1995).

An interesting illustration of this principle is presented by Thelen and Fisher (1982) by examining the organization of infant leg movements. They found that newborn stepping and kicking responses had the same movement patterns. That is, the comparison of the kinematics of the joint movements and muscle activation patterns of the two responses for the same infants were very similar. The difference was in the position of the body: upright in the stepping response and supine in the kicking response. Although the

movement patterns were the same, the relation between the mass of the body and the gravitational field in these two responses was different. The kicking response typically is present throughout infancy, but the stepping response disappears a few months after birth and reappears late in the first year. Thelen and Fisher found that at the time when the stepping response disappears infants exhibit a rapid weight gain that does not translate into muscle tissue gains. They experimentally manipulated mass of the infants' legs. They submerged infants, whose stepping response had disappeared, into torso-deep warm water and observed the stepping response. In contrast, they observed that by adding weights to infants' legs whose stepping response was present the stepping response was inhibited. The general conclusion drawn from these observations was that "...behavior does not reside in some privileged form but emerges on-line within a specific context" (Thelen, 1995).

Davids, Bennett, Kingsbury, Jolley, and Brain (2000) investigated differences in children's ball catching behavior. A sample of 20 primary school students was pretested to evaluate one-handed catching performance. Based on the pretest results, 12 children (6 males and 6 females) were invited to participate in the experiment. They were assigned to two groups – poor catchers, defined as having succeeded on fewer than 50% of the pretest trials, and good catchers, defined as having succeeded on more than 70% of the pretest trials. Each group consisted of equal number of boys and girls. Both groups were exposed to 20 one-handed catching trials in two conditions – standing and seated. A ball projection machine threw tennis balls and participants were required to catch them with their dominant hand. All participants were right-handed. Three dependent measures were used: the number of balls caught under each condition, the number of misses, and the

catching score obtained on a 5-point scale of catching behavior. The data on the number of catches did not show differences between standing and seated positions for good catchers, but for poor catchers, the number of tennis balls caught in a seated position was significantly more than that in standing position. Nevertheless, the catching score for the poor catchers was lower than that of the good catchers. No statistical analysis was conducted on the number of misses. The authors concluded that underdeveloped postural control might have limited learning of one-handed catching. The findings indicate that manipulation of the practice context may enhance skill acquisition for learners whose skills are underdeveloped.

In training complex, new movements it is important to conduct a task analysis, breaking down a complex movement into individual elements. Davids et al. (2000) illustrate the importance of the analysis of individual elements of a complex response. In the studies of operant response, there have been relatively few empirical studies examining mechanisms of acquisition of new response forms (Stokes & Balsam, 1991). Thus, mechanisms of response differentiation and induction are discussed next.

Mechanisms of Response Differentiation and Induction

Response differentiation is the reinforcement of only specifically defined responses while placing all the other members of the response class on extinction. Almost all differentiated operants are also discriminated operants (Keller & Schoenfeld, 1950/1995). Typically, a specific form of a response is associated with some kind of discriminative stimulus that is to a greater or lesser degree identifiable. For example, a piano-playing response is more likely to occur in the presence of a piano keyboard than in its absence. Response differentiation procedures are used to produce selection of some

type of behavior over another that often results in changes in the behavioral repertoire of an organism. Response shaping by successive approximation relies on induction of a new response in the organism's repertoire. In shaping, one characteristic of responding (e.g., topography) is gradually modified by differentially reinforcing successive approximations to a target response class. Shaping is often used to teach novel, complex responses, such as motor skills.

The behavior analysis literature considers the topography of a response as being determined by the interaction of three processes (Leslie, 1996). The first process is the tendency for responding to become less variable or stereotyped. For example, a gear-shifting response by an experienced driver has very little variability from one instance to the next. The second process has been described by Skinner's (1938) "Law of Least Effort" (Skinner, 1938) as the tendency of response topography that requires the least effort to prevail. For example, a person most likely will take the elevator instead of walking up ten flights of stairs. Nevertheless, there are two caveats to this conceptualization of the process: (a) effort has to be measurable and (b) in some situations, "... the hard way has too often been the only reinforced way available" (Keller & Schoenfeld, 1950/1995, p. 178). The third process is the biology of the species and its influence on what can be learned.

In the applied behavior analytic studies examining motor-skill acquisition or modification, shaping is often combined with other procedures such as movement restriction, verbal feedback (Taub et al., 1994), sensory feedback (Budzynski & Stoyva, 1969), instructions, nonverbal feedback (Fitterling & Ayllon, 1983), and physical guidance (O'Brien, Azrin, & Bugle, 1972). For the studies examining shaping alone (e.g.,

Midgely, Lea, & Kirby, 1989; Pear & Legris, 1987; Skinner, 1938) the primary dependent variable has been some quantitative dimension of behavior, such as its rate, latency, and duration. Response topography has not been extensively researched and, as a result, relatively little is known about acquisition of new forms of responding (Stokes & Balsam, 1991). Nevertheless, Stokes and Balsam suggest that there are several theoretical models that provide an account for acquisition of new response topographies.

The theoretical model of response-reinforcer contingencies provided by Skinner (1938, 1953) and earlier by Hull (1932, 1934) proposed that novel responding may be established through shaping by successive approximations. This is achieved through extinction that increases variability and facilitates induction of a closer approximation of the target response that at that point can be reinforced. In addition, chaining may generate response topographies that are closer approximations to the target response because one response component serves as the eliciting or discriminative stimulus for another component. A different view on response shaping was proposed by Bindra (1974). His theoretical model argues that the present motivational state and specific properties of conditioned stimuli determine response topography. Thus, in Bindra's model, shaping is achieved through stimulus-reinforcer contingencies, not through response-reinforcer contingencies as proposed by Skinner and Hull. Moore (1973) has proposed yet another theoretical model for shaping. As in Bindra's model, Moore's model argues for stimulus-reinforcer contingencies and Pavlovian account for shaping; however, it attributes response form to many factors not just conditioned stimulus alone. Finally, the fourth theoretical model may be derived from the literature dealing with constraints on learning (e.g., Breland & Breland, 1961; Shettleworth, 1975; Timberlake, 1983), referred to as the

behavioral systems model by Stokes and Balsam (1991). This derived theoretical model suggests that responses that can be strengthened by a reinforcer, "...will come from a limited set of preorganized behavior patterns, constrained by motivational state, stimulus, and reinforcer type" (Stokes & Balsam, 1991, p. 215).

Theoretical models of shaping predict different outcomes in the final topography of the shaped response. Both the response-reinforcer contingency model, proposed by Skinner and Hull, and Bindra's stimulus-reinforcer contingency model predict individual variation in response topography and the dependence of the final response topography on the approximations reinforced during shaping. In contrast, both the behavioral systems and Moore's models predict little individual variation in response topography and relative independence of the final response topography from the specific approximations reinforced during shaping.

To empirically test these theoretical models, Stokes and Balsam (1991) conducted two experiments examining the effect of different shaping algorithms on the topography of the rat's bar press. The authors devised a special coding system to classify behavior into discrete categories. Topography, location, and function defined each component of the given category. To assess the effects of reinforcing different approximations on the topography of the bar press, changes in component frequency and their sequential organization for each subject were analyzed early (during the 9th through 12th bar presses) and late (trials 1-20, 91-110, 191-210) in training.

The first experiment looked at the response topography early in the shaping process. The subjects of the experiment were 10 experimentally naïve, 10-to-12-weeks-old male rats. They were first trained to drink from the dipper. After dipper training,

subjects were randomly assigned to two experimental groups: the rear group and the nose group. For the rear group, the reinforcer was delivered first for rearing anywhere in the experimental chamber, then for rearing over the bar, and finally for pressing the bar (rearing was not a necessary condition for reinforcement). For the nose group, reinforcer was delivered first for the snout proximity to the bar, then the snout contacting the bar, and finally for pressing the bar (the snout contacting the bar was not a necessary condition for reinforcement). The authors found that there were significantly more rears observed in the rearing group than in the nose group. In addition, rearing was also incorporated into the bar press sequence of all subjects in the rearing group. In the nose group, each subject displayed idiosyncratic bar press sequences, but the snout was incorporated into the bar press sequences of all subjects. The authors concluded that both groups exhibited effects of the contingencies placed on response topography. Because the form of responding varied greatly in both groups, the authors concluded that Pavlovian associations did not determine response form. The behavioral systems model explanation of shaping, however, could not be rejected because only a brief sample of early conditioning was analyzed, and species-based stereotypy conceivably could emerge later in training.

The second experiment was conducted to determine whether species-specific patterns would interfere with effects of shaping during extended training. The subjects of the experiment were 4 experimentally naïve adult female rats. As in the first experiment, subjects were first trained to drink from the dipper. Two days after dipper training, the bar pressing response was shaped. A reinforcer was delivered first for two sets of responses: (a) approach and /or contact with the unlit light located above the bar and (b)

paw contact with the bar. Once the rat was pressing the bar consistently, a reinforcer was delivered only when the bar was pressed with a single paw. The next reinforced approximations were specific sequences without intervening components, such as light-paw-press, paw-light-press, or paw-press-light. Finally, reinforcement contingency did not contain any specific topographic requirements, and all bar presses were reinforced. The results demonstrated that reinforcing topographically specified approximations during shaping does affect response topography both late and early in training. As in the first experiment, the form and the order of responding varied greatly. Subjects did not exhibit similar sequential patterns. Although all subjects drifted into simpler forms of responding, the individual sequences that were reinforced during shaping remained in their repertoire even though they were not required for reinforcement. Thus, neither Pavlovian association nor behavioral systems models can account for novel responding form late in training, at least in shaping the rat's bar press.

Based on the findings of this and other studies, Stokes and Balsam draw several important conclusions regarding shaping of response topography. First, reinforcement of specific topographic approximations during shaping can affect target responding both early and late in training. Second, although the Pavlovian association model can account for the pigeon's key pecking response (Moore, 1973), it cannot account for the rat's bar press. Third, there may be two possible explanations for the effects of shaping on response topography: (a) reinforcement contingencies may generate new components or (b) reinforcement contingency may change the sequencing of components. The data from the Stokes and Balsam study suggest that shaping changes the sequencing of existing behavioral components that are common to rats. Thus, the hypothesis that contingencies

select components is consistent with the response-reinforcer contingency, stimulus-reinforcer contingency, and behavioral systems models. Fourth, Stokes and Balsam provide a list of factors that have been demonstrated to influence the form of a conditioned response: (a) characteristics of the unconditioned stimulus, (b) characteristics of the conditioned stimulus, (c) motivational states of subjects, (d) frequency of the reinforcer, (e) duration of the conditioned stimulus, (f) characteristics of the context, and (g) operant response class. The Stokes and Balsam study demonstrates that response-reinforcer contingencies is another factor influencing the form of a conditioned response that should be added to the above-mentioned list. Finally, Stokes and Balsam suggest that "... the form of the behavior itself may be best understood as a discrete unit composed of a sequence of subunits" (p. 229). The formation of a new topography may be viewed as reorganization of the subunits or minimal units of behavior into new sequences. Similar findings, discussed in terms of the "revealed operant," are reported by Mechner (1992) and Mechner, Hyten, Field, and Madden (1997).

Mechner (1992) proposed a distinction between the "traditional operant," a response as an instantaneous event, and the "revealed operant," a combination of sequential responses and elements of chained and secondary reinforcement schedules. Unlike the "traditional operant" that is an all-or-none event that is recorded, for example, by a switch closure or a step made, the "revealed operant" may have some of its elements or "sub-operants" specified and recorded deliberately within different response patterns. Mechner et al. (1997) conducted several pilot studies with human subjects investigating techniques for measuring response induction. The revealed operant consisted of chained responses of key pressing on a computer keyboard. A computer-administered shaping

program was used to teach the subjects the sequence. The effects of different types of independent variables (e.g., number of repetitions, work requirements, changes in contingency, and fixed ratio schedules) on the internal structure and properties of operant response were evaluated. The authors found that by using multiple measures (e.g., duration of revealed operant, the number and rate of sub-operants, and patterns) that are sufficiently sensitive long-term changes can be observed. Thus allowing "... the study of functional relations not previously observed with more conventional techniques" (p. 65). No doubt those techniques will facilitate future research in this area.

In conclusion, movement as a dependent variable differs from other operant responses in its requirement that we analyze not only the functional but also the topographical response classes available. Moreover, movement is a function of the interaction between the organism and the environment. Finally, the topographical classes are not fixed. Several behavior analysis researchers have empirically studied the structure and dynamic properties of movement (e.g., Mechner et al., 1997; Stokes & Balsam, 1991).

Consequences of Movement

In the analysis of behavior, consequences play a central role. When the focus of the analysis shifts to movement itself, the consequences may be more difficult to measure than the typically programmed consequences manipulated by the experimenter in the usual operant learning experiment. This is because some movements may produce automatic reinforcers that increase their probability of future occurrence over other movements that may otherwise share the same function and yield the externally

programmed reinforcers. Thus, consequences of movement are discussed next in terms of (a) movement- produced ecological reinforcers and (b) different types of feedback.

Movement-Produced Ecological Reinforcers

In studying movement, it is very important to consider possible ecological (Bijou & Baer, 1961) or automatic reinforcers for behavior that are not mediated by another organism. Such reinforcers are the natural product of the movement itself. For example, twelve-month old infants tend to spend a considerable amount of time trying to pull themselves up to standing position, which allows them to see and reach for novel objects. According to Schlinger (1995), "... ecological reinforcers are perhaps the primary source of reinforcement for the development of motor behavior in human infants" (p. 90).

Interesting experimental evidence of the effects of differential reinforcement on movement by ecological reinforcers can be inferred from the experimental studies of the infants' kicking response (Rovee-Collier, Morrongiello, Aron, & Kupersmidt, 1978; Rovee-Collier, Sullivan, Enright, Lucas, & Fagen, 1980). These studies looked at group differences in rate of kicking. They examined the effects of conjugate reinforcement, reinforcement whose magnitude was proportional to the response rate, on infant learning. The response measured was the number of kicks per minute. One group of infants was exposed to contingent reinforcement of kicking. Kicking controlled the movement of an overhead mobile. Their kicking response rate increased compared to baseline. The other group of infants was exposed to noncontingent mobile movement. For this group, the rate of kicking did not change. These findings support the importance of ecological reinforcers on response selection in infants. Nevertheless, these studies did not address parameters other than frequency of movement that might have changed as a result of the

transition from respondent to operant responding. Other parameters were included in a study by Thelen and Fisher (1983) who conducted kinematic analyses of the temporal and topographical dimensions of leg kicks of six 3-month-old infants.

The experimental design of the Thelen and Fisher (1983) study was similar to the Rovee-Collier et al. (1978, 1980) studies in that movement of an overhead mobile was used as the reinforcing stimulus. Six three-month-old infants were assigned to experimental and control groups. The experimental group was exposed to a conjugate reinforcement schedule and the control group to noncontingent reinforcement. Frequency of leg kicks increased over baseline for the experimental group. Additionally, the experimental group exhibited an increase from baseline to treatment in the amplitude of the leg kicks, measured as trajectory of the knee in the horizontal plane during flexion and extension. In contrast, the control group did not show change in either of these measures. Interestingly, there was no difference between the experimental and control groups in motor control parameters: absolute duration of the movement phases of the kick (i.e., flexion and extension) and the movement distribution patterns (i.e., flexion, extension, and interval between the kicks). The authors concluded that both the rate and amplitude of movement can be modified, however they were not able to determine the extent to which these parameters are independent of each other. Other movement parameters, such as the absolute duration of the movement phases of kicking and the rhythmical quality of kicking, such as movement distribution patterns, may be less susceptible to reinforcement operations.

In addition to considering possible ecological reinforcers in studying movement, it is important to take a closer look at feedback, information that is provided to the learner following a particular motor task.

Feedback

According to Catania (1998), feedback can be defined as “a stimulus or stimulus property correlated with or produced by the organism’s own behavior” (p. 390). Thus ecological reinforcers can be classified as feedback. Feedback may change the behavior and, in turn, be changed by the behavior. Although feedback is provided following a particular motor task, the behavior analysis literature shows that feedback may serve reinforcing, punishing, or discriminative functions (Sulzer-Azaroff & Mayer, 1991). It often results in differential reinforcement of some dimension of a motor skill performance and correction of another. In addition, feedback may come from several sources. Two sources of information are considered in motor tasks: sensory feedback (visual, auditory, proprioceptive, and cutaneous) provided by the learner’s sense organs and augmented feedback (“knowledge of results,” “knowledge of performance,” and biofeedback) provided from an external source (Rose, 1997).

Sensory Feedback

Although every movement provides sensory feedback, during the acquisition of a new motor skill, the learner may not be able to discriminate between correct and incorrect movement patterns. Similarly, successful performance of a motor skill may be impeded because incorrect movement patterns that may have been acquired earlier. Initially, augmented feedback that provides information on the quality of the movement patterns or

feedback about performance may be used. Nevertheless, the ultimate goal is for the learner to be able to use his or her own sensory feedback.

In behavior analysis studies on teaching complex motor skills, a combination of procedures is often used. Such a skill-training package might include modeling, instruction, rehearsal, and feedback. Motor-skill-related information is typically presented through modeling and instruction that is followed by rehearsal of the skill, and that rehearsal may contain prompts and feedback. As a part of a skill-training package, feedback on performance has been used in (a) teaching leisure dance to profoundly retarded persons (Lagomarcino, Reid, Ivancic, & Faw, 1984); (b) enhancing ballet skills in ballet students (Fitterling & Ayllon, 1983); (c) training gross-motor skills to preschoolers (Kirby & Holborn, 1986; Vintere et al., 2004); and (d) training different sports skills (Allison & Ayllon, 1980; Kladopoulos & McComas, 2001; Koop & Martin, 1983).

From the above mention studies, only two of these studies (Koop & Martin, 1983; Allison & Ayllon, 1980) have embedded discriminative stimuli for sensory feedback in a form of feedback about the movement process. For example, in the Allison and Ayllon (1980) study, during behavior coaching the football coach provided feedback to players by asking them to “feel the patterns” in their muscles while holding the proper blocking position. In the Koop and Martin (1983) study, part of an error-correction procedure was for swimmers to role-play correct and incorrect movement patterns. Afterward they were asked, “Can you feel the difference?” The intention with this type of feedback is to provide the motor-skill learner with discrimination training of sensory feedback and stimulus control transfer from external to internal feedback. Nevertheless, we have not

found a way to directly measure this transfer. This presents a problem for science.

According to Guthrie (1959), movement-produced stimuli and serial movement responses might be open to observation and analysis, but such observations may require more than recording the instantaneous action. Such observation requires measurement of the way in which the movement is produced, not just the product of the movement. Guthrie holds that movement-produced stimuli and serial responses are "...as open to the experimenter's control as are the sounds and lights so much used as signals in current research" (p.181). Nevertheless, Guthrie does not provide such methodology. It is possible to measure stimulus transfer indirectly by correlating self-report, observing learner's movements, and using functional anatomy, which is the study of the body components required to perform movement. Jacobson (1938) provides an example of a possible approach to measuring such stimulus transfer in a progressive relaxation procedure:

While lying down, the individual flexes his left arm steadily, avoiding unnecessary contraction of other groups as previously stated, and reports whether he notes the sensation from contraction of the biceps group. To strengthen the sensation, the physician offers passive resistance. Some patients perceive at once, while others require many repetitions, particularly the agitated and unobserving types. The experience from muscular contraction, as illustrated both by a maintained flexion of the forearm and by a quick flexion, is by agreement between physician and patient to be called "tenseness." This applies whenever this type of experience appears anywhere in the body. But the physician clearly explains, at this or some other more favorable moment, that "tenseness" will not

mean the same as physical tautness occurring when a tissue is stretched during some movement or otherwise (p.47).

Later, while the individual judges his or her progress by diminution of the sense of “tension,” the physician observes external signs of relaxation, such as palpation of the muscle-group and passive movement of the body part. Thus, transfer of stimulus control from external to internal stimuli may be measured subjectively. Such subjective measurement is well accepted in a field like optometry. Vision is measured subjectively, when the optometrist asks one to report on, for example, the acuity with which a symbol is read through a given set of lenses. The optometrist supplements this subjective measure with objective measures of the angle of light refraction from a beam of light projected onto the retina. Both subjective and objective measures, taken together, yield useful measures of visual acuity. As Skinner (1953) noted, “...events which are, for the moment at least, accessible only to the individual himself often occur as links in chains of otherwise public events and they must then be considered” (p. 229).

There are several reasons that sensory feedback may be useful in motor-skill learning. First, in many motor skills, there is a mutual dependence between form and function, called technique. Technique is needed to achieve the best qualitative and quantitative results. Second, lack of a proper movement may lead to injuries. There is a paucity of behavioral literature addressing sensory feedback and its possible application to motor learning and rehabilitation.

Augmented Feedback

There are many different forms in which augmented feedback may be provided. The forms generally used in movement training are verbal instruction, video playback of

performance, and biofeedback. Kinematic feedback or “knowledge of performance” provides a learner with information on production or quality of movement patterns. For example, a gymnast may be told to hold her arms out and back straight on her dismounting from the balance beam. Feedback about the results provided, perhaps by a coach, provides a learner with information on critical quantitative parameters of performance, such as speed of a runner and distance of a ball throw, but such feedback might not provide information on kinematic movement patterns.

One type of augmented feedback is one that highlights the kinematic aspects of performance in videotape replays of learner performance. There is evidence that in many areas of sport training the use of videotape as a teaching tool is widespread (Starek & McCullagh, 1999). The effectiveness of this feedback tool depends on the skill level of the learner, the length of time of the videotape feedback use, and the use of additional verbal feedback as described below.

In the sport-skill literature, Rothenstein and Arnold (1976) provided an extensive review of over 50 studies on video feedback (published from 1958 to 1975) using two research data bases: Completed Research in Health, Physical Education, and Recreation, and Dissertation Abstracts. First, all studies were divided into those showing significant and not significant results. Next, chi-square analysis was conducted on the frequency data on sex and age of participants, task employed, participants’ skill level (beginner, intermediate, advanced, and mixed), type of test performed (form, result, both, and not given), treatment conditions, and time length of study. They found that only 19 of these studies were able to demonstrate the effectiveness of videotape viewing as an effective teaching tool. According to Rothenstein and Arnold (1976), skilled performers benefited

more than novices from videotape replay alone. Newell and Walter (1981) suggested that the behavior of novices might not be brought under the control of the key aspects of a new motor skill. In terms of the stimulus-control literature, the same complex stimulus may be exerting selective control over responding in the form of acquired distinctiveness of discriminative stimuli for the novices and skilled performers. This phenomenon is a two-step process that involves mediation of the stimulus cues and their association with an operant response. For example, if two cues are presented simultaneously, the degree to which each of the cues will associate with a particular response will depend on performer's previous experience with those cues. One of the cues may acquire distinctiveness and, therefore, have a stronger association with the operant response. Unlike the blocking or overshadowing effects that assume the absence of one cue's association with a response, acquired distinctiveness of cues suggest that all the cues are associated with a response, however, this association is relative (Lawrence, 1949, 1950). This is just what the Rothenstein and Arnold (1976) review found. When novices were presented with the videotape replay accompanied with skill-related verbal instructions on the key elements of the motor skill and error detection, they showed an improvement in the performance of the skill. In addition, it appears that motor-skill learners should be trained in the use of the video feedback to obtain the most useful information for motor-skill performance. Based on their review, Rothenstein and Arnold suggest that at least five weeks are needed for this process.

Although kinematic information contained in "knowledge of performance" (KP) is important in motor-skill acquisition, many early motor skill studies have demonstrated the effectiveness of information on the consequences in "knowledge of results" (KR)

(Adams, 1971; Towbridge & Cason, 1932). Thus, the question is what might be the most effective feedback. The Kernodle and Carlton (1992) study has examined this question by comparing relative effectiveness of four information feedback conditions on the learning of the over-arm ball throw: (a) only KR; (b) KP in a form of videotape replay; (c) KP and verbal cues; and (d) KP and transitional information, information on what to change and how to change the movement. Forty-eight participants with limited experience in throwing were randomly assigned to one of four experimental conditions. They were taught the over-arm throw with the nondominant arm. All participants received feedback after every trial, however, the form of feedback varied across the four conditions. The participants in the KR condition received verbal information on distance thrown. The KP condition participants were given a videotape replay of their ball throwing. The participants in the KP and verbal cues condition were given verbal prompts before viewing the videotape replay. The KP and transitional information participants were given a videotape replay of their ball throwing along with information on how to improve throwing distance on the following trial. After evaluating performance outcomes and form ratings, the authors concluded that KR alone and KP in a form of videotape replay were the least effective and KP with the verbal cues and KP with transitional information were the most effective. In addition, authors point out to the specificity of the learning task, "When the learner must acquire a whole body action and new coordination mode, the usefulness of KR is limited." Nevertheless, other studies (Young & Schmidt, 1990, Schmidt & Young, 1991) have demonstrated that in learning complex motor skills both knowledge of results and knowledge of performance should be incorporated into feedback.

Finally, augmented sensory feedback or biofeedback is information on physical function. It is often used in rehabilitation settings. Biofeedback is used to inform patients about the level of their muscle activity, joint displacement, force generated, posture, or other level of activity. Feedback is typically provided in a visual or auditory form and it may function as either a discriminative or consequential stimulus, or both.

In the behavior analysis literature, the Azrin, Rubin, O'Brien, Ayllon, and Roll (1968) study found that the use of biofeedback in the auditory form was effective in reducing slouching. The authors developed an apparatus that provided a participant with a warning stimulus (a click sound) that was followed by an aversive tone during slouching. Twenty-five adults participated in this study. During the treatment condition, slouching produced a warning signal. If slouching discontinued, the aversive tone was avoided. If slouching continued, the warning signal was followed by an aversive tone. For all participants slouching decreased. A similar effect of biofeedback in the auditory form was found by Schulman, Stevens, Suran, Kupst, and Naughton (1978) in increasing a 10-year-old hypoactive boy's activity level and decreasing an 11-year-old hyperactive boy's activity level. The issue not addressed by these studies is stimulus control transfer from external feedback to proprioceptive feedback.

Biofeedback has become an effective component of physical-activity monitoring devices. For example, to quantify one's physical activity, pedometers or computerized linear accelerometers are routinely used. Nevertheless in movement rehabilitation, effects on physiological changes resulting from biofeedback are not always persistent and they may not necessarily relate to changes in functional movement, which is movement essential for everyday life tasks (Taub, Crago, & Uswatte, 1998). Biofeedback, when

used in movement rehabilitation, is applied for limited time periods. A change that occurs in movement during treatment sessions does not necessarily transfer to everyday life and, as a result, may not develop functional movement. Rose (1997) points out that one of the guiding principles for effective use of biofeedback in the physical rehabilitation process is for the patient to match the biofeedback signal with appropriate proprioceptive feedback. As suggested earlier, there is a paucity of behavioral literature regarding proprioceptive feedback. Taub et al. (1998) argue that operant conditioning and physical therapy have the same goal – the study of systematic change in behavior. Therefore, these two disciplines should have equal influence on physical rehabilitation. Nevertheless, Taub et al. concluded that the behavioral approach “has had little impact on the rehabilitation of movement, in part, because of the failure of biofeedback techniques to consistently effect changes in functional activity when applied to the treatment of movement disorders (p. 153).” Clearly this is an area that is ripe for further behavior analytic research.

The above review of the studies examining ecological reinforcers and different types of feedback underscores the importance of some aspects of behavioral consequences to be considered when studying movement. Although antecedents of movement may not be different from any other operant, there may be some issues that need to be considered when conducting a behavioral analysis of movement. Thus, antecedents of movement are discussed next.

Antecedents of Movement

Antecedent stimuli have a widespread influence on both operant and respondent behavior in everyday life (Dinsmoor, 1995). They provide a link between present

behavior and past reinforcement. In the analysis of behavior, antecedent stimuli that form functional relations between environment and behavior have stimulus control over behavior. These stimuli consist of multidimensional physical characteristics. The behavior of an organism can be influenced only by those stimulus characteristics that can be perceived by the organism. Nevertheless, in a given context, some, but not all, potentially perceived characteristics of a stimulus may have a controlling effect. For example, the object's shape and size, not its color, will affect the naming of an object as "ball." Stimuli that have a common effect on behavior while varying across physical dimensions form stimulus classes. In addition, the context in which responding occurs should also be considered.

When the focus of the analysis is movement, antecedents typically investigated are context, instructions, modeling, physical guidance, and visual stimuli. Also, because movement may be trained in one situation and performed in a different one, strategies for programming stimulus generalization are considered along with the antecedents. Thus, the following antecedents of movement are discussed next: (a) context, (b) instructions, (c) modeling, (d) physical guidance, (e) visual stimuli, and (f) strategies for programming stimulus generalization.

Context

The context in which discriminative stimuli are presented may signal different contingencies and, as a result, may guide behavior in different directions (Rachlin, 2000). Different settings, learning histories, and motivational levels are some of the possible contextual variables. Thus, conditional discrimination is a situation in which reinforcement for responding in a presence of a discriminative stimulus depends on other

stimuli, and the contingency thus formed is a four-term contingency (Catania, 1998). In complex behavior, conditional discrimination is common. For example, when talking about human locomotion, Thelen (1995) provides an example of environmental constraints participating in conditional discrimination:

Although the system permits jumping, hopping, crawling, or dancing the tango to cross the room, organic constraints and surface properties make it more efficient for humans to walk, and this is the pattern that all nonimpaired people discover and prefer. (In the moon's reduced gravity, however, astronauts chose to jump!) (p. 81).

Conditional discrimination may be observed in one's choice of movement. For example, when playing ball in water, swimming to get a ball is more efficient in deep water than running; however, running to get the ball in shallow water may be more efficient. In this situation, reinforcement for responding in a presence of a discriminative stimulus (the ball) depends on the depth of the water. Although choice has been extensively studied (e.g., Baum, 1973, 1974, 1979; Baum & Rachlin, 1969; Herrnstein, 1961, 1970, 1974), there is a paucity of such studies with respect to movement. Indeed, in a complex, naturally occurring environment, where reinforcement schedules are not manipulated by the experimenter, it is difficult to determine the types and rates of reinforcement available. According to Baum (2002), one could think of stimulus control as discriminative stimuli setting the context for certain activities or behavior patterns that are reinforced and, therefore, have longer duration. Thus, when behavior patterns need to be changed, discriminative stimuli setting the context for different behavior patterns are

introduced. Often such discriminative stimuli are rules, goals, and instructions for self-control.

Regarding discriminative stimuli and self-control, Rachlin (2000) suggests that there are three important determinants of responding: self-monitoring, delay of gratification, and global contingencies. Self-monitoring is often the first step in the development of self-control. In recent years there have been many new technological advances in monitoring and feedback devices, such as pedometers, accelerometers, treadmills, bikes, and computerized video dance machines, to increase one's physical activity (Chodzko-Zajko, 2001). Nevertheless, self-monitoring alone may not be effective. Delay of gratification is another important element of self-control in which discriminative stimuli for the given activity signal a higher value than discriminative stimuli for a competing activity. Delay of gratification is sensitive to rules and instructions. For example, a person may be instructed to engage in a particular physical activity four times a week to improve one's health. Finally, global contingencies indicate the overall value of reinforcers for particular behavior patterns that need to be developed. For example, one might understand the importance of physical activity, but first one has to arrange a context for this activity to occur. Second, the engagement in physical activity should produce reinforcers. Third, with time, long-term patterns of physical activity may be developed.

A study by Vintere, Schnall, and Poulson (2004), for example, examined the effects of a brief exercise program on activity patterns of hospital health-care executive managers with sedentary jobs. The brief exercise program consisted of ten mobility exercises and one breathing exercise. Three health-care executive managers participated

in the study. Self-monitoring used in this study was perceived physical stress level. There were two experimental conditions: baseline and maintenance. Participants' choice for physical activity and their movement patterns during the last five minutes of a 20-minute session were examined. Each participant had 5 or 6 movement-training sessions in which instructions were given not only on the proper movement execution, but also on the specific benefits of each exercise. None of the participants engaged in exercise activity during the baseline. Nevertheless, all participants engaged in the brief exercise instead of a more sedentary activity during maintenance. For two of the three participants, there was an increase in percentage of minutes spent in "relatively relaxed gross-motor activities" as opposed to "relatively tense gross-motor activities" during the last 5 minutes of the maintenance sessions, compared to the baseline sessions. This change in behavior patterns for the two participants was gradual, rather than abrupt, which might indicate a change in global contingencies (i.e., relaxation sessions became a part of workday routine that allowed for a change in behavioral patterns).

Instructions

One form of antecedents often presented in the context of motor-skill training is instructions. They may contain information such as reminders, statements, or goals. Thus, instructions used in motor-skill training are discussed next.

Some information about the purpose of the movement may be conveyed through instructions. In sports settings, for example, verbal instruction of the specific skills and their consequences may be provided to athletes (Allison & Ayllon, 1980; Kladopoulous & McComas, 2001) and goal setting is used to improve performance of the target behavior (Brobst & Ward, 2002; Ward & Carnes, 2002). Clinical studies have

demonstrated that patients with Parkinson's disease can improve their gait by changing walking variables such as step length, rhythm, ambulation velocity, and arm swing through a set of verbal instructions (Behrman, Teitelbaum, and Cauraugh, 1998). Similarly, verbal reminders to write "big" decreased micrographia, writing in small letters, of Parkinson's patients (Oliveira, Gurd, Nixon, Marshall, & Passingham, 1997). Oliveira et al. describe this phenomenon as a change from "open loop" performance, motor tasks that are automatic and do not depend on external stimuli, to "closed loop" performance, motor tasks that are sensitive to external stimuli. From the behavior analysis perspective, all behavior of an organism is under control of environmental stimuli (Dinsmoor, 1995). Instructions to write "big" may help bring writing under the control of the relation between a particular dimension of the stimulus (size of written letters) and a response (writing). Thus, even well practiced skills, such as writing and walking, may be modified by instructions.

Typical instructions given to motor-skill learners provide information on coordination of their body movements. A number of studies have questioned this practice, instead providing evidence for more effective learning by instructing the learners to focus on the effects of their movements (Wulf, McConnel, Gärtner, & Schwartz, 2002; Wulf & Prinz, 2001; Wulf, Prinz, & Hob, 1998). Beilock, Carr, MacMahon and Starkes (2002), however, demonstrated that the effectiveness of skill-focused instructions might vary depending on the learner's mastery or the setting.

The Beilock et al. study (2002) examined the differential effects of skill-focused and dual-task instructions on experienced and novice athletes. Dual task consisted of performance of a physical skill while listening and providing verbal responses to auditory

stimuli. Two experiments were conducted. In the first experiment, participants were 21 undergraduate students (7 women and 14 men) with 2 or more years of high school varsity golf experience. They were asked to perform the golf-putting task on an indoor putting green under two conditions: skill-focused and dual-task. Accuracy of putting was measured as mean distance (measured in centimeters) from the target of the 20 putts in each condition. Under the skill-focused condition, participants were instructed to monitor the swing of their clubs and when bringing the club to a stop to say out loud “stop.” Under the dual-task condition, participants were instructed to listen to different tones (500 ms each, occurring at random once within every 2-s time interval) while performing the golf-putting task and when they heard the target tone to say out loud “tone.” All participants were given 20 practice putts before starting the experimental conditions. The order of the experimental conditions was counterbalanced across participants. The results demonstrated that when instructed to focus on a specific component of the golf swing, accuracy of golf putting was degraded compared to both practice and dual-task conditions. The authors concluded that focusing on specific components of movement might compromise performance on well-learned movements.

In the second experiment Beilock et al. examined the effects of skill-focused instruction on a soccer dribbling task at different levels of skill proficiency. Twenty undergraduate students participated in the experiment. All reported to be right-handed and right-footed. Ten participants (8 women, 2 men) were novices, having less than 2 years of organized soccer experience. Ten participants (8 women, 2 men) were experienced soccer players, having more than 8 years of competitive soccer experience. Participants were asked to dribble a soccer ball in an indoor gymnasium through a slalom

course (10.5 m long) consisting of 6 cones set 1.5 m apart. Each participant was exposed to the soccer-dribbling task under two conditions: skill-focused and dual-task. Prior to each dribbling trial, participants were told which foot to use (right or left) to dribble the ball through the cones. The dribbling speed in seconds for each error-free trial was measured. Under the skill-focused condition, participants were instructed to dribble the ball, and upon hearing a single tone (occurring at a random time during every 6-s interval) to verbally indicate whether at that instance the inside or the outside of the foot touched the ball. Under the dual-task condition, participants were asked to monitor the list of words and say out loud the target word, “torn,” while performing the dribbling task through the slalom course. Words were spaced randomly within the 2-s time intervals and the target word was randomly embedded in the word list. All participants were given 4 dribbling practice trials (2 with the right foot and 2 with the left foot). The order of the experimental conditions was counterbalanced between participants. Each participant performed 4 sets of 2 dribbling trials (2 trials for each foot in the two experimental conditions). The results for right-foot dribbling replicate the findings of the first experiment: experienced soccer players performed at lower levels in the skill-focused condition compared to both practice and dual-task conditions. The novices, however, showed an improvement in their performance level under the skill-focused condition and a decrement under the dual-task condition when compared to practice performance levels. The results for left-foot dribbling differed from those of right-foot dribbling. Both novices and experienced soccer players performed better under the skill-focused condition compared to both practice and dual-task conditions. This study demonstrated that the effectiveness of skill-focused instruction may be different under different

conditions. The authors suggest that early in the acquisition of the motor skill, skill-focused instruction may be the most beneficial. For well-learned skills, however, this type of instruction may be detrimental in situations in which maximized performance is desired, such as during competitions. Nevertheless, under some conditions, such as practice when maximal performance is not essential, and such as modification of some elements of a skill, skill-focused instruction may be beneficial for well-learned skills.

In addition to instructions modeling may be used in introducing a new motor skill. Despite the fact that there are a variety of ways to instruct learners in movement, modeling is often selected. Writing about sport skills, Weiss, Ebbeck, and Rose (1992) suggest that “because visual information is such powerful means of conveying information about sport skill in particular, modeling is one of the most important instructional strategies for broadening the physical skill repertoire of children and adolescents”(p. 292).

Modeling

Modeling has been shown to facilitate the acquisition of not only sports skills (Allison & Ayllon, 1980; Shapiro & Shapiro, 1985), but also other motor skills, such as dancing (Fitterling & Ayllon, 1983; Lagomarcino, Reid, Ivancic, & Faw, 1984; Vintere, Hemmes, Brown, & Poulson, 2004), toy play (Poulson & Kymissis, 1988), and more fundamental motor skills, such as rolling, skipping, pushing, and catching (Goodway & Branta, 2003). In teaching a new motor skill through modeling, it is important to evaluate the individual elements comprising this stimulus complex because they may have an influence on the learner’s subsequent imitative responding. McCullagh, Weiss, and Ross (1989) claim that there are three elements that have been shown to affect motor

performance levels. In behavioral terms these elements might be described as: (a) task strategies, such as imitation (b) discriminative stimuli accompanying modeling, such as verbal instruction, and (c) characteristics of the modeled stimuli themselves.

One of the McCullagh et al. (1989) elements of modeling consists of task strategies. In the behavior analysis literature, strategy is defined as relations among stimuli, responses, and consequences across trials or conditions, not by specific stimulus and response properties (Catania, 1998). One of the examples of a task strategy might be generalized imitation. According to Poulson, Nunes, and Warren (1989), generalized imitation is observed when

...(1) a potential imitator observes the responding displayed by a model, (2) an imitator's responding temporally follows the demonstrated responding, (3) the topography of an imitator's responding is functionally controlled by the topography of a model's responding, (4) this topographical control is exhibited over a wide variety of modeled responses, (5) imitative responses that have seldom or never been reinforced are performed as long as other imitative responses continue to be reinforced (p. 272).

Object manipulation is one of the tasks that may be learned through generalized imitation. The evidence that 9- and 10- month old infants are able to imitate object manipulation has been experimentally demonstrated (Melzoff, 1988; Poulson & Kymisses, 1988). For example, Poulson and Kymisses (1988) examined the effects of parental modeling and contingent praise on motor response topographies of three-10-month-old infants. Each infant's mother modeled toy-play responses and provided praise contingent on infant's responses that matched her model. Some of the toy-play responses

were peering through a tube-like object, placing a smaller object into a bigger one, and tossing an object into air. All three infants showed an increase in the percentage of toy-presentation trials in which the targeted response topographies were emitted. This study experimentally demonstrated generalized imitation with infants. Thus, modeling may be used in teaching novel responses very early in human development.

Another McCullagh et al. (1989) element of modeling that may affect motor performance is modeling that is accompanied by additional discriminative stimuli, such as verbal instructions. In some situations, a visual model can be enhanced by additional verbal stimuli that emphasize important components of the modeled skill (Weiss, 1983). The “show and tell” models have been effective with young children in their learning of gross-motor sequences (Weiss, Ebbeck, & Rose, 1992; Weiss & Klint, 1987). For example, Weiss et al. (1992) examined effects of modeling and verbal rehearsal on motor-skill-sequence learning by assessing the correct sequencing and form. Two age groups (5 to 6 years and 11 months and 8 to 9 years and 11 months) of 60 children were randomly assigned to three experimental conditions (verbal rehearsal only, model only, and model plus verbal rehearsal). The children were taught a 6-part motor-skill sequence. In the verbal-rehearsal only condition, children were presented with two videotaped demonstrations of the motor-skill sequence. One of the demonstrations showed a rear-view angle and the other showed a side-view angle. These demonstrations were accompanied by the experimenter’s naming the skills while they were demonstrated. A verbal-model-plus-verbal rehearsal condition was the same, except that after viewing the two videotaped demonstrations, children were asked to name all the skills in the order in which they were presented. The children recited the skill sequence. If children were not

able to remember all the names of the skills, they were prompted. In a verbal-rehearsal-only condition, children stood next to the motor-skill course and the experimenter provided instructions on the order of the skills and recited the names of the skills. Instructions and naming of the skills were presented twice and then children were asked to report what they are going to do. Results demonstrated that older children performed equally well in both sequence and form under the model-only and model-plus-verbal-rehearsal conditions. The younger children performed sequences better under the model-plus-verbal-rehearsal condition and they performed equally well in form under modeling-only and modeling-plus-verbal-rehearsal procedure.

Verbal stimuli may direct attention to the relevant elements of the task.

Nevertheless, these stimuli could be provided in many different ways, such as a detailed instruction, key words, or modeled self-instruction. Vintere, Hemmes, Brown, and Poulson (2004), for example, used self-instruction as part of the modeled gross-motor response to examine the acquisition of six complex gross-motor chains in six preschool-age children. Three of the six gross-motor chains were taught using a modeling and praise procedure and the other three were taught using self-instruction, modeling, and praise. The motor learning measures of acquisition curves demonstrated a faster acquisition rate in five of the six gross-motor chains under the self-instruction, modeling, and praise condition.

Finally, the third McCullagh et al. (1989) element of modeling that may affect motor performance is characteristics of the modeled stimuli themselves. These authors, along with Sulzer-Azaroff and Mayer (1991), agree that to increase the probability of an imitative response there are three characteristics of the model to be considered: (a)

mastery level of the given skill of the model; (b) the model's similarity to the observer; and (c) prestige of the person modeling. In the motor-learning literature, many writers of contemporary textbooks have presented the model's mastery level in the given skill as the most important characteristic (Magill, 1993; Schmidt, 1991). In reviewing the modeling literature on motor learning, Scully and Newell (1985) indeed found a large number of studies demonstrating better performance for the observers who watched a skilled model before practicing. Nevertheless, an equally large number of studies have failed to replicate this finding. Scully and Newell suggest that the explanation for these contradictory findings may lie in the familiarity level of the given movement. If the skill modeled is new for the observer, a skilled model may be more effective. With familiar skills the mastery level of the model becomes less important. Nevertheless, Pollock and Lee (1992) demonstrated that in learning a computer tracking game it was equally effective for the observers to watch either skilled or unskilled models. Lee and White (1990) and McCullagh and Caird (1990) demonstrated similar findings.

The model's similarity to the observer refers to characteristics shared by the two (e.g., age, experience, and appearance). The observer is more likely to imitate someone who is more similar (Bandura, 1968). In the motor-learning literature, similarity of the model to the observer has been examined (McCullagh, 1987; Gould & Weiss, 1981). For example, McCullagh (1987) examined model similarity effects on a ladder-climbing task. Seventy-five college women were randomly assigned to two groups: the experimental group was exposed to a model-similarity manipulation (similar and dissimilar) and the control group was not presented with a model. All participants in the experimental group were presented with a videotaped demonstration of ladder climbing in which the goal was

to balance the ladder in front of oneself and climb up the ladder. In the similar model condition, participants were informed that the model was, like them, a college student who had not had previous experience with this task. In the dissimilar model condition, participants were informed that the model, unlike them, was a dancer and gymnast who had experience in this task. The dependent measure was performance scores, defined as height climbed. The results of the initial performance demonstrated that participants exposed to the similar model condition performed better (e.i., climbed higher) than participants exposed to the dissimilar model condition or to the control group.

Nevertheless, with practice, the modeling and control groups scored similarly. The author concluded that when a novel motor skill is learned, only the initial acquisition is enhanced by providing a model with characteristics similar to those of the learner.

Furthermore, Scully and Newell (1985) in their review of the above and similar studies on motor learning suggest that “kinematic” (molecular) and “outcome” (molar) measures might produce different results. The McCullagh (1987) study used only molar measures.

Finally, effects of prestige of the person modeling have been investigated in the motor learning literature (Landers & Landers, 1973; McCullagh, 1986). For example, in the Landers and Landers (1973) study of in vivo modeling, a high-status model was a classroom teacher and a low-status model was a student. In the McCullagh (1986) study of video modeling, a high-status model was a university cheerleader and a low-status model was a university student. The findings of these studies were similar to the findings of the model-similarity studies. That is, a transitory effect of the model’s status was observed when the high- and low-status model conditions were compared. Participants in

the high-status model condition performed better during the initial performance of the skill, but this difference disappeared as more time was spent in practice.

From the above review, it is clear that an observer's performance can be affected, at least initially, by such characteristics of a model as mastery level of the given skill, similarity to the observer, and prestige or status of the person modeling the responses. Nevertheless, the extent to which these characteristics serve discriminative or motivational functions is unclear (McCullagh, Weiss, & Ross, 1989). In addition there is no clear evidence that any of the characteristics of the model affect how well the skill is eventually learned (McCullagh, 1986; McCullagh, 1987).

In movement training, especially teaching a novel response, in addition to instructions and modeling, physical guidance may be used. Thus, physical guidance is discussed next.

Physical Guidance

In the behavior analysis literature, physical guidance or physical prompts are defined as another person physically assisting the learner to engage in the correct response, such as an instructor correcting dancer's arms or a coach spotting a gymnast during a new stunt (Baldwin & Baldwin, 1998; Sulzer-Azaroff & Mayer, 1991). Nevertheless, in the motor-learning literature, mechanical prompts (Baldwin & Baldwin, 1998) such as training wheels on children's bicycles, floating devices for swimmers, and baby walkers are also considered physical guidance (Rose, 1997; Wulf, Shea, & Whitacre, 1998). These prompts may give kinesthetic guidance, reduce errors, provide security in potentially risky situations, and produce faster skill acquisition. Thus, whether the physical guidance is manual or mechanical, it serves the same function: it assists the

learner in some aspects of movement. Nevertheless, to avoid extended dependence on physical guidance it is important to gradually transfer stimulus control from the physical prompt to the naturally occurring stimulus (Sulzer-Azaroff & Mayer, 1991).

In the behavior analysis literature, physical prompts have been demonstrated to be effective in teaching locomotion to developmentally disabled children (Horner, 1971; O'Brien, Azrin, & Bugle, 1972). In the O'Brien, Azrin, and Bugle study, the goal was to reduce crawling and increase walking by profoundly retarded children. These children seldom walked and frequently crawled. They exhibited greater fluency and speed in crawling than walking. These two responses have different topographies, but they serve the same function – they provide movement through space. The researchers implemented a training program that consisted of two types of physical prompts: “restraint-for-crawling” and “priming-for-walking” (O'Brien et al., 1972). “Restraint-for-crawling” was defined as the trainer allowing the child to make crawling movements without allowing him or her to move forward, but at the same time holding the child by the waist from behind for 5 s. “Priming-for-walking” was defined as the trainer raising the child to a standing position and allowing the child to walk in the direction in which the child had been crawling. Physically preventing the crawling for a 5-second interval and then releasing the child decreased subsequent crawling. Simultaneously, with the crawling procedure, physically priming allowed the children to improve the fluency and speed of their walking skills. This intervention that combined two physical prompting procedures was successful for these children because the frequency of daily crawling decreased and frequency of daily walking increased systematically with the introduction of treatment. Following the combined procedure, using restraint for crawling alone was effective.

When the treatment was discontinued, there was a notable improvement in the walking of all participants. Thus, arranging conditions in which the learner is able to contact the presumptive ecological reinforcers was effective in training walking in profoundly retarded children.

In the motor-learning literature, the Wulf, Shea, and Whitacre (1998) study, discussed earlier in this paper in the context of kinetic movement analysis, examined the benefits of physical guidance in learning to perform slalom-type movements on a ski-simulator. Two groups of participants practiced the same task in which they had to move the platform of the ski-simulator making slalom-type movements. The control group practiced without physical guidance, whereas the experimental group practiced with physical guidance, using poles. Two dependent measures were used: overall performance, measured as movement amplitude (in centimeters) of the platform movement and the efficiency of the movement pattern, measured as relative foot-force onsets. The response measures were taken during the practice, immediate retention, and delayed retention trials. The experimental conditions differed only during the practice trials. During immediate retention and delayed retention trials, both groups performed slalom-type movements on a ski-simulator without poles. The results showed that, on the overall performance measure, there was no difference between the two groups during the immediate and delayed retention trials. The physical guidance group demonstrated more efficient movement patterns than the no-physical guidance group during immediate and delayed retention trials. These findings suggest that, in complex motor skills, physical guidance may be beneficial in helping the learner to produce more efficient movement patterns and shorten the learning process without degrading the overall performance of

the task. Nevertheless, many motor-learning researchers have concluded that physical guidance is of a limited value because they may not aid movement proficiency and often result in dependence on these prompts (Rose, 1997). According to Rose (1997), the situations in which physical guidance may be effective are: (a) teaching a movement pattern not previously experienced; (b) helping learner to overcome fear related to an activity; and (c) guiding the learner early in skill acquisition to prevent an injury. In addition, according to Sulzer-Azaroff and Mayer (1991), two specific guidelines should be followed when using physical prompts. First, conditions should be arranged for the learner to attend to relevant proprioceptive cues. Second, gradual stimulus transfer from physical prompt to another stimulus should be introduced. The Wulf, Shea, and Whitacre (1998) study is an example of teaching a movement pattern not previously experienced by the learner. Although practice conditions allowed the experimental group to experience greater movement amplitude and therefore, be exposed to relevant proprioceptive cues, stimulus transfer was not introduced.

As discussed above, physical guidance may be used as a prompt to facilitate acquisition of new physical responses. Several studies have demonstrated that visual stimuli may also be effective prompts used in motor-skill training (e.g., Mosk & Bucher, 1984; Osborne, Rudrud, & Zezoney, 1990).

Visual Stimuli

Visual stimuli often are used as prompts that facilitate discrimination along a particular stimulus dimension (e.g., location, height, or speed of rotation) and fading are used in visual-motor skill training to improve visual discrimination and to develop the independence from the prompts (Mosk and Bucher, 1984; Osborne, Rudrud, &

Zezoney, 1990; Schilmoeller, G. L., Schilmoeller, R. J., Etzel, B. C., & LeBlanc, J. M., 1979; Touchette, 1968). For example in sports-skill training, Osborne, Rudrud, and Zezoney (1990) used prompt stimuli in baseball to help batters estimate the rate of ball rotation to improve the hitting of curve balls. Two training conditions were used. In one training condition baseballs were highlighted with ¼-in. orange stripes and in the other with ⅛-in. orange stripes. This stimulus prompt improved the batters' hitting the marked curveballs. The mean increase in hitting the marked curveballs in the ¼ -in. condition was higher compared to the ⅛-in. condition. This study did not implement a planned fading procedure to transfer stimulus control from ¼-in. orange stripes to ⅛-in. and to unmarked curveballs. Thus, the improvement in the batters' hitting curveballs was limited to the two training conditions. Nevertheless, participants reported perceived improvement in the hitting of curve balls following the training.

Unlike Osborne, Rudrud, and Zezoney (1990), Mosk and Bucher (1984) used a carefully planned fading procedure in teaching visual-motor skills to children with mental retardation. Six children were trained on two pegboard-insertion tasks using errorless learning procedures (Etzel & LeBlanc, 1979; Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979; Terrace, H. S., 1963). The final task criterion was to place two pegs into specific holes of a six-hole Plexiglas board. Each task had 13 levels of increasing difficulty. During a control procedure, children were immediately introduced to the highest difficulty level (Level 13). During the errorless learning condition, all children began at Level 1. Advancement to the next level was contingent on a correct response that was not prompted. At each level criterion related cues of the number and size of incorrect holes were manipulated. Compared to the control condition, errorless learning

produced faster acquisition for five of the six participants, resulted in fewer errors, and required fewer prompts. Unfortunately, there was a greater density of reinforcement in the errorless learning condition so that one cannot conclude that the errorless learning procedure alone caused the improved performance.

In conclusion, the above reviewed studies examined antecedents of movement: context, instructions, modeling, physical guidance, and visual stimuli. Nevertheless, behavior control often occurs and is programmed to occur in the presence of novel stimuli that are similar to the training stimuli. Thus, strategies for programming stimulus generalization are discussed next.

Strategies for Programming Stimulus Generalization

When behavior control occurs in the presence of novel stimuli that are similar to the previously trained stimuli, the phenomenon is referred to as stimulus generalization. The Guttman and Kalish (1956) study provided a method of studying stimulus generalization by looking at a generalization gradient, the relation between rate of responding and a given stimulus dimension. While it is possible to specify the exact physical dimensions of stimuli in the laboratory settings, it is much more difficult in everyday life. For instance, a learner having learned to shoot a basketball with the rim that is 18 inches in diameter that does not have the net will most likely exhibit the same skill with the rim of the same diameter that has the net. Nevertheless, other stimulus dimensions might control this response, such as the shape of the backboard, the texture of the board, and the support structure. To achieve relative control over responding a systematic approach to generalization has been proposed (Martin, 2003; Stokes & Baer, 1977).

In an environment that is constantly changing, stimulus generalization “gives stability and consistency to our behavior” (Keller & Schoenfeld, 1950/1995, p. 116). To achieve stability and consistency in complex-motor skills and to program for stimulus generalization such strategies as simulations, programming of common stimuli, and varying training conditions are used (Martin, 2003; Stokes & Baer, 1977).

Conditions in which the training stimuli are made as similar as possible to the naturally occurring stimuli are referred to as simulations. Athletes often use simulations when training for competitions, such as wearing the competition outfits and going through pre-competition warm-up routines (Orlick & Partington, 1988). In terms of proprioceptive stimulus generalization, complex swimming maneuvers often are practiced out of a swimming pool before performing them in water (Koop & Martin, 1983). Similarly, dress rehearsals in performing arts may be viewed as simulations to promote stimulus generalization from rehearsal to performance. Pilots and military personnel often use simulators in their training of complex skills that are needed to operate complicated and expensive equipment.

An alternative strategy to simulations is to bring the target behavior under control of a few specific stimuli in training that most likely are going to be present in the naturally occurring situations. This strategy is referred to as “programming common stimuli” (Stokes & Baer, 1977). Lagomarcion et al. (1984), for example, used common stimuli in teaching social dancing to teenagers with mental retardation by including common supervisory elements, performed by trainers and staff, during training in one location and post-training in a different location. Similarly, music may serve as a common stimulus during a choreographed ballet-sequence presentation by the teacher

and subsequent performance of the same sequence by a learner (Starkes, Deakin, Lindley, & Crisp, 1987). Generalization from training to naturally occurring situations was observed using identical instructional materials for relaxation exercises used by hospital health-care executive managers (Vintere, Schnall, & Poulson, 2004) and using activity schedules for various types of activities for children with autism (McClannahan & Krantz, 1999).

Finally, varying the training conditions is a strategy that involves training under a wide variety of conditions. Typically, this strategy is used with skills that demand a high level of movement consistency in a relatively stable environment (e.g., playing basketball, platform diving, dancing, and gymnastics). For example, to prepare a gymnast for a competition, he or she should be exposed to different practice conditions, such as presence of other athletes, noise, and the simultaneous practice of other gymnasts. Martin (2003) provides two assumptions underlying this type of strategy: (a) during training, complex-motor skills are brought under the control of a variety of stimuli and (b) during competition, the athlete may be less susceptible to distractions.

Conclusion

There has been no cohesive research program on the study of movement in behavior analysis. Nevertheless, the present paper reveals that there are many behavior analytic studies pertaining to movement. This paper argues that when movement is defined in behavioral terms, it is a viable and socially important area of study. In behavior analysis, the study of movement may require a shift in the kinds of dependent variables studied and a consideration of ecological reinforcers. In terms of antecedent stimuli, there is still further need to analyze the role of antecedent stimuli as they may

affect not only the function of movement, but also its topography. As Bult and Rispens (1999) note, "...man's movement abilities are the result of 3.5 billion years of evolution"(p.1). Perhaps by addressing the issues of movement acquisition and maintenance behavior analysts might influence the future of man's movement abilities.

Appendix B

Lectures on three classical ballet movements.

Lecture 1

We have been working on the *en dehors pirouette* for some time now.

Unfortunately, we have not made much progress with this movement. Your performance level is below that of a chance. In dance, having technique means that the performance of a given movement is above the chance level, succeeding at least 70% to 80% of the time.

In this lecture, we are going to examine the technique of performing the *en dehors pirouette* from 5th position. First, we will analyze the task by looking at the basic components of the pirouette and will discuss the relation between form and function of the *en dehors pirouette*. Also, we will look at the role of the dynamic properties. Next, we will examine the errors associated with the *en dehors pirouette* and discuss the work of various muscle groups involved in this particular movement.

It is clear that you know what the *en dehors pirouette* is. You have seen it many times and you have succeeded in performing it correctly at least some of the time. That is, you know the form of this movement. I think we can agree that the *en dehors pirouette* consists of three distinct components: preparation for the turn, the turn itself, and the ending of the turn. Let us look at each of the components of the pirouette separately, assuming that the turn will be made to the right.

In terms of form during the preparation for the turn, the feet are in the 5th position with the right foot in front. The right arm is in the 1st position and the left arm in the 2nd position. The body is held straight with the knees bent in a *demi pli e*. The function of this component is to create the downward force. It is possible to have a correct form; nevertheless it may not be functional. For the preparation, in order for the turn to be functional, the dynamic properties should be controlled.

There are three dynamic properties to consider: force, speed and effort. In our work on *en dehors pirouette*, we will focus on the two of them – force and speed. We have to be aware of constantly changing conditions that a dancer creates, such as the amount of force and speed. Consequently, the dancer has to control to succeed in a given movement. In the preparation for the turn, bending the knees and pushing the heels down into the floor while keeping the body straight create the downward force for the turn.

The next component of the pirouette is the turn. In terms of form, the right arm opens out in the 2nd position, just before going up on a *demi pointe*. Then both arms close in the 1st position while going up on a *demi pointe* and turning with the right leg in a *passé* while keeping the body straight. The function of a single pirouette is to make a full turn.

In terms of the dynamic properties, the speed with which the right arm is opened may affect the turn, sometimes creating too much force. Similarly, too much or not enough force for the turn may be produced by the speed with which one goes up on a *demi pointe* or by the level of engagement of the supporting leg muscles. Finally, the timing of the leg and arm movements must be coordinated with the pivoting motion of the supporting foot going up on a *demi pointe*.

The final component of the pirouette is the ending of the turn. In terms of the form, one should go down in a *demi pli  * with the feet in the 5th position and the arms opening in the 2nd position. The function of this component is to stop the turn and hold the position for at least one second. Once again, the dynamic properties of the turn should be controlled. Unlike the first two movement components where the force was created, in this component, the force has to be cancelled out and sometimes it may be difficult to

stop the turn. Often errors in the first two components are affecting the final component of the pirouette.

You probably are wondering how to manage the dynamic properties of movement. Of course, it is clear that, depending on the given goal, some movements need to be performed faster and others slower. Another important factor is the muscles that help us control the amount of force. A relatively complex movement, such as a pirouette, typically is not controlled by just one muscle. In coordinating movements, the action of two or more muscle groups is needed. If we look at an isolated muscle action, we can identify six muscle actions: flexion, extension, abduction, adduction, inward rotation, and outward rotation.

As an example for these six actions, let us look at the arm movement. First, bend your right elbow by keeping your right palm opened and moving your right hand toward your right shoulder. The group of muscles that accomplishes this action is called the flexors. For the second action, start from the elbow being bent and straighten the arm. The muscle group that accomplishes this action is called the extensors. For the third action, move the arm out to the side keeping the elbow straight and move it to the shoulder level. The abductors accomplish this action. For the fourth action, start from the arm being out at your side, at shoulder level, and slowly move it down. The adductors are responsible for this action. Next, keep the arm down at your side and turn it outward. You probably can guess which muscles are responsible for this action, the outward rotators. Now, keeping the right arm down at your side, turn it inward; the muscle group responsible for this action is called the inward rotators. In movement, it is helpful to know that muscle groups work in oppositional pairs: flexors against extensors, adductors

against abductors, and inward rotators against outward rotators. In addition, we have to consider that some muscle groups counteract gravity, while other muscle groups work in the same direction as gravity. In our arm exercise, when you lift the arm up the adductors work with gravity and the abductors work against it. That is, the abductors must be used to oppose gravity. To produce movement or to maintain a position, muscles must oppose gravity.

Although the *en dehors pirouette* is much more complex movement than the isolated actions that we just examined, we can look at the muscle groups that oppose gravity. The main muscle groups that we should focus on in the *en dehors pirouette* are (a) abdominals that keep the trunk in a stable position; (b) upper back muscles that help stop the body's movement forward; (c) outward rotators that keep the leg turned out; (d) extensors of the leg – quadriceps – that keep the leg straight; and (e) muscles around the ankle that provide a solid support on a *demi pointe*. When errors occur, several muscle groups may not be properly engaged and result in various faulty outcomes.

Now let us examine various outcomes of the *en dehors pirouette*. I have observed that typically there are four major types of errors. Please look at the handout where the four outcomes are listed under the *Type of Error*. In *Error I*, the turn is not accomplished. In *Error II*, the turn goes beyond the full turn. Extra movements characterize *Error III*, whereas in *Error IV*, the supporting leg does not provide enough support to maintain the balance on a *demi pointe*. In your performance of the *en dehors pirouette*, you have extra movements at the end of the turn, *Error III*. Each type of error is associated with specific errors. I would like you to experience the specific errors associated with each type.

As you can see in your handout, for *Error I*, when the turn is not accomplished, there are six specific errors listed. Some of these errors occur at the beginning of the pirouette, the others during the turn or at the end of the turn. The first specific error is “Not enough force is exerted against the floor when bending the knees in a *demi pli  * just before the turn.” Please make a *demi pli  * barely bending your knees and barely keeping your heels on the floor, but keeping your body properly aligned over your feet. Now, try doing the pirouette. As you can see, you could not complete a full turn. The second specific error – “The heels do not stay on the floor during a *demi pli  * just before the turn” – appears to be very similar to the first, but the heels typically start going off the floor when the body is not kept straight; the upper back is not fully engaged. Try now performing this error. As you noticed, once again, you were not able to complete the turn. The third specific error – “The rising and pivoting backward on the ball of the foot is too slow” – is the error in which the speed of movement has to be controlled. Try rising slowly and you see that there is not enough force produced for a full turn. The fourth specific error deals with the synchronization of movements of the arms and feet – “Timing of the movement series – rising and pivoting backward on the ball of the foot and closing of the arms in the first position – is not synchronized” – the result quite often is an incomplete turn. For the next specific error, error five – “The muscles of the upper back are not fully engaged at the end of the turn” – try to deliberately disengage the muscles of the upper back at the end of the turn. The result of this type of error is ending the turn in the 4th position because the body starts falling forward. Finally, commit specific error six – “The knees are not bent and the heels are not down on the floor at the end of the turn.” The result of this error is finishing the turn on a *demi pointe*. Now you

have sampled all incorrect outcomes of the *en dehors pirouette* listed under *Error I*. Of course, there is always a possibility that more than one error may occur.

For *Error II*, when the turn goes beyond a full turn, there are four specific errors listed. The first specific error – “The opening of the right arm creates too much force at the beginning of the turn” – deals with faulty arm movement. Try opening your right arm forcefully at the beginning of the turn. Even in the absence of any other errors, your turn may go beyond the starting position. The second specific error deals with the speed of the movement – “The rising and pivoting backward on the ball of the foot is too fast.” Try committing this error and observe the outcome. For a single turn you have to learn to find a proper speed or you may not be able to stop the turn at the required position. The third specific error deals with not being able to isolate movement of the leg – “The right hip moves with the knee at the start of a turn.” In this case, the body may not be properly aligned over the supporting leg and the outward rotators may not be fully engaged to isolate the leg movement. Thus, there is centrifugal force created, which results in overturning. Finally, specific error four deals with canceling out rotational force – “The arms open to the 2nd position too late.” Often it is difficult to create just enough force to complete the turn and that is why the opening of the arms in 2nd position is helpful to slow down the rotational force. Try now to make a turn not opening the arms upon completion of the turn and notice how difficult it is to stop the turn. Now you have sampled all specific errors listed under *Error II*. As in *Error I*, there may be more than one error occurring.

As I mentioned earlier, extra movements characterize *Error III*. Let us look at nine specific errors listed in your handout. The first specific error relates to the body

falling forward – “The muscles are not fully engaged in the upper back during the turn or at the end of the turn.” Typically when the upper back is not fully engaged the body tends to fall forward. Try standing in *passé* and slightly disengage the muscles of the upper back; you see you are not falling yet. Now, try disengaging the same muscles while balancing on a *demi pointe*; now you did lose your balance. Actually, it is not the position, *demi pointe* versus keeping the heel on the floor, but the combination of the degree of muscle engagement and the base area over which one balances. Now, try committing this error during the pirouette. As you can see, your body fell forward. Now let us examine the second specific error in which the body tends to fall backward – “The abdominal muscles are not fully engaged during the turn or at the end of the turn.” As in the previous error, even though you are able to complete the turn, the body falls backward. The third specific error deals with the body falling sideways – “As the right foot moves down, the body tips to the left at the end of the turn.” This error indicates that even though the turn was completed, the dancer was not over the supporting leg, rather the weight was pushed too far toward the side of the supporting leg, and in this case it is the left leg. Try committing this error. Now, the next specific error, error four, deals again with the body tipping sideways, but this time to the right – “As the right foot moves down, the body tips to the right at the end of the turn.” In order to commit this error, your weight should not be fully shifted over the supporting leg. As you experience these two errors, you see that in the former case you may overcompensate the weight shift, whereas in the latter case the weight shift may be incomplete. Next, let us look at two specific errors, five – “Arms are lower than the *1st position* during the turn” and six – “Arms are higher than *1st position* during the turn.” Although in both cases it may be possible to

complete a pirouette, the incorrect positioning makes it more difficult and often leads to a failed turn. Try committing both of these errors. You see that in the specific error five the centrifugal force is pulling you away from the center. In the specific error six the arms are not providing enough support to maintain the center. Finally, specific errors seven, eight, and nine may produce a hop at the end of the turn. Let us look at error seven – “The thigh muscles of the supporting leg are not fully engaged during the turn.” Try turning and slightly disengaging the supporting leg thigh muscles. Because the muscles are not fully engaged, it is more difficult to maintain the center. A hop at the end of the turn may allow you to adjust your positioning to finish the turn being centered, but that leads to the error that we are discussing now. Error eight – “A *demi pli * is not deep enough at the end of the turn” – deals with canceling rotational force. Try finishing your pirouette by barely bending your knees. As you noticed, it was difficult to stop the rotation and a hop occurred. Error nine – “Too much force is created at the beginning of the turn” – also deals with canceling rotational force. As you generate excessive force for a single pirouette, you may find it difficult to stop the turn and a hop breaks this force and allows you finish the turn at the starting position; thus producing the error that we have just been discussing. Now that you have sampled all incorrect outcomes of the *en dehors pirouette* listed under *Error III*, let us focus on *Error IV*.

For *Error IV*, the supporting leg does not provide enough support to maintain the balance on a *demi pointe*, there are two specific errors. They both deal with muscles counteracting gravity. Specific error one – “The thigh muscles of the left leg are not fully engaged at the end of the turn” – indicates that there was not enough power to sustain the elevated positioning. Unlike in *Error III*, the turn is completed without a hop, but the last

portion of the turn is completed with the supporting leg heel being down on the floor. Specific error two – “The muscles of the left ankle are not fully engaged at the end of the turn,” – indicates that the source of weakness in sustaining the elevated position is at the ankle. Now carefully try committing this error. As you can see, you were not able to complete the turn on *demi pointe*.

As you sampled each of the specific errors, you were exaggerating them. When you are asked to perform the *en dehors pirouette* correctly, you may find that there is more than one error occurring simultaneously. Some of the errors you will be able to correct as you perform the movement and you may end up with a correct outcome. For example, at the end of the pirouette you may notice that you are about to travel forward. By engaging the upper back muscles you may correct this error and finish the turn at the starting position without traveling forward, *Error III*.

Finally, we are ready to start the practical work on the *en dehors pirouette*. For the following practice sessions you will take an active part in your error analysis. You will be asked to practice pairs of the *en dehors pirouettes*, the “correct” and “incorrect.” First, I will ask you to perform the pirouette the “correct” way. Once you complete it, I will ask you to label it as “correct” or “incorrect.” If the pirouette is not performed correctly and you label it as such, I will ask you to identify one or several specific errors that you think contributed to the given outcome. If the pirouette is performed correctly and you label it as such, you will move to the next type of practice. Next, I will ask you deliberately make a specific error. You may or may not succeed in performing the requested error, however, once again, you will have to label the outcome of your performance as “correct” or “incorrect” and tell me, in your opinion, whether you

committed the error that I asked you to perform. For both types of practice I will provide feedback and you may be asked to practice the turn.

I can imagine that all of this sounds a little confusing. Do you have any questions? Perhaps we should start the first practice session with the pairs of the *en dehors pirouettes*.

Lecture 2

In this lecture we are going to examine technique of performing the *piqué in 1st arabesque*. As with the *en dehors pirouette*, we will analyze the task by looking at the basic components of the *piqué in first arabesque*, discuss the relation between form and function and the dynamic properties of this movement, followed by looking at the errors associated with this movement.

The *piqué in 1st arabesque* consists of three components: preparation, the step and the balance on the *demi pointe*, and step forward in the preparation position. Let us look at each of the components of the *piqué in 1st arabesque* separately, assuming that you will balance on the right foot.

In terms of form, during the preparation component, the left knee bends in the *demi plié* while the right leg goes through the *coup de pied* extending in front and both arms are in the *préparation position*. The function of this component is to shift the weight of the body over the left leg. Going down in the *demi plié* creates a downward force. By keeping the back straight and having all the weight shifted over the left leg, a greater downward force can be created.

During the step and balance, the weight is shifted over the right leg on a *demi point* while the left leg is being lifted up in the back, the right arm reaches out in front of

you and the left reaches out to the side. The function of this component is to shift the weight of the body over the right leg and maintain the balance for at least four seconds. In terms of the dynamic properties, a forward force is created by moving the weight over the right foot and this force is then cancelled out by engaging the muscles of the upper back and lifting the left leg up once the weight is transferred over the right foot.

During the last component – step forward in the preparation position – a step forward is made on the left foot, keeping the right foot in the *préparation* position while both arms come down at your sides. The function of this component is to shift the weight of the body over the left foot. In terms of the dynamic properties, a forward force is created moving the weight over the left foot and this force is then cancelled by holding the upper back.

We will focus on the same muscle groups as in the *en dehors pirouette*: (a) abdominals that keep the trunk in a stable position; (b) upper back muscles that help stop the body's movement forward; (c) outward rotators to keep the leg turned out; (d) extensors of the leg – quadriceps – that keep the leg straight; and (e) muscles around the ankle that provide a solid support on the *demi pointe*. As I mentioned in the first lecture, several muscle groups are engaged in controlling a given movement. Consequently, errors may occur in controlling more than one muscle group. The outcome often informs you which dynamic properties were not sufficiently controlled.

Now let us examine various outcomes of the *piqué in 1st arabesque*. I have categorized incorrect outcomes into six major types of errors. Please look at the handout where the six outcomes are listed under the *Type of Error*. The first three types of errors are concerned with the failure of the weight shift while stepping on the right foot. In the

Error I the body falls backward, in *Error II* the body falls forward, and in *Error III* the body falls sideways. *Error IV* deals with maintaining balance for less than four seconds. Errors in form, bent knee or the working leg being lower than a 90-degree level, characterize *Error V*. *Error VI* deals with the last component of the *piqué in 1st arabesque*. In your performance of the *piqué in 1st arabesque*, you tend to fall forward, *Error IV*. Now, I would like you to experience each of the specific errors associated with each of the six types of errors.

As you can see in your handout, for the *Error I*, when the body falls backward, there are four specific errors listed. The first specific error – “The leg is lifted up too slow” – deals with the speed with which you lift the leg. Try committing this error. You probably feel that when your leg is lifted up too slowly, it feels as if the leg is pulling you back; that is, the entire weight of the body is not shifted over the supporting leg. The next specific error, error two, deals with timing of the movement sequence – “Timing of the movement sequence – lifting of the leg and shifting the weight over the right foot – is not synchronized.” This error is related to the first one because it produces the same outcome, however, it is a little more complex. Try shifting the weight and then lifting the leg up. The weight shift may work with keeping the leg low; however, when you start lifting the leg up, balance is lost. Thus, synchronizing the movement sequence is important in achieving a balanced position required for the *piqué in 1st arabesque* to be correct. The next specific error, error three, deals with a deficiency in controlling abdominal muscles – “While stepping forward over the right foot, the abdominal muscles are not fully engaged.” As we discussed earlier, abdominal muscles keep the trunk in a stable position. If the abdominal muscles are not engaged during the weight shift, the body tends to fall

toward the direction of the greatest tension. In this case particular case it is backward, probably indicating a combination of several errors. Finally, specific error four – “The step forward is too small,” – indicates that, in order to balance for four seconds or longer, the step has to be fairly big. Now you have sampled all incorrect outcomes of the *piqué in 1st arabesque* listed under *Error I*. As always, it is important to remember that there is always a possibility that more than one error may occur.

Let us look at the specific errors listed under *Error II*. The first specific error – “The leg is lifted up too fast” – deals with the speed with which you lift the leg. Try committing this error and exaggerating it by kicking the leg up quickly. You probably felt that the entire weight of the body was pushed forward and you were not able to balance at all. This error is a direct opposite of the first specific error listed under *Error I*. The second specific error – “The muscles of the upper back are not fully engaged” – deals with the upper back muscles not counteracting gravitational force. To shift the weight forward on a *demi pointe*, one should lean forward a little. To stop this movement once the weight has been shifted over the *demi pointe*, the muscles of the upper back have to be engaged. As you commit this error, notice that your body tends to fall forward. The last specific error under *Error II* is error three – “The step forward is too small” – is actually the same as under *Error I*. The difference in the outcome may be explained by the weight shift being too big, causing the body fall forward. Of course, this error as other errors may occur in a combination.

Let us look at *Error III* next. The first specific error deals with not having sufficient support – “The muscles of the right ankle are not fully engaged.” Try committing this error by slightly disengaging the muscles around your ankle once you are

on a *demi pointe*. As you can see, your body tends to fall sideways. Of course, that may not be the only reason why your body falls sideways. The second specific error – “The outward rotators are not fully engaged allowing the pelvis to move to the left – indicates that the leg is not positioned correctly behind the shoulder and tends to create force that pulls the entire body sideways. Try committing this error and notice how the working leg is pulling you sideways. The third specific error under *Error III* – “The abdominal muscles are not fully engaged” – is the same as under *Error I*. Different outcomes may be explained by the instability of the trunk, allowing the body to fall either backwards (*Error I*) or sideways (*Error III*). Try committing this error and notice that even though the outward rotators are engaged, your hip slightly moved up, making your body collapse on one side.

Now, let us look at *Error IV*, which deals with the reasons for maintaining balance for less than four seconds. There are four specific errors listed under *Error IV*. The first specific error – “The thigh muscles of the right leg are not fully engaged” – indicates that one of the reasons why balance is not maintained is the weakness of the supporting leg muscles. Try stepping on a *demi pointe* and immediately disengage the supporting leg thigh muscles. You see that the support for the *arabesque* is compromised and you start losing your balance. This may happen at any point of balancing, causing a dancer to terminate this position. The second specific error – “The adjustment is not being made in the upper back muscles at the moment when the body starts tipping forward,” deals with adjustments in the positioning of the body. The *piqué in 1st arabesque* is a dynamic position and constant adjustment is needed to counteract gravity. Once again, try committing this error, perhaps balancing just for one or two seconds but

pay close attention to the upper back muscles, slightly disengaging them once you feel yourself being centered. Notice that in this context this error may not necessarily lead to a loss of balance, rather to a premature termination of balancing. The third specific error – “The adjustment is not being made in lifting the left leg up at the moment when the body starts tipping backward” – indicates that because of the absence of adjustment or late adjustment of positioning, one may not be counteracting gravity. Try committing this error. As in the previous error practice, balance just for one or two seconds, and notice the effect the slight lowering of the left leg does to your balance. If you fall backward, you are committing *Error I*; if you prematurely terminate the balance, you are committing *Error IV*. The specific error four – “The abdominal muscles are not fully engaged,” – indicates weakness in the trunk that may affect the balance and may eventually lead to a premature termination of the balancing position. As in previous two practices, balance just one or two seconds and notice the effect the slight disengagement of the abdominal muscles does to your balance. If you fall sideways, you are committing *Error III*; if you prematurely terminate the balance, you are committing *Error IV*. You probably noticed that there is a difference in the degree of errors as they relate to the outcome. Actually, performance of a given movement may be classified as correct even though some of the errors related to the dynamic properties are present. What makes the entire performance of the skill correct is the degree of control, such as being able to balance for at least for four seconds without losing balance.

Next, let us examine the five specific errors listed under *Error V* that deal with problems with form and control of dynamic properties. The first specific error – “The thigh muscles of the right leg are not fully engaged” – indicates that the extensors of the

leg – quadriceps – that keep the leg straight and counteract gravity are not properly engaged. Try stepping on a *demi pointe* and partially disengaging the quadriceps. Although you may be able to balance, this kind of position is unstable and this may create excessive stress on other muscles in your supporting leg. The specific error two – “The thigh muscles of the left leg are not fully engaged” – is form related. By definition, *arabesque* must have the working leg extended. In addition, keeping the working leg extended allows a dancer to have a greater control over the working leg movement. When committing this error notice how it looks and feels to keep the thigh muscles partially engaged. Chances are that your working leg is not reaching the 90-degree level. The next error, error three, – “The weight of the body moves backward” – indicates that the dynamic properties of movement are not controlled. You may find a centered position, but to maintain it you may have to make adjustments. Try committing this error and notice that when the weight of the body moves backward, the supporting foot heel moves down on the floor. In the fourth specific error – “The muscles of the right ankle are not fully engaged” – the outcome is the same as in error three, but the reason for this outcome may be the weakness in the ankle of the supporting leg. The specific error five – “The body is not aligned over the right leg, the muscles of the upper back are not fully engaged, and the left leg is not being lifted up” – comprises a group of errors. As you are trying to commit this error, notice that you may remain balancing over the supporting leg, but the heel of the supporting leg moves down. In concluding our work on *Error V*, it is important to note that the errors that we just reviewed may not always be apparent to a dancer.

Error VI deals with problems during the last component of the *piqué in 1st arabesque*. The first specific error – “The weight of the body is not pushed forward” – indicates that one is not making a step forward, rather one is coming down right where one was balancing, often resulting in a hop, or a step backward. Try committing this error and notice the subtle differences leading to two different outcomes. By coming down right where you were balancing, you may not always absorb force to be able to stay still and may be forced to make a hop. The step backward during the last component of the *piqué in 1st arabesque* often indicates downward movement of the working leg that has force that moves the body backward. Thus, a step backward instead of forward is made. The second specific error – “The abdominal muscles are not fully engaged upon stepping down,” – indicates that the trunk was not kept in a stable position. When you try committing this error, notice that it is much more difficult to control the direction of movement of your body. This may result in either a hop or a step backward.

Now you have sampled each of the specific errors for the six types of errors. As with the *en dehors pirouette*, you may find that there is more than one error occurring while performing the *piqué in 1st arabesque*. Please remember when asked to perform this movement correctly to make the adjustments as soon as you notice the error starting to occur. This way you may be able to avert the error.

Finally, we are ready to start the practical work on the *piqué in 1st arabesque*. As with the *en dehors pirouettes*, you will have to take an active part in your error analysis. Once again, the practice sessions will consist of the “correct movement” and “incorrect movement” trials. First, I will ask you to perform the *piqué in 1st arabesque* the “correct” way. Once you complete it, I will ask you to label it as a “correct” or “incorrect.” If the

piqué in 1st arabesque is not performed correctly and you label it as such, I will ask you to identify one or several specific errors that you think contributed to the given outcome. If the *piqué in 1st arabesque* is performed correctly and you label it as such, you will move to the next type of practice. Next, you will be asked deliberately commit a specific error. You will then be asked to label the outcome of your performance as being “correct” or “incorrect” and tell whether you have committed the error that I asked you to perform. I will provide feedback for both types of practice.

Because you have already experienced this type of practice during our work on the *en dehors pirouettes*, the same type of practice with the *piqué in 1st arabesque* should not be much of a novelty. If you do not have any questions, let us start.

Lecture 3

Today we are going to examine technique of performing the *grand fouetté in 1st arabesque*. First, we will analyze the task by looking at the basic components of the *grand fouetté in 1st arabesque*; discuss the relation between form and function and the dynamic properties of this movement. Next, we will look at the errors associated with this movement.

The *grand fouetté in 1st arabesque* consists of three components: preparation, the jump, and landing. Let us look at each of the components of this jump separately, assuming that the landing is on the right foot.

During the preparation component, a sideways *chassé* on the right foot is made while arms are held in the 2nd position. The function of this component is to create force for the *fouetté* jump. This is achieved by making this step small and fast. Once again, the dynamic properties of movement play an important role here.

During the jump component, there is a step made on the right foot while kicking the left leg in front and then a jump made during which both arms are moved to the 3rd position and the body turning in the air away from the left leg. The function of this component is to make a 180-degree turn in the air. In terms of dynamic properties, a greater force is generated when the kick and the jump are executed simultaneously, producing a high jump.

During the landing component, the right leg makes a *demi pli  * and the left leg extends in the back in 1st arabesque. The function of this component is to absorb the force and to stop the movement by holding the landing position for at least three seconds. In terms of dynamic properties, bending the supporting leg knee, holding the upper back and holding the left leg up in the air cancel the moving force.

As before, we will focus on the same muscle groups as in the previous two movements, *en dehors pirouette* and *piqu   in 1st arabesque*. These muscle groups are abdominal muscles, muscles of the upper back, outward rotators of the leg, and leg extensors. As I mentioned in the previous lecture, the movement outcome often informs you of which dynamic properties were not sufficiently controlled. Let us then look at the faulty outcomes and specific errors associated with them.

I have categorized incorrect outcomes of the *grand fouett   in 1st arabesque* into four major types of errors. Please look at the handout where the four outcomes are listed under *Type of Error*. *Error I* deals with the jump not being high enough to point the right foot. Both *Error II* and *Error III* deal with poor control of dynamic properties during the landing. In *Error II* the body continues to travel in the direction of the jump, failing to land in the required position. In *Error III*, the body is falling forward or sideways upon

landing, failing to maintain the required position. *Error IV* is concerned with the balance being maintained for less than three seconds. In your performance of the *grand fouetté in 1st arabesque*, you quite often fail to land in the required position because your body tends to travel in the direction of the kick during the jump, *Error II*. Now, it is time for you to experience each of the specific errors associated with each of the four types of errors.

As you can see in your handout, for *Error I*, when the jump is not high enough to point the right foot, there are two specific errors listed. The first specific error – “The *chassé* is too big and slow before the jump” – deals with both speed and force. Typically all preparatory steps should be small and fast to create an upward force. Try committing this error and see what effect making the *chassé* big and slow has on the jump. The second specific error deals with movement synchronization – “Timing of the movement sequence – the jump and movement of the arms to the 3rd position – is not synchronized.” As in the first specific error, the result is a low jump. Try performing the *fouetté* jump, moving your arms up in the 3rd position only when you already are up in the air. As you can see, it was difficult for you to jump high.

Next, let us move to *Error II* in which the body continues to travel in the direction of the jump, failing to land in the required position. There are five specific errors associated with this type of error. The first specific error – “While kicking the leg forward the body travels in the direction of the kick” – indicates a problem in movement performance occurring at the beginning of the jump. Try committing this error and notice how difficult is to cancel the force that makes you travel in the direction of the leg. This error makes landing in the required position less likely. The second specific error – “The

outward rotators are not fully engaged during the jump, allowing the pelvis to move backward” – addresses a problem in movement performance that occurs in the middle of the jump. The outward rotators, together with the gluteus, hold the working leg in place during the turn in the air while preventing the leg to pull the pelvis backward upon landing. Of course, when you are attempting to commit this error, disengage the outward rotators and notice how this error affects the outcome of the *grand fouetté in 1st arabesque*. The movement in the air appeared to be disjointed. The next error, error three – “Upon landing, the *demi plié* is not deep enough” – increases the chance of producing either a hop or allowing the supporting foot to move. One should always deepen the *demi plié* upon landing in order to cancel out the force that produced movement. When attempting this error, exaggerate it by barely bending the supporting leg knee and observe the outcome, not being able to stay still. Regarding the next error, I have observed you committing this error, error four, quite often – “Upon landing, the muscles of the upper back are not fully engaged and the left leg is not lifted up in the back.” When attempting this error, notice that it is extremely difficult to maintain the balance upon landing because the working leg tends to pull you backward, while the upper part of the body tends to fall forward. Finally, specific error five – “Abdominal muscles are not fully engaged during the jump or landing, or both” – indicates that the trunk is not kept in a stable position. As we discussed it in training of other movements, it is difficult to control the direction of movement of your body when the abdominal muscles are not fully engaged. Now try committing this error and notice how difficult is to control the positioning upon landing.

Let us move to *Error III* in which the body tends to fall either forward or sideways. There are four specific errors listed under *Error III*. The first specific error – “Upon landing the muscles of the upper back are not fully engaged” – appears to be almost the same as in *Error II* (specific error four). The difference is in the positioning of the leg. Because the first specific error indicates that only the upper back is not fully engaged, this produces movement forward, rather than backward, as in *Error II* (specific error four). Perhaps you should try committing both types of errors to be able to differentiate them. The next two specific errors are very similar. The second specific error often produces a failure to land in the required position and is frequently accompanied with a hop – “Upon landing, the body tips to the right.” The third specific error also may produce a failure to land in the required position that may be accompanied with a hop – “Upon landing, the body tips to the left.” Try committing both of these errors and notice how a relatively minor departure from a straight position affects the landing. The specific error four – “Upon landing, the outward rotators are not fully engaged and the left leg moves to the left” – may remind you of *Error II* (specific error two). They differ in (a) when the error occurs and (b) the direction in which the leg is moving. The specific error four occurs (a) upon landing and (b) as the leg moves the pelvis to left making the body fall to the left. Try committing this error and notice that when the outward rotators are disengaged the left leg becomes more susceptible to move to the side.

Error IV deals with maintaining balance for less than three seconds. There are three specific errors that often occur together, however they are listed separately to observe the contribution of each. The first specific error – “Upon landing, the left leg is

not lifted up in the back” – may indicate a possible tension in the positioning of the body. In this case, one may land in the required position without falling backward, yet if the leg is not being lifted up one may be forced to step out of the position prematurely. When you attempt to commit this error, deliberately hold the leg relatively low to observe the effect this error has. The second specific error – “Upon landing, the muscles of the upper back are not fully engaged” – once again may indicate a possible tension in the positioning of the body. Here one may land in the required position without falling forward, yet if the upper back is not fully engaged one may be forced to step out of the position prematurely. Try committing this error by deliberately disengaging the muscles of the upper back to observe the effect of this error. Finally, the specific error three – “The *demi pli  * is not deep enough,” – as with the previous two specific errors, may indicate a possible tension in the positioning of the body. In this case, there is no hop made; yet there may be a residual force that may cause one to step out of the position too early. Now, try committing this error.

As you sampled each of the specific errors, you were exaggerating them. When you are asked to perform the *grand fouett   in 1st arabesque* correctly, you may find that there is more than one error occurring simultaneously. Actually, the goal of our work on the errors is to develop better motor control. By engaging the proper muscle groups, you may be able to correct your errors as you perform the movement; thus, being able to classify your performance as “correct.”

It is time for you to start the practical work on the *grand fouett   in 1st arabesque*. The practice sessions, as with the other two movements, will consist of the “correct movement” and “incorrect movement” trials. You will start with the “correct-way” trial

followed by the “incorrect-way” trial. At the end of each trial, I will ask you to label your performance of the *grand fouetté in 1st arabesque* as being “correct” or “incorrect.” As before, you will have to identify your errors when they occur and I will provide feedback for both types of practice. If you do not have any questions, let us start the practice trials.

Appendix C

Questionnaire.

QUESTIONNAIRE

1. Checkmark one of the three classical ballet movements that you had practiced the most prior to the study.

- En Dehors Pirouette from 5th Position
- Grand Fouetté Sauté in 1st Arabesque
- Piqué in 1st Arabesque

2. Checkmark one of the three classical ballet movements that presented the greatest difficulty during conventional training.

- Grand Fouetté Sauté in 1st Arabesque
- Piqué in 1st Arabesque
- En Dehors Pirouette from 5th Position

3. Checkmark one of the three classical ballet movements that presented the greatest difficulty during behavioral movement training.

- Piqué in 1st Arabesque
- Grand Fouetté Sauté in 1st Arabesque
- En Dehors Pirouette from 5th Position

4. Checkmark one of the three classical ballet movements that presented the least difficulty during behavioral movement training.

- En Dehors Pirouette from 5th Position
- Piqué in 1st Arabesque
- Grand Fouetté Sauté in 1st Arabesque

5. On the scale 1-10 (1 being the lowest possible rating and 10 being the highest possible rating) how would you rate the usefulness of the conventional training procedure in working on technique development?

6. On the scale 1-10 (1 being the lowest possible rating and 10 being the highest possible rating) how would you rate the usefulness of the behavioral movement-training procedure in working on technique development?

Appendix D

Interobserver agreement observations.

Table 1

*Percentage of Total Sets of Ten Trials for Which Interobserver Agreement was Obtained
Across Experimental Conditions and Participants for Six Classical Ballet Movements*

Classical Ballet Movements	Percentage of Sets of Ten Trials			
	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	31% of 90	33% of 36	33% of 36	30% of 60
A2	42% of 19	_____	_____	36% of 11
B1	28% of 86	35% of 49	35% of 49	28% of 60
B2	53% of 15	_____	_____	36% of 14
C1	27% of 102	32% of 44	32% of 44	30% of 54
C2	33% of 21	_____	_____	36% of 11

Table 2

Percentage of Total Sets of Ten Trials for Which Interobserver Agreement was Obtained Across Experimental Conditions and Classical Ballet Movements for Three Participants

Percentage of Sets of Ten Trials				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	27% of 115	31% of 51	31% of 51	32% of 71
Beth	36% of 87	43% of 21	43% of 21	30% of 56
Carol	30% of 131	32% of 57	32% of 57	29% of 83

Table 3

*Interobserver Agreement Scores for the Sets of Ten Trials With Correct Movements
Across Experimental Conditions and Participants for Six Classical Ballet Movements*

Interobserver Agreement Scores				
Classical Ballet Movements	Behavioral Movement			
	Baseline - Conventional Training	Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	99.7%	————	————	98.5%
	R=90-100%			R=90-100%
A2	98.3%	————	————	98.3%
	R=80-100%			R=90-100%
B1	98.5%	————	————	99.2%
	R=80-100%			R=90-100%
B2	98.9%	————	————	100%
	R=90-100			

C1	100%	——	——	100%
C2	98.9%			96.7%
	R=90-100%	——	——	R=90-100%

R = range

Table 4

Interobserver Agreement Scores for the Sets of Ten Trials With Specific Type of Errors for Incorrectly Performed Movements Across Experimental Conditions and Participants for Six Classical Ballet Movements

Interobserver Agreement Scores				
Classical Ballet Movements	Behavioral Movement			
	Baseline - Conventional Training	Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	95.0%	————	————	96.7%
	R=80-100%			R=90-100%
A2	96.7%	————	————	93.3%
	R=80-100%			R=90-100%
B1	92.0%	————	————	97.0%
	R=70-100%			R=90-100%

B2	93.3%			93.3%
	R=80-100	——	——	R=80-100%
C1	88.3%			95.0%
	R=70-100%	——	——	R=90-100%
C2	86.7%			95.0%
	R=60-100%	——	——	R=90-100%

R = range

Table 5

Interobserver Agreement Scores for the Sets of Ten Trials With the Movements Matching Experimenter's Request For a Correct or an Incorrect Movement Across Experimental Conditions and Participants for Six Classical Ballet Movements

Interobserver Agreement Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement		Maintenance - Conventional Training
		Training		
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	100%	97.7% R=93-100%	98.0% R=97-100%	100%
A2	100%	_____	_____	100%
B1	100%	99.7% R=99-100%	99.0% R=98-100%	100%
B2	100%	_____	_____	100%

C1	100%	99.3%	97.7%	100%
		R=98-100%	R=95-100%	
C2	100%	——	——	100%

R = range

Table 6

Interobserver Agreement Scores for the Sets of Ten Trials With Correct Verbal Labeling of Movement Across Experimental Conditions and Participants for Six Classical Ballet Movements

Interobserver Agreement Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement		Maintenance - Conventional Training
		Training		
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	100%	98.3%	100%	100%
		R=95-100%		
A2	100%	——	——	100%
B1	100%	100%	100%	100%
B2	100%	——	——	100%
C1	100%	100%	100%	100%
C2	100%	——	——	100%

R = range

Table 7

Interobserver Agreement Scores for the Sets of Ten Trials With a Correct Verbal Description of Performance Errors Across Experimental Conditions and Participants for Six Classical Ballet Movements

Interobserver Agreement Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement		Maintenance - Conventional Training
		Training		
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	100%	97.7% R=93-100%	99.3% R=98-100%	100%
A2	100%	_____	_____	100%
B1	99.7% R=90-100%	100%	98.7% R=97-100%	100%
B2	100%	_____	_____	100%

C1	100%	99.7%	96.3%	100%
		R=99-100%	R=95-100%	
C2	100%	——	——	100%

R = range

Table 8

*Interobserver Agreement Scores for the Sets of Ten Trials With Correct Movements
Across Experimental Conditions and Classical Ballet Movements for Three Participants*

Percentage of Sets of Ten Trials				
Participants	Behavioral Movement Training			
	Baseline - Conventional Training	Correct - Movement Trials	Incorrect- Movement Trials	Maintenance - Conventional Training
Anna	99.0%	——	——	98.8%
	R=90-100%			R=90-100%
Beth	100%	——	——	99.0%
				R=90-100%
Carol	99.0%	——	——	99.7%
	R=90-100%			R=90-100%

R = range

Table 9

Interobserver Agreement Scores for the Sets of Ten Trials With Specific Type of Errors for Incorrectly Performed Movements Across Experimental Conditions and Classical Ballet Movements for Three Participants

Percentage of Sets of Ten Trials				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	94.0%	———	———	94.0%
	R=70-100%			R=80-100%
Beth	91.0%	———	———	97.0%
	R=60-100%			R=90-100%
Carol	90.0%	———	———	95.7%
	R=90-100%			R=90-100%

R = range

Table 10

Interobserver Agreement Scores for the Sets of Ten Trials With The Movements Matching Experimenter's Request For a Correct or an Incorrect Movement Across Experimental Conditions and Classical Ballet Movements for Three Participants

Percentage of Sets of Ten Trials				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	100%	97.7% R=93-100%	98.3% R=97-100%	100%
Beth	100%	100%	97.3% R=95-100%	100%
Carol	100%	99.0% R=98-100%	99.0% R=98-100%	100%

R = range

Table 11

Interobserver Agreement Scores for the Sets of Ten Trials With Correct Verbal Labeling of Movement Across Experimental Conditions and Classical Ballet Movements for Three Participants

Percentage of Sets of Ten Trials				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	100%	98.3%	100%	100%
		R=95-100%		
Beth	100%	100%	100%	100%
Carol	100%	100%	100%	100%

R = range

Table 12

Interobserver Agreement Scores for the Sets of Ten Trials With a Correct Verbal Description of Performance Errors Across Experimental Conditions and Classical Ballet Movements for Three Participants

Percentage of Sets of Ten Trials				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	99.7% R=90-100%	97.7% R=93-100%	97.7% R=97-98%	100%
Beth	100%	100%	98.3% R=95-100%	100%
Carol	100%	99.7% R=99-100%	98.3% 96-100%	100%

R = range

Appendix E

Procedural reliability measures.

Table 1

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Instruction to Perform a Given Named Movement Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Behavioral Movement			
	Baseline - Conventional Training	Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	100% of 90	_____	_____	100% of 60
A2	100% of 19	_____	_____	100% of 11
B1	100% of 86	_____	_____	100% of 60
B2	100% of 15	_____	_____	100% of 14
C1	100% of 102	_____	_____	100% of 54
C2	100% of 21	_____	_____	100% of 11

Table 2

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Lecture on Technique of Performing the Classical Ballet Movement Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Behavioral Movement			
	Baseline - Conventional Training	Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	100% of 90	100% of 36	100% of 36	100% of 60
A2	100% of 19	_____	_____	100% of 11
B1	100% of 86	100% of 49	100% of 49	100% of 60
B2	100% of 15	_____	_____	100% of 14
C1	100% of 102	100% of 44	100% of 44	100% of 54
C2	100% of 21	_____	_____	100% of 11

Table 3

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Request for the Specific Movement Outcome Across Experimental Conditions and Participants for Six Classical Ballet Movements

Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement		Maintenance - Conventional Training
		Training		
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	100% of 90	100% of 36	100% of 36	100% of 60
A2	100% of 19	_____	_____	100% of 11
B1	100% of 86	100% of 49	100% of 49	100% of 60
B2	100% of 15	_____	_____	100% of 14
C1	100% of 102	100% of 44	100% of 44	100% of 54
C2	100% of 21	_____	_____	100% of 11

Table 4

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Request for the Participant to Describe Her Own Performance Errors Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	100% of 90	99.0% of 36 R=90-100%	97.3% of 36 R=80-100%	100% of 60
A2	100% of 19	_____	_____	100% of 11
B1	100% of 86	96.3% of 49 R=80-100%	99.3% of 49 R=90-100%	100% of 60
B2	100% of 15	_____	_____	100% of 14

C1	100% of 102	99.0% of 44	100% of 44	100% of 54
		R=90-100%		

C2	100% of 21	_____	_____	100% of 11
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R = range

Table 5

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Praise Statement Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	98% of 90 R=90-100%	94.3% of 36 R=80-100%	97.0% of 36 R=90-100%	98.7% of 60 R=90-100%
A2	100% of 19	_____	_____	100% of 11
B1	98.0% of 86 R=80-100%	97.3% of 49 R=80-100%	100% of 49	100% of 60
B2	100% of 15	_____	_____	100% of 14

C1	100% of 102	96.0% of 44 R=70-100%	99.7% of 44 R=90-100%	97.7% of 54 R=80-100
C2	100% of 21	_____	_____	100% of 11

R = range

Table 6

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Corrective Feedback Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	98.7% of 90 R=90-100%	97.0% of 36 R=80-100%	96.7% of 36 R=80-100%	98.7% of 60 R=90-100%
A2	100% of 19	_____	_____	100% of 11
B1	98.0% of 86 R=80-100%	98.3% of 49 R=90-100%	100% of 49	100% of 60
B2	100% of 15	_____	_____	100% of 14

C1	100% of 102	96.0% of 44 R=70-100%	100% of 44	97.7% of 54 R=80-100
C2	100% of 21	_____	_____	100% of 11

R = range

Table 7

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Modeling Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	97.3% of 90 R=80-100%	99.3% of 36 R=90-100%	99.3% of 36 R=80-100%	100% of 60
A2	100% of 19	_____	_____	100% of 11
B1	99.3% of 86 R=90-100%	100% of 49	99.7% of 49 R=90-100%	100% of 60
B2	100% of 15	_____	_____	100% of 14

C1	97.0% of 102 R=80-100%	99.3% of 44 R=80-100%	99.3% of 44 R=90-100%	100% of 54
C2	100% of 21	_____	_____	100% of 11

R = range

Table 8

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Physical Guidance Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	98.7% of 90 R=80-100%	100% of 36	97.0% of 36 R=80-100%	100% of 60
A2	100% of 19	_____	_____	100% of 11
B1	99.3% of 86 R=90-100%	97.0% of 49 R=80-100%	99.0% of 49 R=90-100%	99.7% of 60 R=90-100
B2	100% of 15	_____	_____	100% of 14

C1	99.0% of 102 R=90-100%	99.3% of 44 R=80-100%	99.7% of 44 R=90-100%	100% of 54
C2	100% of 21	_____	_____	100% of 11

R = range

Table 9

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Request to Repeat the Movement Across Experimental Conditions and Participants for Six Classical Ballet Movements

Reliability Scores				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	99.0% of 90 R=80-100%	99.3% of 36 R=90-100%	97.7% of 36 R=90-100%	99.3% of 60 R=70-100%
A2	100% of 19	_____	_____	100% of 11
B1	97.3% of 86 R=70-100%	100% of 49	98.3% of 49 R=80-100%	100% of 60
B2	100% of 15	_____	_____	100% of 14

C1	99.7% of 102	100% of 44	100% of 44	100% of 54
	R=90-100%			

C2	100% of 21	_____	_____	100% of 11
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R = range

Table 10

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Instruction to Perform a Given Named Movement Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	100% of 115	————	————	100% of 71
Beth	100% of 87	————	————	100% of 56
Carol	100% of 131	————	————	100% of 83

Table 11

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Lecture on Technique of Performing the Classical Ballet Movement Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	100% of 115	100% of 36	100% of 36	100% of 71
Beth	100% of 87	100% of 49	100% of 49	100% of 56
Carol	100% of 131	100% of 44	100% of 44	100% of 83

Table 12

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Request for the Specific Movement Outcome Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	100% of 115	100% of 36	100% of 36	100% of 71
Beth	100% of 87	100% of 49	100% of 49	100% of 56
Carol	100% of 131	100% of 44	100% of 44	100% of 83

Table 13

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Request for the Participant to Describe Her Own Performance Errors Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
Anna	100% of 115	97.3% of 36 R=80-100%	97.7% of 36 R=80-100%	100% of 71
Beth	100% of 87	97.7% of 49 R=80-100%	100% of 49	100% of 56
Carol	100% of 131	99.3% of 44 R=90-100%	99.0% of 44 R=90-100%	100% of 83

R = range

Table 14

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Praise Statement Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Behavioral Movement Training			
	Baseline - Conventional Training	Correct - Movement Trials	Incorrect- Movement Trials	Maintenance - Conventional Training
Anna	98.3% of 115 R=80-100%	95.8% of 36 R=70-100%	99.3% of 36 R=90-100%	100% of 71
Beth	98.0% of 87 R=90-100%	93.0% of 49 R=80-100%	98.0% of 49 R=90-100%	97.3% of 56 R=80-100%
Carol	99.7% of 131 R=90-100%	99.0% of 44 R=90-100%	99.6% of 44 R=90-100%	98.9% of 83 R=90-100%

R = range

Table 15

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Corrective Feedback Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Behavioral Movement Training			
	Baseline - Conventional Training	Correct - Movement Trials	Incorrect- Movement Trials	Maintenance - Conventional Training
Anna	98.3% of 115 R=80-100%	95.2% of 36 R=70-100%	99.0% of 36 R=80-100%	100% of 71
Beth	99.0% of 87 R=90-100%	97.0% of 49 R=80-100%	98.0% of 49 R=90-100%	97.3% of 56 R=80-100%
Carol	99.7% of 131 R=90-100%	99.0% of 44 R=90-100%	99.6% of 44 R=90-100%	98.9% of 83 R=90-100%

R = range

Table 16

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Modeling Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Behavioral Movement Training			
	Baseline - Conventional Training	Correct - Movement Trials	Incorrect- Movement Trials	Maintenance - Conventional Training
Anna	99.0% of 115 R=80-100%	99.3% of 36 R=90-100%	98.5% of 36 R=80-100%	100% of 71
Beth	97.3% of 87 R=80-100%	100% of 49	100% of 49	100% of 56
Carol	97.3% of 131 R=80-100%	99.1% of 44 R=80-100%	99.6% of 44 R=90-100%	100% of 83

R = range

Table 17

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of Physical Guidance Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Behavioral Movement Training			
	Baseline - Conventional Training	Correct - Movement Trials	Incorrect- Movement Trials	Maintenance - Conventional Training
Anna	99.6% of 115 R=90-100%	100% of 36	99.3% of 36 R=90-100%	100% of 71
Beth	99.0% of 87 R=90-100%	98.0% of 49 R=90-100%	100% of 49	100% of 56
Carol	98.5% of 131 R=80-100%	97.7% of 44 R=80-100%	96.3% of 44 R=80-100%	99.5% of 83 R=90-100%

R = range

Table 18

Procedural Reliability Scores and the Number of Ten-Trial Sets for Which They were Obtained for the Presence or Absence of a Request to Repeat the Movement Across Experimental Conditions and Classical Ballet Movements for Three Participants

Reliability Scores				
Participants	Behavioral Movement Training			
	Baseline - Conventional Training	Correct - Movement Trials	Incorrect- Movement Trials	Maintenance - Conventional Training
Anna	98.0% of 115 R=70-100%	99.3% of 36 R=90-100%	100% of 36	100% of 71
Beth	99.0% of 87 R=80-100%	100% of 49	97.0% of 49 R=90-100%	99.3% of 56 R=70-100%
Carol	99.4% of 131 R=90-100%	100% of 44	99.0% of 44 R=80-100%	100% of 83

R = range

Appendix F

Procedural validity measures.

Table 1

Procedural Validity Scores for the Experimenter Delivering a Praise Statement Across Experimental Conditions and Classical Ballet Movements for Anna

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	4.0%	25.0%	15.5%	45.9%
B1	11.55%	21.0%	28.0%	52.0%
C1	0.59%	7.3%	16.0%	36.8%

Table 2

Procedural Validity Scores for the Experimenter Delivering Corrective Feedback Across Experimental Conditions and Classical Ballet Movements for Anna

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	95.0%	75.0%	18.9%	54.1%
B1	88.4%	79.0%	71.0%	48.0%
C1	99.0%	92.6%	84.0%	63.2%

Table 3

*Procedural Validity Scores for the Experimenter Modeling the Movement Across
Experimental Conditions and Classical Ballet Movements for Anna*

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	14.0%	6.1%	6.7%	5.6%
B1	5.6%	4.0%	0.6%	1.5%
C1	21.0%	14.7%	8.7%	4.1%

Table 4

Procedural Validity Scores for the Experimenter Providing Physical Guidance Across Experimental Conditions and Classical Ballet Movements for Anna

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	6.0%	3.3%	6.7%	5.2%
B1	12.7%	10.6%	7.2%	3.8%
C1	31.0%	39.3%	14.0%	11.8%

Table 5

Procedural Validity Scores for the Experimenter Requesting to Repeat the Movement

Across Experimental Conditions and Classical Ballet Movements for Anna

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	39.0%	42.0%	46.7%	23.0%
B1	72.2%	57.8%	36.6%	11.5%
C1	58.0%	68.0%	42.0%	20.5%

Table 6

Procedural Validity Scores for the Experimenter Delivering a Praise Statement Across Experimental Conditions and Classical Ballet Movements for Beth

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	14.6%	38.6%	34.0%	70.0%
B1	17.3%	38.8%	16.3%	62.3%
C1	8.1%	30.0%	90.0%	69.3%

Table 7

Procedural Validity Scores for the Experimenter Delivering Corrective Feedback Across Experimental Conditions and Classical Ballet Movements for Beth

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	85.0%	61.4%	65.7%	29.0%
B1	82.7%	61.3%	83.8%	37.7%
C1	91.9%	75.0%	20.0%	30.7%

Table 8

*Procedural Validity Scores for the Experimenter Modeling the Movement Across
Experimental Conditions and Classical Ballet Movements for Beth*

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	6.5%	1.4%	4.3%	1.3%
B1	3.6%	1.3%	0%	0%
C1	10.9%	0%	0%	0.7%

Table 9

Procedural Validity Scores for the Experimenter Providing Physical Guidance Across Experimental Conditions and Classical Ballet Movements for Beth

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	6.2%	0%	2.8%	4.0%
B1	19.0%	11.3%	8.8%	4.6%
C1	34.3%	35.0%	10.0%	4.3%

Table 10

Procedural Validity Scores for the Experimenter Requesting to Repeat the Movement

Across Experimental Conditions and Classical Ballet Movements for Beth

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	60.8%	44.3%	42.8%	17.0%
B1	48.2%	46.3%	27.5%	23.1%
C1	67.6%	65.0%	10.0%	17.9%

Table 11

Procedural Validity Scores for the Experimenter Delivering a Praise Statement Across Experimental Conditions and Classical Ballet Movements for Carol

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	15.7%	40.0%	34.0%	70.5%
B1	4.0%	24.5%	35.5%	59.4%
C1	0%	7.6%	24.0%	48.1%

Table 12

Procedural Validity Scores for the Experimenter Delivering Corrective Feedback Across Experimental Conditions and Classical Ballet Movements for Carol

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	84.3%	60.0%	66.0%	29.5%
B1	96.0%	75.5%	64.1%	40.7%
C1	100%	92.4%	76.0%	51.9%

Table 13

*Procedural Validity Scores for the Experimenter Modeling the Movement Across
Experimental Conditions and Classical Ballet Movements for Carol*

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	6.0%	1.0%	5.0%	0%
B1	60.0%	3.2%	4.6%	0.7%
C1	10.9%	6.8%	3.6%	0%

Table 14

Procedural Validity Scores for the Experimenter Providing Physical Guidance Across Experimental Conditions and Classical Ballet Movements for Carol

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	9.7%	0%	6.0%	3.3%
B1	34.0%	16.8%	12.7%	4.5%
C1	41.8%	32.4%	11.2%	6.9%

Table 15

Procedural Validity Scores for the Experimenter Requesting to Repeat the Movement

Across Experimental Conditions and Classical Ballet Movements for Carol

Mean Percentage of Ten-Trial Sets				
Classical Ballet Movements	Baseline - Conventional Training	Behavioral Movement Training		Maintenance - Conventional Training
		Correct - Movement Trials	Incorrect- Movement Trials	
A1	61.7%	48.0%	50.0%	21.0%
B1	56.0%	51.8%	32.3%	33.5%
C1	77.7%	82.0%	56.8%	34.4%

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