Motor Sequencing of Boys With Learning Disabilities: Modeling and Verbal Rehearsal Strategies

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This study examined the effects of model type and verbal rehearsal strategy in relation to motor sequencing of boys with learning disabilities (LD). Eighty boys, ages 7 and 8 years, were exposed to four experimental conditions in a 2 × 2 (Model × Verbal Rehearsal Strategy) design. Subjects were randomly assigned to one of four groups: (a) visual-silent model/verbal rehearsal, (b) visual-verbal model/verbal rehearsal, (c) visual-silent model/no verbal rehearsal, and (d) visual-verbal model/no verbal rehearsal. The four groups were statistically equal on measures of age, IQ, behavior, learner modality preference, and motor proficiency. Data collected for experimental analysis were generated by the Motor Sequencing Test which measured the ability to model seven locomotor tasks in the correct order. Results revealed that the boys with LD performed significantly better on the motor sequencing test when trained in verbal rehearsal strategy. However, results indicated no significant difference in motor sequencing under visual-silent and visual-verbal model conditions.

Currently many students with learning disabilities (LD) are mainstreamed into regular physical education classes, often creating additional challenges for the physical educator. Frequently these children have difficulty in following instructions, benefiting from teacher demonstrations, or generating appropriate strategies for success in motor activities. The learning disabled population is extremely heterogenous. Because of the diversity of behaviors associated with the population, subgroups or clusters have been identified according to characteristics (Lazarus, 1990). One characteristic of many children with LD is inefficient motor control. Some children display subtle motor difficulties (Lazarus, 1990) while others display more apparent motor awkwardness including poor balance, visual-spatial difficulties, and poor coordination (Haubenstricker, 1982; O’Brien, Cermak, & Murray, 1986).

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Central to physical awkwardness are problems of motor planning and motor sequencing (Ayres, 1975; Cratty, 1980, 1986; Das, 1986). Motor sequencing is the serial ordering and integration of individual components to form smooth and efficient movement (Lazarus, 1990). Motor sequencing deficits of children with LD have been reported on various subtests (visual-motor control, upper limb speed and dexterity, and upper limb coordination) requiring sequencing (Bruininks, 1978; Bruininks & Bruininks, 1977), combining independent tasks to perform a series (Williams, Temple, & Bateman, 1977), performing a sequential hopping task (Halverson & Roberton, 1988), and on sequential motor tasks selected from the Devereaux Test of Extremity Coordination (Kendrick & Hanten, 1980).

A possible explanation for deficits in motor sequencing may come from an information processing perspective, which posits that children with LD have not developed effective strategies for processing and using information (Kerr & Hughes, 1987). According to Das (1986), a processing deficit in simultaneous and successive coding of information or in the use of coded information may result in the failure to plan or sequence coded information, adversely affecting motor output. Additionally, other processing deficits in children with LD have been demonstrated in selective attention (Pihl & Niauro, 1982; Vrana & Pihl, 1980), accuracy and speed of processing (Cermack, 1983; Whiting, 1972), and inferior rehearsal strategies (Cermack, 1983; Tarver, Hallahan, Kauffman, & Ball, 1976).

The use of verbal rehearsal (i.e., overt or covert speech used to guide performance) has been reviewed with regard to information processing and motor sequencing (Gallagher & Hoffman, 1987; Thomas, 1980). Verbal rehearsal of information in short-term memory helps to focus attention on relevant cues and contributes to the processing of information from short-term to long-term memory (Dusek, 1978). Early verbal rehearsal research (Flavell, Beach, & Chinsky, 1966; Fuson, 1969; Keeney, Cannizzo, & Flavell, 1967; Reese, 1962) indicates that young children do not spontaneously engage in verbal rehearsal on tasks they are required to remember. Concurrent with this research on nondisabled children in the 1960s were studies on the use of verbal rehearsal to teach hyperactive, impulsive, or attention-deficit children to attend to relevant or central stimuli (Meichenbaum & Goodman, 1971; Tarver et al., 1976). Results of these studies clearly indicated that verbal rehearsal is an effective strategy in increasing selective attention and recall.

The primary method used by physical educators to teach new movement skills or modify existing skills is visual demonstration or modeling (Bird & Ross, 1984). Existing research which had explored modeling and motor performance predominantly employed isolated novel tasks such as a stabilometer (Carroll & Bandura, 1985; Landers & Landers, 1973; Thomas, Pierce, & Ridsdale, 1977). Although these studies have provided valuable information, it becomes increasingly important to design research in which data are collected using realistic activities in ecologically valid contexts. For example, Weiss (1982, 1983) investigated the effects of modeling, age, and verbal rehearsal on the performance of a motor sequence using tasks commonly taught at the elementary school level. This study revealed that 4- to 5-year-olds learn better under a verbal model condition than under a silent model condition. Weiss concluded that developmental factors such as attentional, retentional, and verbal-cognitive abilities play a critical role in learning to model motor sequences. Weiss and Klint (1987) conducted a similar study with two groups of children ages 5 to 6 and 8 to 9, respectively, in which
earlier findings were supported. The findings of Weiss (1983) and of Weiss and Klint (1987) are of particular interest when considering children with LD and motor deficits.

Although considerable research has been conducted on the motor proficiency of children with LD (Bruininks & Bruininks, 1977; Haubenstricker, 1982; Sherrill & Pyfer, 1985), no research has yet focused on modeling and verbal rehearsal strategies that might help them in a gross motor context. Given the well-documented information processing problems and physical awkwardness of children with LD (Das, 1986; Lorsbach & Gray, 1984; Wall, McClements, Bouffard, Finlay, & Taylor, 1986), the need for research in this area is clear. The findings of Weiss and Klint (1987) on the effectiveness of a verbal model with young children requires examination with this population, particularly because existing research indicates that children with LD are developmentally immature in the use of rehearsal strategies (Cermack, 1983; Tarver et al., 1976). Verbal rehearsal training with these children (Kendall, 1977; Meichenbaum & Goodman, 1971) has proven effective in the classroom, but no research has been conducted on this learning strategy in a gross motor context. Considering the high incidence of physical awkwardness in this population, examining the effectiveness of verbal rehearsal strategies in aiding these children within the gymnasium setting is extremely important. Therefore it was the purpose of the present study to examine the effects of model type and verbal rehearsal strategy in relation to motor sequencing of boys who are learning disabled.

**Method**

**Subjects**

Subjects were 80 boys with LD, 7 and 8 years of age (M age = 7 yrs, 10 mos), from six school districts in the North Texas region. All met the following criteria: diagnosis of LD in accordance with PL 94-142 eligibility criteria, an IQ of 85 or above, and verification by classroom teachers of no extreme behavior or orthopedic problems. The federal definition of learning disabilities in accordance with PL 94-142 was used in identifying subjects. A second part of this definition, considered operational, was added in the Federal Register of December 29, 1977. These criteria were also used in determining subject eligibility. Administrators of 12 school districts in the North Texas region were contacted for permission to participate in the study. The sample was composed of 6 districts that responded within the time frame. Written permission to collect data was obtained from all principals and every parent or guardian.

**Design**

Subjects were randomly assigned to one of four experimental conditions in a 2 × 2 (Model × Verbal Rehearsal Strategy) factorial design. The four experimental groups (n=20) were (a) visual-silent model/verbal rehearsal (VSM/VR), (b) visual-verbal model/verbal rehearsal (VVM/VR), (c) visual-silent model/ no verbal rehearsal (VSM/NVR), and (d) visual-verbal model/ no verbal rehearsal (VVM/NVR). For the purposes of this study, silent/verbal modeling refers to the absence or presence of verbal cues during demonstration. Verbal rehearsal refers to the presence of overt speech during the learning and performance of a motor sequence.
Preliminary data collection procedures included obtaining ages and IQs from students' school files and administering the Bruininks-Oseretksy Test of Motor Proficiency—Short Form (BOTMP-S; Bruininks, 1978). Additionally, classroom/resource teachers were given the Devereaux Elementary School Behavior Rating Scale (DESB; Swift, 1982) and the Learner Modality Preference Checklist (Hayes, 1975) to complete on each child. The DESB yielded 14 separate scores on behavior: work organization, creative initiative/involvement, positive toward teacher, needs direction for work, socially withdrawn, failure anxiety, impatience, irrelevant thinking/talk, blaming, negative/aggressive, perseverance, peer cooperation, confusion, and inattention. The Learner Modality Checklist permitted children to be categorized as predominantly visual or auditory learners or mixed. The BOTMP—S yielded separate scores for eight areas: running speed and agility, balance, bilateral coordination, strength, upper limb coordination, response speed, visual-motor control, and upper limb speed and dexterity. A standard total BOTMP—S was calculated also.

These data were collected so that equality of the groups on factors that might affect motor sequencing performance could be checked. Statistical analysis verified that there were no significant differences between groups on age, IQ, behavior ratings yielded by the DESB, modality preference, and motor proficiency measured by the BOTMP—S. Thus it was ensured that all groups were balanced on factors that may have affected the results of the study.

Instrumentation

Ability to model a seven-part motor sequence was measured by the Motor Sequencing Test (MST), a protocol developed specifically for this study (Kowalski & Sherrill, 1990). Guided by similar tests by Weiss (1982, 1983) and Weiss and Klint (1987), we conducted extensive pilot testing to determine the number and type of motor tasks the children would be asked to demonstrate. Based on the findings, the locomotor tasks selected for the motor sequence were jump, giant step, turn, doggie walk, elephant walk, log roll, and tiptoe walk.

The goal of the MST was to measure the ability to perform the seven locomotor tasks in correct sequence (exact order as demonstrated). Children were given eight trials to achieve this goal. The MST yielded two scores. First, the number of trials to reach a criterion (NTC) of correct sequencing was recorded. Testing was concluded when the criterion of two consecutive correct trials was met. A perfect score was achieved when the criterion was met in the first two trials. Therefore NTC scores could range from 2 (best) to 8 (worst). Second, a total score (MST—T) was calculated by a two-step procedure. One point was awarded for each part of the task sequence performed correctly; therefore a maximum of 7 points was possible in each trial. When the test was completed, the number of points achieved was totaled and divided by the maximum number of points possible. A perfect score for MST—T, when the subject reached criterion in the first two trials, was 1.00 (14/14). The score when a subject reached criterion in later trials was variable, depending on the number of tasks performed correctly within each trial. Thus MST—T scores could range from 0.00 to 1.00.

Manipulation of Independent Variables

Subjects were randomly assigned to one of two model conditions: a visual-silent model (VSM) and a visual-verbal model (VVM). Children in the VSM condition
viewed a videotape in which the model silently performed the task sequence, providing no verbal cues. Children in the VVM condition viewed a videotape in which the model performed the task sequence while concurrently stating the name of each task. In order to control for possible order effects, seven orders of the locomotor tasks in the MST were used. Because there were two modeling conditions (VSM and VVM), this resulted in the production of 14 videotapes. Task order was randomly assigned. The model for the study was a male graduate student, who was selected because he projected a healthy, athletic appearance and had the ability to perform all seven tasks according to criteria determined by the investigator.

Subjects were also randomly assigned to one of two verbal rehearsal conditions: verbal rehearsal (VR) or no verbal rehearsal (NVR). In the VR condition, children were trained to state aloud the name of each task of the motor sequence as they performed it. Verbal rehearsal training was thus given to half of the subjects prior to their receiving instructions in performing the MST. Practice continued until the child could use the strategy without being prompted. Children randomly placed in the NVR condition were merely exposed to one of the model conditions and were not trained in the use of verbal rehearsal strategy.

Procedures

Children were tested individually at their respective schools in a room designated by the principal for data collection. Test protocol were consistent with the procedures used by Weiss (1982, 1983) and by Weiss and Klint (1987), including linear mat setup, use of a pretest to ensure motor capability of individual tasks, and the instructional protocol. Differences included the maximum number of trials allowed to reach criterion, selection of tasks, use of seven mats rather than six, and the presence of a videotape monitor. Videotapes of the MST task sequence were used instead of a live model to ensure consistency of model demonstration from trial to trial. The room was free of distraction, with no one present except the investigator and the child. All subjects were tested by the same person. The MST setup consisted of seven carpet mats (3 x 5 ft) clearly marked from 1 to 7, arranged linearly across the floor, and placed 5 feet apart. The Copy-Cat Screening Test was also administered to each subject and was set up in a separate area of the room. It was used to screen potential subjects to ensure that they could perform and verbally label the individual tasks in the motor sequence. If a subject was unable to perform or correctly label one of the seven tasks, he was thanked, taken back to class, and excluded from the study.

Upon passing the Copy-Cat Screening Test, children were escorted to the MST area. In keeping with the Weiss (1982, 1983) protocol, each child was given two repetitions of verbal instructions in which a specific sequence of tasks was identified. The child was then exposed to one of the model/verbal rehearsal conditions. In addition, each child was screened to ascertain that he had learned the sequence and could reproduce it in a nonmotor fashion. This screening consisted of either reciting or placing pictures (to avoid verbal rehearsal) of all the tasks in the correct order, depending on experimental condition.

After the memory screening test, each child viewed a videotape of a model performing two repetitions of his specified task sequence. Prior to seeing the videotape, the investigator told each boy that he was to perform the tasks in the same order as just learned, so to watch carefully. Children were told they had
eight chances to copy these tasks exactly the way they were shown. After the videotaped demonstration of the task sequence, the investigator immediately directed the child to the carpet square marked START, saying,

Now it's your turn to be a copy-cat! Go over to the carpet square marked START and wait for me to tell you to start. Each task gets done only one time. If you make a mistake, don't go back. Just keep going till the end because you'll have more tries. If you can't remember a task, but remember some after it, just walk to the next mat and keep going. Remember, you have eight tries. Do your best each time. Get ready, start!

The investigator gave verbal feedback after each trial. In keeping with the Weiss (1982, 1983) protocol, if the sequence was performed correctly, the child was praised and asked to repeat the sequence. If there were errors, the investigator praised the child for the effort and identified the number of tasks performed in the correct order. After every two incorrect trials, instructions were repeated and the child was shown another repetition of the videotaped demonstration.

Results

Preliminary screening of the data revealed that 10 of the 80 subjects (12.5%) did not meet the criterion of two consecutive correct trials over eight trials on the Motor Sequencing Test. Because these subjects did not reach the criterion, they did not receive an NTC score and thus were not included in the statistical analyses. Sample sizes thus changed to 20 subjects in the VSM/VR group, 19 subjects in the VVM/VR group, 14 subjects in the VSM/NVR group, and 17 subjects in the VVM/NVR group.

Initial analyses of the data were conducted to determine that the four groups were statistically equal on measures of age, IQ, behavior, learner modality preference, and motor proficiency. Separate two-way factorial analyses of variance were performed on age, IQ, and the BOTMP–S standard score. No significant differences were revealed, thus the four experimental groups were demonstrated to be equated on age, IQ, and motor proficiency. Behavior rating and learner modality preference were measured by the Devereaux Elementary School Behavior Rating Scale (DESB; Swift, 1982) and the Learner Modality Preference Checklist (Hayes, 1975), respectively. Instead of a total or overall score, the DESB yielded separate scores for 14 subscales. Analysis of variance revealed that group means were within the set criterion (+1 SD from the normative group mean) for each of the 14 subscales. The Learner Modality Preference Checklist enabled classification into three categories: visual, auditory, mixed. Because the Learner Modality Preference Checklist (Hayes, 1975) yielded nominal data, a chi square analysis was performed, revealing no significant relationships between groups. Thus the four groups were statistically equal on all five control variables. Descriptive statistics for the two sets of data generated by the Motor Sequencing Test represent only the 70 children (87.5%) who passed the test (see Table 1).

Data were analyzed using a 2 × 2 (Model × Verbal Rehearsal Strategy) analysis of variance. Initially a multivariate analysis was planned for examining the data. Because the dependent variables (NTC and MST–T) were correlated at $r=.85$, this represented multicollinearity and thus multivariate analysis of variance could not be used (Thomas & Nelson, 1985). The decision not to apply this level
Table 1
Motor Sequencing Scores of Four Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Range</th>
<th>M</th>
<th>SD</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trials to criterion (NTC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSM/VR</td>
<td>2.0 – 8.0</td>
<td>4.40</td>
<td>1.88</td>
<td>.42</td>
</tr>
<tr>
<td>VVM/VR</td>
<td>2.0 – 8.0</td>
<td>4.26</td>
<td>1.79</td>
<td>.41</td>
</tr>
<tr>
<td>VSM/NVR</td>
<td>2.0 – 8.0</td>
<td>5.57</td>
<td>2.44</td>
<td>.65</td>
</tr>
<tr>
<td>VVM/NVR</td>
<td>3.0 – 8.0</td>
<td>5.76</td>
<td>1.60</td>
<td>.39</td>
</tr>
<tr>
<td>Motor sequencing test total score (MST-T)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSM/VR</td>
<td>.60–1.00</td>
<td>.86</td>
<td>.10</td>
<td>.24</td>
</tr>
<tr>
<td>VVM/VR</td>
<td>.59–1.00</td>
<td>.87</td>
<td>.12</td>
<td>.03</td>
</tr>
<tr>
<td>VSM/NVR</td>
<td>.66–1.00</td>
<td>.83</td>
<td>.12</td>
<td>.03</td>
</tr>
<tr>
<td>VVM/NVR</td>
<td>.70–.90</td>
<td>.80</td>
<td>.05</td>
<td>.01</td>
</tr>
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</table>

Note. Perfect score for NTC is 2; perfect score for MST-T is 1.0.

of analysis was based on the definition of high collinearity (i.e., .80–1.00) as stated in the SPSSX manual (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975) and the fact that related studies (Weiss, 1982, 1983; Weiss & Klint, 1987) did not conduct multivariate analysis because of similar problems of multicollinearity. Consequently, a univariate analysis of variance (ANOVA) was conducted for each dependent variable: number of trials to criterion (NTC) and MST total score (MST-T). Because of an unequal number of subjects in the four groups, Levene’s test (Huck, Corimer, & Bound, 1974) was used to verify that the assumption of equality of variances was met.

Because two separate univariate analyses of variance were performed, the Bonferroni technique (Thomas & Nelson, 1985) was used to adjust for inflated alpha level. With the level of significance set at .05, the adjusted p value used to examine the hypotheses was .025. Findings for NTC revealed a significant main effect for verbal rehearsal strategy, $F(1,65)=8.33$, $p<.01$. All other findings for NTC and MST-T were nonsignificant. Results indicated that subjects who used a verbal rehearsal strategy reached criterion on the MST in significantly fewer trials than subjects who did not use verbal rehearsal. Verbal rehearsal reduced the number of trials needed to score to criterion but did not appear to affect the number of correct parts per trial. Nonsignificant results for model indicated that subjects did not score significantly different when viewing either a videotaped visual-silent model or a videotaped visual-verbal model.

Discussion

Results failed to support the first research hypothesis of this study. Specifically, it was hypothesized that 7- and 8-year-old boys with LD would perform better under the visual-verbal model condition than the visual-silent model condition. The rationale for this hypothesis was based on research documenting that verbal modeling has been successful with nondisabled children (McCullagh, Weiss, &
Ross, 1989; Weiss, 1982, 1983; Weiss & Klint, 1987) and is considered a critical component in training children with clinical problems (Kendall, 1977; Meichenbaum, 1977).

One reason for the present findings may be that children with LD, 7 years of age and older, respond equally to model types. In a developmental modeling study with nondisabled children, Weiss (1982, 1983) found that the efficacy of model type was dependent on the age of the observer. She stated in this regard, "7- to 8-year-old children performed equally well in either a verbal or silent model condition while 4- to 5-year-old children performed significantly better when exposed to the verbal model only" (Weiss, 1982, p. 86; 1983). Because of possible developmental delays in information processing (Kerr & Hughes, 1987) and/or motor performance (Bruininks & Bruininks, 1977; Haubenstricker, 1982; Sherrill & Pyfer, 1985), it was believed that children who are LD may perform below their same-age peers. The hypothesis for the study was based on the assumption that 7- to 8-year-old children with LD would resemble the 4- to 5-year-old children in the Weiss study and therefore would perform better in the verbal model condition only. This assumption was refuted by the findings.

In a later study, Weiss and Klint (1987) examined developmental differences in motor performance on a six-part sequential motor task under various modeling and verbal rehearsal conditions. Children in this study represented two age groups (5 to 6 yrs and 8 to 9 yrs) and were randomly assigned to one of four instructional conditions: (a) verbal model only, (b) verbal model plus verbal rehearsal, (c) verbal rehearsal only, or (d) no model/no rehearsal. Findings were the same for both age groups, which indicated that a verbal-model-plus-rehearsal condition facilitated performance and contradicted the age related differences found by Weiss (1982, 1983). Findings of the present study support those of Weiss and Klint (1987) in that the model type may not be as important after age 7 as before.

Another explanation for the lack of significance between model types may be related to ineffective information processing strategies in children with LD (Kerr & Hughes, 1987). Subjects in the visual-verbal model group were required to simultaneously attend to two pieces of information, one visual and one auditory. Research has indicated that when sensory information must be integrated, it is likely that stimuli will compete for space in the limited channel (Keele, 1973). Intersensory integration, or the ability to integrate multiple sources of sensory information, has important implications in the child’s growth and development (Williams, 1983). According to Das (1986), children with learning disabilities typically have deficits in simultaneous and successive information coding. It is possible therefore that intersensory integration did not adequately occur in our subjects.

There might also be deficits in selective attention. Children must attend to relevant information if it is to be integrated. These children may perceive information that is irrelevant to the task as important, or have difficulty processing task relevant information (Hallahan, Gajar, Cohen, & Tarver, 1978; Hasher & Zacks, 1979; Tarver & Hallahan, 1974; Tarver et al., 1976). Additionally, these children may use a different processing mode, one that involves more global processing as opposed to focal processing (Lazarus, 1990). The expected superiority of the verbal model might not have occurred for several reasons: ineffective information processing strategies, deficits in selecting attention, or a different processing style.
The model providing overt verbal cues may have acted as a distracter rather than as an aide to focusing on relevant stimuli, as was expected.

The second research hypothesis of the study stated that subjects would perform significantly better on a motor sequencing test when engaging in verbal rehearsal strategy than when not so engaged. This hypothesis was supported for the dependent variable NTC but not for MST–T. However, it should be noted that although verbal rehearsal was not statistically significant at the .025 level for MST–T, it did approach significance ($p=.041$). This may have greater clinical significance because MST–T is a global representation, reflecting the number of correct tasks per trial as well as the number of trials to criterion.

Findings revealed that subjects in the verbal rehearsal condition reached criterion in significantly fewer trials. These findings support the assumption that verbal rehearsal strategy serves a memory encoding function (Bandura & Jeffery, 1973; Weiss & Klint, 1987; Wheeler & Dusek, 1973). Verbal rehearsal has been proven effective in attentional focusing and retentional facilitation (Dusek, 1978; Flavell et al., 1966; Gallagher & Thomas, 1984; Keeney et al., 1967; Rose, Cundick, & Higbee, 1983; Winther & Thomas, 1981). Whereas early research (Flavell et al., 1966; Keeney et al., 1967; Tarver et al., 1976) confined the study of verbal rehearsal to memory function and fine motor skills, Weiss (1982, 1983) and Weiss and Klint (1987) examined verbal rehearsal in relation to gross motor skills. Specifically, Weiss and Klint (1987) found that verbal rehearsal strategies aided the retention of a six-part locomotor sequence for elementary age children.

The results of the present study show that training in verbal rehearsal strategy reduces the number of trials necessary when replicating the sequence of motor tasks with boys who are learning disabled.

In conclusion, verbal rehearsal is an effective strategy in aiding children with LD in remembering a total body action motor sequence. This study illustrates the value of employing verbal rehearsal strategies when teaching children with motor sequencing deficits, especially in a mainstream setting. It is our opinion that instruction in verbal rehearsal strategy should be incorporated throughout all aspects of the physical education program.

The lack of studies focusing on modeling and/or verbal rehearsal and motor performance among special populations is cause for concern. Motor planning/motor sequencing and information processing must be considered when examining the modeling process in relation to the performance of motor skills of children with LD. It is imperative that research continue in the areas of modeling and verbal rehearsal strategies as related to the motor sequencing of these children. Areas for future research include training studies involving collaboration with public school physical educators, examining the effectiveness of verbal rehearsal with children exhibiting severe motor planning/motor sequencing deficits, and the effects of verbal rehearsal on retention.

References


