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COMPLEXITY OF RHYTHMIC ABILITY AS MEASURED IN PRESCHOOL CHILDREN[1]

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Summary.—There are many aspects which need to be explored before a comprehensive description of young children's rhythmic ability can be developed. The present study examined the relation of age and sex and preschool children's rhythmic ability expressed in performance with one and two hands, bilateral and parallel use of upper and lower limbs. Two groups of preschool children participated ($N=77$), 4.5 to 5.5 and 5.6 to 6.5 yr. of age. A version of the High/Scope Beat Competence Analysis Test was used to assess rhythmic ability. The children performed the same six movements, e.g., parallel movement of hands, bilateral movement of hands, movement of the preferred hand, movement of the nonpreferred hand, bilateral movement of feet in a seated position, and bilateral movement of feet in a standing position. Analysis showed that girls were more accurate than boys on bilateral movement of hands while boys were more accurate than girls on bilateral movement of feet in a seated position. Also, children were more accurate (a) on the movement with the preferred hand than with parallel movement of hands and nonpreferred hand movement, (b) on bilateral movement of hands than with parallel movement of hands and bilateral movement of feet in a seated position, and (c) on bilateral movement of feet while standing than seated. It can be concluded that the various rhythmic movements with upper and/or lower limbs follow different rates of development in preschool children. The above findings may assist physical educators in implementing a physical education program more effectively for the corresponding age groups.

Rhythm has generally been considered an important factor in development and in learning and performance of motor skills. It is common accepted that children respond to rhythm very early in life. Dalcroze wrote that "rhythm is a series of connected movements forming a whole and capable of being repeated" (Findlay, 1971). Laban (1980) stated that aptitude for rhythm requires training to be of maximum benefit to an individual. However, there is little agreement concerning the exact nature of rhythm, the extent of its influence on motor ability, or the ways in which it is related to motor learning. Terms such as "sense of timing", rhythm, smoothness, flowing action, etc. have been used to describe rhythmic ability. However, these subjective terms need quantitative measurement. Rhythmic ability is best described as the ability to perform a succession of regulated, recurring gross motor events requiring both spatial and temporal accuracy. There is general

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agreement that rhythm is the periodic succession or regular recurrence of events in time which constitute the organization of temporal relationships (Smoll, 1973). It has also been assumed that rhythm can be perceived in various ways, since all of the senses are capable of experiencing a rhythmic organization of sensations (Bond, 1959).

In preschoolers, age has been one of the greatest factors affecting both structured and spontaneous movement responses (Groves, 1969; Sims, 1985). Metz (1989) investigated factors involved in 2-, 3-, and 4-yr.-old children's free-choice rhythmic responses while listening to music in a preschool setting. She concluded that disposition, developmental stage, and mode of representation affected children's rhythmic responses and that children spontaneously responded to music with movement. She also found no significant differences among 2-, 3-, and 4-yr.-old children in the ability to synchronize body movements with music. There is a discrepancy between these findings and Moog's results (1976) as he observed movements to music in 500 children, ages 6 months to 6 years, and reported that, for older groups of children, ability to synchronize body movements with a musical stimulus were improved. Other researchers indicated that children's nonlocomotor responses to rhythmic stimuli become more accurate with maturity (Rosenbusch & Gardner, 1968; Smoll, 1974a, 1975b; Thomas & Moon, 1976). Studying children 3 to 12 years old, Smoll (1975b) and Thomas and Moon (1976) reported that across age groups children synchronized arm movements more accurately with external auditory and visual stimuli.

Several researchers (Ashton, 1953; Thomas & Moon, 1976; Gilbert, 1980; Metz, 1989) have reported tests that purport to evaluate rhythmic ability. The Rhythmic Ability Analysis System, which was designed and constructed by Smoll (1973), enabled assessment of spatial-temporal characteristics of gross motor responses to a rhythmic auditory stimulus. It was an assessment of ability to be at a specified point in space (spatial accuracy) at a specific time (temporal accuracy). Results from studies conducted by Smoll (1974a, 1974b, 1975) using this system indicated that both spatial and temporal errors decrease with increased age (6–11 years) and that boys do not differ from girls in spatial-temporal accuracy when responding to a rhythmic stimulus. Thus, overall disparities exist not only in the research literature regarding the effects of maturation on the development of fundamental rhythmic skills.

Researchers also have drawn varying conclusions regarding the role of sex on the development of these same skills. Groves (1969) found that, while age and pre-existing motor ability were factors in learning to synchronize rhythmic motor responses, sex was not. Also, Gardner (1971), Smoll (1975a), and High (1987) found no significant differences in rhythmic performances between males and females.

However, Moore (1974), Flohr (1991), and Gilbert (1980) concluded that girls were more accurate on motor music skills, e.g., motor pattern coordination, eye-hand coordination, than boys. Schleuter and Schleuter (1989) conducted a study with 212 kindergarten, first, second, and third grade children and concluded that girls significantly outperformed boys, as measured on the Rhythm Response Test. Weikart (1982) noted that boys had more difficulty with rhythmic tasks than girls. She found that 63% of the girls and 60% of the boys were competent in the nonlocomotor skills of bilateral patting. On the locomotor skill of walking forward, 43% of the girls and 25% of the boys were rhythmically accurate. Moreover, Wolff (1980) concluded that motor skill development was related to sex of primary age children.

Rainbow (1981) studied rhythmic ability of preschool children, ages 3 to 4 years, in a three-year study in which children were asked to synchronize movements with a steady beat, and he reported that 60% of the 4-yr.-olds could clap a steady beat with a musical stimulus but only 20% of the same group could march rhythmically to the same beat. He concluded that large motor movements such as marching are too difficult for young children to perform rhythmically. Gordon (1979) suggested that both small and large muscle movements may be used in rhythm tests with young children, but large muscle movements should be encouraged because preschool children find it more difficult to respond with precision when using small muscle movements.

The difficulty of differentiating between failure to sense the rhythm and failure to coordinate well enough to express the felt rhythm represents one of the weaknesses found on the tests measuring the nature of rhythmic ability. Another weakness of these tests relies on the difficulty of differentiating between failure to sense the rhythm and failure to remember the rhythm pattern during an interval until judgment may be given (Haight, 1944).

Other questions arising from the utilization of rhythm tests concern the relation between locomotor and nonlocomotor movements, one-hand and two-hand, and bilateral and parallel movements as well as the necessity to be incorporated in a rhythm test. Robertson (1984) stated that synchronizing nonlocomotor responses with rhythmic stimuli requires less skill than does synchronizing locomotor responses with rhythmic stimuli. In his research, children 4 to 5 years of age successfully learned nonlocomotor synchronization tasks, whereas children of the same age group encountered more difficulties with basic locomotor synchronization skills, such as walking, running, and skipping.

Young children, aged three to six years, were subjects of a developmental study of motor music skills (Gilbert, 1980). Gilbert developed a scale to measure selected rhythmic music skills using the Motoric Music Skills Test, which consisted of five subtests: (a) motor pattern coordination, (b) eye-

hand coordination, (c) speed of movement, (d) range of movement, and (e) compound factors. Performances were recorded on videotape for observation and evaluation by two judges. From the data collected, she concluded that the skills assessed by the test improve across groups of increasing age. Gilbert also noted that one-hand skills develop earlier than the two-hand skills and that the latter develop first bilaterally and then in parallel.

These studies provide insight into the evaluation of children's rhythmic ability. It is clear, however, that there are other aspects which need to be explored before a comprehensive description of young children's rhythmic ability can be developed. The present study examined age and sex for preschool children in relation to different aspects of rhythmic ability concerning performance with one and two hands, bilateral and parallel use, and upper and lower limbs. It was hypothesized that (a) older children would score higher than younger on the measures of rhythm, (b) girls would score higher than boys, (c) subjects would score higher on the movement of the preferred hand than on parallel movement of hands and on movement of the nonpreferred hand, on bilateral movement of the hands than on parallel hands movement, and bilateral feet movement in a seated position, and on bilateral feet movement in a standing than in a seated position.

Method

Subjects

Two groups of children ($N=77$) from preschool centers in Greece participated. Group 1 consisted of 23 boys and 18 girls of ages ranging from 4.5 to 5.5 yr. ($M=5.0$, $SD=.5$). Group 2 consisted of 18 boys and 18 girls whose ages ranged from 5.6 to 6.5 yr. ($M=6.1$, $SD=.4$). Children were observed to be right-handed. Children received parental permission for participating in this study.

Measures

Rhythmic ability was assessed by a version of the High/Scope Beat Competence Analysis Test (Weikart, Schweihart, & Larner, 1987). The children performed the same six movements: patting knees with both hands (parallel movement of hand), patting knees with alternating hands (bilateral movement of hands), patting a knee with the preferred hand (movement of the preferred hand), patting a knee with the nonpreferred hand (movement of the nonpreferred hand), tapping the floor with alternating feet in a seated position [bilateral movement of feet (seated)], and walking in place in a standing position [bilateral movement of feet (standing)]. One trial was given to the child who listened 36 beats (rhythm tempo: 100 beats per min.) for each rhythm task and tried to synchronize movements with the beat. One practice trial, e.g., 5 beats, was allowed for each task. The number of

the synchronized movements to the steady metronome beat was used in the assessment of each aspect of rhythmic ability.

Weikart, *et al.* (1987) found responses to the test gave coefficients alpha of internal consistency from .70 to .79. The concurrent validity of the test was shown by its statistically significant, positive correlation with the test of gross motor ability (Kiger, 1994).

Procedure

The subjects were tested individually, and standard instructions were provided to familiarize them with the testing environment and the nature of the tasks. Their performance was videotaped and subsequently independently scored twice by two trained raters. An 89% intraobserver and 85% interobserver agreement was obtained.

Results

Means and standard deviations for measures of the rhythm by boys and girls in the two age groups are depicted in Table 1. Separate univariate analyses of variance [2 (age groups) × 2 (sex) × 2 (movements)] with repeated measures on the last factor were used for each pair of movements. More specifically, the pairs of movements were (a) parallel movement of hands with movement of the preferred hand (Pair 1), (b) parallel movement of hands with bilateral movement of hands (Pair 2), (c) movement of the preferred hand with movement of the nonpreferred hand (Pair 3), (d) bilateral movement of hands with bilateral movement of feet in a seated position (Pair 4), and (e) bilateral movement of feet in a seated position with the same movement in a standing position (Pair 5).

TABLE 1
MEANS AND STANDARD DEVIATIONS FOR NUMBER OF SYNCHRONIZED BEATS ON ALL MEASURES OF RHYTHMIC ABILITY FOR BOTH AGE GROUPS OF BOYS AND GIRLS

Rhythmic Movement	Age Group 1 (4.5–5.5 yr.)				Age Group 2 (5.6–6.5 yr.)			
	Boys		Girls		Boys		Girls	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Parallel hands	21.22	4.99	23.50	6.33	21.33	5.98	24.28	4.76
Bilateral hands	22.83	6.74	23.72	6.40	24.28	5.29	25.22	7.28
Preferred hand	21.22	5.26	24.78	7.63	23.78	4.80	26.28	5.13
Nonpreferred hand	14.78	4.35	17.72	6.19	18.00	5.72	18.94	5.59
Bilateral feet (seated)	19.04	3.98	18.39	5.62	21.06	5.24	19.00	5.16
Bilateral feet (standing)	21.78	6.37	21.83	6.17	23.78	6.20	24.17	6.56

Analysis showed that the interactions of movement × age group, movement × sex, and movement × age group × sex were not significant for the pairs of movement examined. Only on Pair 4 was the interaction between movement and sex significant ($F_{1,74}=5.27$, $p<.05$). As shown in Table 2, girls

were more accurate than boys on bilateral movement of hands while boys were more accurate on bilateral movement of feet in a seated position than girls.

TABLE 2
MEANS AND STANDARD DEVIATIONS FOR NUMBER OF SYNCHRONIZED BEATS ON ALL MEASURES OF RHYTHMIC ABILITY FOR BOTH AGE GROUPS OF BOYS AND GIRLS

Rhythmic Movement	Boys		Girls		Whole Sample	
	M	*SD*	*M*	*SD*	*M*	*SD*
Parallel hands	21.27	5.38	23.95	5.41	22.56	5.52
Bilateral hands	23.46	6.12	24.70	6.85	24.05	6.46
Preferred hand	22.34	5.16	25.87	6.45	24.04	6.04
Nonpreferred hand	16.20	5.19	18.22	5.81	17.15	5.55
Bilateral feet (seated)	19.93	4.63	18.92	5.51	19.44	5.07
Bilateral feet (standing)	22.66	6.30	22.95	6.22	22.80	6.22

The main effect of movement, however, was significant for pairs of movements (Pair 1: $F_{1,75}=8.88$, $p<.01$); (Pair 2: $F_{1,74}=5.52$, $p<.05$); (Pair 3: $F_{1,74}=31.70$, $p<.001$); (Pair 4: $F_{1,74}=92.90$, $p<.001$); and (Pair 5: $F_{1,75}=47.76$, $p<.001$). Children had better scores (a) on movement with the preferred hand than on parallel movement of hands, (b) on bilateral movement of hands than on parallel movement of hands, (c) on bilateral movement of hands than on bilateral movement of feet in a seated position, (d) on movement with the preferred hand than with the nonpreferred hand, and (e) on bilateral movement of feet in a standing than a seated position (Table 2).

DISCUSSION

Various motor responses to auditory or visual stimuli have been used for an objective assessment of motor rhythm. These include finger tapping (Knights & Moule, 1967), foot tapping (Rosenbusch & Gardner, 1968), and locomotor patterns (Ashton, 1953; Simpson, 1958). In tests incorporating motor responses to imposed rhythmic stimuli, the performer tries to match his movements to the rhythmic structure of the stimulus series. Since the concern of the investigation is related with the adaptation to rhythmic stimuli, the use of a motor response that does not present inherent difficulties of coordination is more appropriate (Haight, 1944).

One of the factors that affect rhythmic performance and is studied in this research is age. Studies investigating this factor noted that, as children develop ability to synchronize body, movements with a rhythmic stimulus improve (Rosenbusch & Gardner, 1968; Moog, 1976; Smoll, 1974a, 1975b; Thomas & Moon, 1976). In the present study, however, although the 6-yr.-old children had better scores than those in the 5-yr.-old group on all measures of rhythm, this difference was not significant and, consequently, the

first hypothesis was rejected. The lack of an age effect associated with rhythmic ability might be attributed to the large interindividual differences.

Between sexes, significant differences were found only on two measures of rhythmic ability. Girls were more accurate than boys on bilateral movement of hands while boys were more accurate than girls on bilateral movement of feet in a seated position. Although girls had better performance than boys on other measures, these differences were not significant and, thus, the second hypothesis was confirmed only for the above measures. Smoll (1975a) came to the same conclusion, reporting that among preschool children, girls and boys did not differ in regard to their motor response in time and space to a rhythmic stimulus. The finding was supported by Groves (1969) and Thomas and Moon (1976) who stated that sex was not a significant factor in synchronizing motor rhythmic responses in preschool and primary grade children. On the contrary, Moore (1974), Flohr (1991), and Gilbert (1980) concluded that girls scored significantly higher on rhythmic tasks than boys. Also, Schleuter and Schleuter (1989) stressed that girls in the first, second, and third grade significantly outperformed boys, as measured by the Rhythm Response Test.

The discrepancy in sex differences in rhythmic performance was based, probably, on the differences among the tests used in these studies. In research which supported that girls showed better rhythmic performance than boys, the subjects were examined using complex rhythmic patterns, while the subjects in the current study and in the studies of Smoll (1975) and Thomas and Moon (1976) were examined on simple rhythmic patterns. It seems that the rhythmic performance of the two sexes is influenced by the complexity of the rhythmic pattern, with girls able to perform better than boys the complex rhythmic patterns which demand better rhythmic synchronization. It is possible that differences between boys and girls would not be reported if children were examined on simple rhythmic patterns. Although the perception of rhythmic patterns is apparently a more complex process than time perception, it is generally believed that both perceptual phenomena employ the same sensory and neurological mechanisms. Yet, little is definitely known about the nature of the underlying mechanisms.

The study of Rainbow (1981) showed that large motor movements such as marching are too difficult for young children to perform rhythmically. Gordon (1979) stated that both small and large muscle movements may be used in rhythm tests with young children, but large muscle movements should be encouraged because preschool children find it more difficult to respond with precision using small muscle movements. The rhythm test in this study used both small and large muscle movements, and the children showed greater difficulty in synchronizing large muscle movement than small muscle movement with the auditory rhythmic stimulus. Thus, children had bet-

ter scores on bilateral movement of hands than on bilateral movement of feet in a seated position. In addition, the version of the High/Scope Beat Competence Analysis Test used in this study included five nonlocomotor movements. According to Robertson (1984), synchronizing nonlocomotor responses with rhythmic stimuli requires less skill than does synchronizing locomotor responses with rhythmic stimuli.

Gilbert (1980) noted that one-hand skills develop earlier than two-hand skills and that bilateral movement develops earlier than parallel movement. The results here support these findings since children had better scores on the movements using the preferred hand and the hands bilaterally than for using the hands in parallel. The third hypothesis was confirmed for all the rhythmic ability measures.

Bond (1959) stated that the rhythmic components which are integrated to produce coordinated motor performance may involve ability to perceive the specialized form of rhythm expressed in simple periodic successions of visual, aural, or tactile events. However, the multiplicity of rhythmic components and the complexity of their integrated interrelationships are such that isolation of a single element, such as ability to perceive periodic successions, provides little insight into the nature of the integrated whole. Further study of the rhythmic phenomenon should increase our understanding of the mechanisms and assist in identifying the experiences which can enhance children's motor development.

REFERENCES

Ashton, D. (1953) A gross motor rhythm test. *Research Quarterly*, 24, 253-260.

Bond, M. (1959) Rhythmic perception and gross motor performance. *Research Quarterly*, 30, 259-265.

Findlay, E. (1971) *Rhythm and movement: application of Dalcroze Eurythmics*. Evanston, IL: Summy Birchard.

Flohr, J. (1991) A preliminary study of young children's ability to perform a steady beat. Paper presented at the 1991 Texas Music Educators Convention, San Antonio.

Gardner, H. (1971) Children's duplication of rhythm patterns. *Journal of Research in Music Education*, 19, 355-360.

Gilbert, J. (1980) An assessment of motor music skill development in young children. *Journal of Research in Music Education*, 28, 167-175.

Gordon, E. (1979) *Primary measures in music education*. Chicago, IL: G.I.A.

Groves, W. (1969) Rhythmic training and its relationship to the synchronization of motor-rhythm responses. *Journal of Research in Music Education*, 17, 408-415.

Haight, E. (1944) Individual differences in motor adaptations to rhythmic stimuli. *Research Quarterly*, 15, 38-43.

High, L. (1987) Effects of selected rhythmic teaching strategies on beat performance skills of kindergarten children. *Dissertation Abstracts International*, 48, 3067A.

Kiger, J. (1994) Relationships among the development of fundamental motor skills, basic timing, and academic performance in elementary school age children. *Dissertation Abstracts International*, 78, 5680B.

Knights, R. M., & Moule, A. D. (1967) Normative and reliability data on finger and foot tapping in children. *Perceptual and Motor Skills*, 25, 717-720.

Laban, R. (1980) *The mastery of movement*. Plymouth, GB: Macdonald & Evans.

METZ, E. (1989) Movement as a musical response among preschool children. *Journal of Research in Music Education*, 57, 48-60.

MOOG, H. (1976) The development of musical experience in children of preschool age. *Psychology of Music*, 14, 38-47.

MOORE, D. (1974) A study of pitch and rhythm responses of five-year-old children in relation to their early music training. *Dissertation Abstracts International*, 34, 6689A.

RAINBOW, E. (1981) A final report on a three-year investigation of the rhythmic abilities of preschool aged children. *Bulletin of the Council for Research in Music Education*, 66, 69-73.

ROBERTSON, M. A. (1984) Changing motor patterns during childhood. In J. R. Thomas (Ed.), *Motor development during childhood and adolescence*. Minneapolis, MN: Burgess. Pp. 143-172.

ROSENBUSCH, M. H., & GARDNER, D. B. (1968) Reproduction of visual and auditory rhythm patterns by children. *Perceptual and Motor Skills*, 26, 1271-1276.

SCHLEUTER, S., & SCHLEUTER, L. (1989) The relationship of grade level and sex differences to certain rhythmic responses of primary grade children. *Journal of Research in Music Education*, 33(1), 23-30.

SIMPSON, S. (1958) Development and validation of an objective measure of locomotor response to auditory rhythmic stimuli. *Research Quarterly*, 3, 342-348.

SIMS, W. (1985) Young children's creative movement to music: categories of movement, rhythmic characteristics, and reactions to changes. *Contributions to Music Education*, 12, 42-50.

SMOLL, F. L. (1973) Communications: a rhythmic ability analysis system. *Research Quarterly*, 44, 232-236.

SMOLL, F. L. (1974a) Development of rhythmic ability in response to selected tempos. *Perceptual and Motor Skills*, 39, 767-772.

SMOLL, F. L. (1974b) Development of spatial and temporal elements of rhythmic ability. *Journal of Motor Behavior*, 6, 53-58.

SMOLL, F. L. (1975a) Preferred tempo in performance of repetitive movements. *Perceptual and Motor Skills*, 40, 439-442.

SMOLL, F. L. (1975b) Variability in development of spatial and temporal elements of rhythmic ability. *Perceptual and Motor Skills*, 40, 140.

THOMAS, J. & MOON, D. (1976) Measuring motor rhythmic ability in children. *Research Quarterly*, 47, 20-32.

WEIKART, P. (1982) *Teaching movement and dance: sequential approach to rhythmic movement*. Ypsilanti, MI: High Scope Press.

WEIKART, P., SCHWEIHART, L., & LARNER, M. (1987) Movement curriculum improves children's rhythmic competence. *High/Scope Resource*, 6(1), 8-10.

WOLFF, K. (1980) The effects of general music education on the academic achievement, perceptual-motor development, creative thinking and school attendance of first grade children. *Dissertation Abstracts International*, 40, 5359A.

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