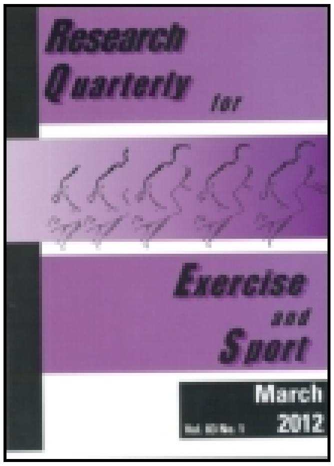

Research Quarterly for Exercise and Sport
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/urqe20

A Prelongitudinal Test of Motor Stage Theory

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Published online: 22 Feb 2013.

To cite this article: Stephen Langendorfer (1987) A Prelongitudinal Test of Motor Stage Theory, Research Quarterly for Exercise and Sport, 58:1, 21-29, DOI: 10.1080/02701367.1987.10605415

To link to this article: http://dx.doi.org/10.1080/02701367.1987.10605415

RESEARCH QUARTERLY
FOR EXERCISE AND SPORT
1987, VOL. 58, NO. 1, PP. 21-29

A Prelongitudinal Test of Motor Stage Theory

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A test of motor stage theory was conducted to screen cross-sectionally for the existence of "horizontal structure" among motor sequences within four movement components of overarm throwing and overarm striking for force. A total of 58 male subjects were filmed performing five trials of each task. Comparisons were made between movement component sequence levels as assessed by Roberton's Component Category Checklist for the Overarm Throw and Langendorfer's Component Category Checklist for Overarm Striking. Results indicated that longitudinal study of sequences within the components of trunk, humerus, forearm-racquet actions was warranted and that intertask comparisons of motor sequences were best represented by combinations of stage models proposed by Wohlwill (1973). The observed movement commonalities in the present data were consistent with constructs in both Piagetian developmental stage theory and Schmidt's schema theory in motor control and learning.

Key words: horizontal structure, motor sequences, motor stage theory, longitudinal study of sequences.

Piaget's stage theory of cognitive development serves as a powerful theoretical model for developmental psychologists (Flavell, 1982; Pinard & Laurendeau, 1969). The theory emphasizes qualitative changes in cognitive function as a result of a dialectical process of equilibration or adjustments to environmental and maturational fluctuations (Piaget, 1975). The interactive equilibration process manifests itself through the acquisition of an invariant series of broad structural configurations in thought called "stages." It is important to note that Piaget reserved the term stages solely for those developmental sequences capable of fulfilling a rigorous set of criteria which include hierarchization, integration, consolidation, and structuralization (Pinard & Laurendeau, 1969). Thus, all stages represent developmental change, but not all developmental changes are stage-like.

Early motor development researchers borrowed the idea of stages from embryology and used the term to describe the qualitative, sequential changes in movement tasks (Gesell, 1939; Shirley, 1931; Wild, 1938). These researchers, however, viewed stages primarily in a descriptive sense. Wohlwill (1973, p. 193), in noting the relative absence of theoretical dimensionality for motor stages, likened them more to "places on the itinerary of a bus line" than to the robust construct suggested by Piaget. While both Piaget's stage theory and the motor stage theory have biological origins, motor stage theory has focused primarily on "maturational" determinants of developmental changes rather than on the interactive equilibratory processes suggested by Piaget. Finally, motor sequence researchers generally have accepted stage changes as axiomatic and have focused on the descriptive identification of sequences rather than on empirical tests of the theory. In fact, motor development researchers often erroneously have labeled all developmental changes as stage changes.

More recently, Roberton (1977, 1978a) has urged that a stage theory in motor development should have theoretical and heuristic value for generating and testing research within the field of motor development. In particular, she proposed that adoption of several basic Piagetian stage criteria (hierarchic, invariant order; universality; stability) would permit researchers to evaluate hypothesized motor sequences for "stage-like" qualities of change (Roberton, 1977, 1978b, 1982). Indeed, the initial cross-sectional and "prelongitudinal" screening tests and subsequent longitudinal validation of intratask motor sequences for overarm throwing provided empirical demonstration of stage-like characteristics for some of the observed changes in the movement patterns (Roberton, 1977, 1978a, 1982; Roberton & Langendorfer, 1980). Based upon these studies, therefore, some motor sequences can be characterized as developing in a robust, invariant order for all subjects while levels within the sequences were characterized by a remarkable categorical stability across trials. These findings could be interpreted as a demonstration of a strong "vertical structure" (Wohlwill, 1973), or a robustness of the across-time order in a change sequence.

According to Piagetian stage theory, there is an additional stage criterion, structural wholeness or *structures d'ensemble*, which describes the degree to which stage structures generalize beyond individual intratask sequences (Pinard & Laurendeau, 1969; Roberton, 1978b). This structuralization criterion, also called "horizontal structure" (Wohlwill, 1973), refers to the existence of across-task commonality among developmental sequences. Roberton (1982) compared the longitudinal throwing and striking behavior of seven children for evidence of such commonality. While she did note similarities across tasks for several subjects, Roberton's conclusions were tentative due to the variability among subjects and the observation of only striking and throwing tasks. The finding of commonality across motor sequence levels would provide an important similarity between motor stage theory and Piagetian cognitive stage theory due to the presence of horizontal structure. A next step in motor stage research, therefore, is to test whether some tasks develop "apace" (Wohlwill, 1973) or in a "structurally whole" manner (Roberton, 1978b).

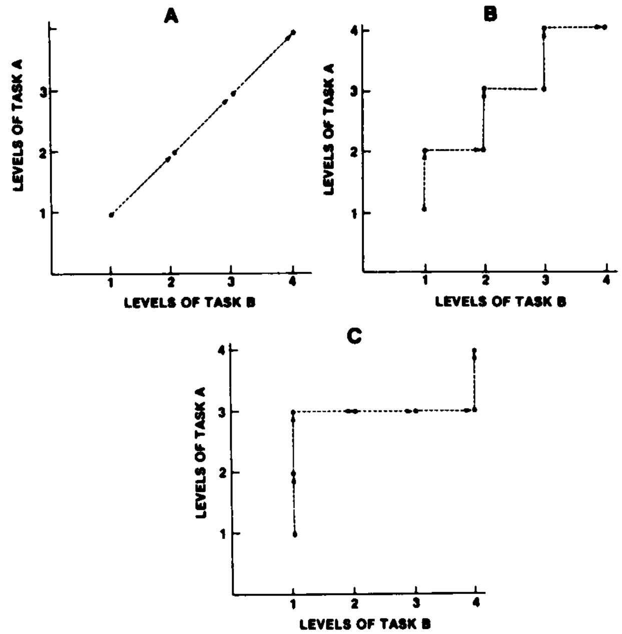

Figure 1—Longitudinal stage models

***1A.* Synchronous development between two, four-level developmental sequences (after Wohlwill, 1973). Concomitant levels in both tasks are achieved simultaneously.**

***1B.* An asynchronous type of development, horizontal *décalage*, between two, four-level sequences (after Wohlwill, 1973). Each level within Task A is achieved prior in time to the achievement of the concomitant level in Task B.**

***1C.* An asynchronous type of development, reciprocal interaction, between two, four-level developmental sequences (after Wohwill, 1973). Several levels within Task A are achieved prior in time to any levels of Task B. Reciprocally, several levels within Task B then are achieved prior in time to further change in levels within Task A.**

Stage Models

An important first step in detecting "structural wholeness" across tasks was to operationalize motor stages behaviorally. Wohlwill (1973) has suggested several "stage models" for the potential forms of across-task sequential change (Figure 1). Figure 1A suggests the ideal, but simplistic, notion of stage change: synchronous development. Within this model, changes for two sequences occur simultaneously, exactly at the same time. Statistically, such across-task changes correlate perfectly.

Figure 1B represents a temporally asynchronous developmental model: horizontal *décalage*. Onset of each level within the motor sequence of Task A occurs prior to the time of acquisition for the concomitant levels within Task B. Thus, change in a level for one task serves as a precursor to change into the similar level in the second sequence. The resulting pattern of change, therefore, is nonlinear.

Finally, Figure 1C illustrates a hybrid variant of the *décalage* model: reciprocal interaction. Within this model, subjects moving at primitive or early developmental levels progress through several levels within Task A prior to achieving any developmental change in levels for Task B. Subjects then attain several levels within Task B, while not demonstrating further development in Task A. Unlike the simple alternating asynchrony of the horizontal *décalage* stage model, within reciprocal interaction several developmental levels of one skill act as prerequisites for the attainment of any levels within the second sequence. Reciprocally, development of several later levels in the second task becomes prerequisite to final development in the first task.

Prelongitudinal screening of stage models

The previous stage models were proposed within a longitudinal framework. Studies by Roberton and colleagues have demonstrated the feasibility, and even advisability, of pursuing prelongitudinal screening methods before embarking on a longitudinal test required for final validation of a development sequence (Halverson & Williams, 1985; Roberton, 1977, 1978a; Roberton, Williams & Langendorfer, 1980; Williams, 1980). The present study adopted such a prelongitudinal screening methodology. Since a cross-sectional sample merely selects points on a longitudinal time continuum, the results of a prelongitudinal study recommend only whether to continue with further cross-sectional screening or to proceed to longitudinal validation.

Patterns of responses from cross-sectional samples which may represent Wohlwill's longitudinal stage models are portrayed in contingency table form (Fig-

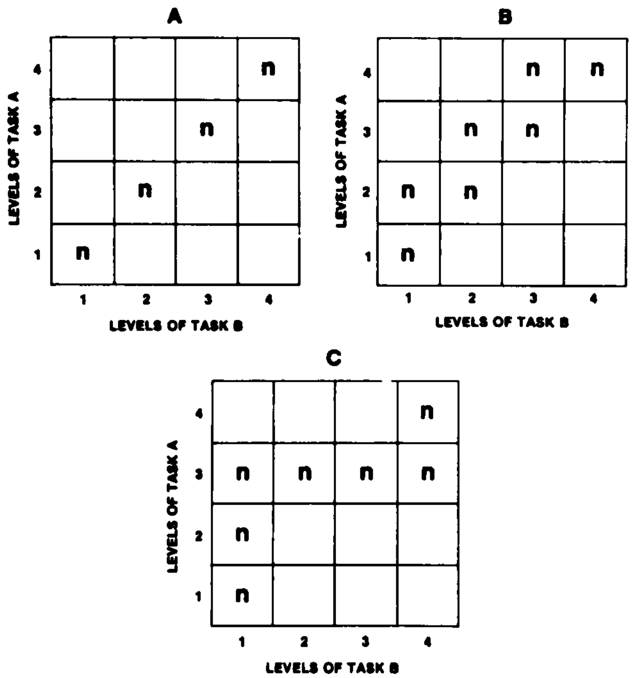

Figure 2—Hypothesized cross-sectional stage evidence.

***2A.* Synchronous stage evidence. Ideally, subjects would be classified only in the cells marked *n*.**

***2B.* Horizontal *décalage* stage evidence. In addition to some subjects being classified synchronously on both tasks, other subjects also are classified one level more advanced on Task A than on concomitant levels of Task B.**

***2C.* Reciprocal interaction stage evidence. Primitive level subjects would be categorized as more advanced on levels within Task A while more advanced subjects would be categorized as superior on Task B.**

ure 2). If all subjects in a cross-sectional sample were classified identically on both tasks, regardless of developmental level, the pattern of responses would predict a synchronous developmental stage model. Figure 2A demonstrates how these responses would be categorized in a contingency table (an "n" represents those cells in which subjects are classified). If, in addition to subjects with synchronous classifications, other subjects consistently move with a level of one task more advanced than the level of the second task, the asynchronous developmental stage model, *horizontal décalage*, would be predicted prelongitudinally (Figure 2B). In turn, Figure 2C demonstrates a reciprocal interaction pattern in which some subjects are more advanced on levels of Task A while others are classified as superior on Task B. The presence of subjects in cells outside those indicated by the *n*'s would indicate deviations, called outliers, from the ideal longitudinal models. Sufficient outlier subjects would lower the monotonic relations among levels of the tasks and cast doubt upon achieving robust validity in a longitudinal test of horizontal structure.

The present investigation extends previous tests of motor stage theory by examining several parallel motor sequences from two different skills for the existence of structural wholeness or horizontal structure. Specifically, the current study tested changes in four movement component sequences within two motor skills (overarm throwing and striking) for evidence of generalized parallel development within individuals across the tasks.

Methods

Subjects

A cross-sectional sample of 58 males, bimodally distributed between 1.5 and 4.3 years (n = 22; M = 2.7 years; SD = 0.9 years) and 6.1 and 10.3 years (n = 36; M = 8.8 years; SD = 1.1 years), was filmed performing the two selected motor tasks. All subjects were volunteers from several daycare centers and elementary schools in the Madison, Wisconsin, area. Subjects had no diagnosed handicapping conditions nor had they received special training in either striking or throwing beyond physical education and youth sport experience. Standard human subjects consent procedures were employed. The sample was limited to males in order to avoid possible interactional gender effects. The lack of four- and five-year old subjects was an anomaly of the sample available at the selection sites.

Measures

The overarm throw for force previously has been used to study vertical structure (i.e., sequentiality) within the development of a single task (Roberton, 1977; 1978a; 1982; Roberton & Langendorder, 1980; Wild, 1939). Due to observed biomechanical similarities in pattern (Broer, 1973, 1984; Cooper, Adrian & Glassow, 1982) and Roberton's previous across-task comparisons (1982), an overarm striking task also was selected for the current study. The development of striking has been studied previously (Deach, 1950; Halverson & Roberton, 1966; Harper & Struna, 1973) and, more recently, Langendorfer (in press) hypothesized and tested sequences within movement components of overarm striking (Table 1).

Procedures

Two Milliken high-speed 16mm cameras (DBM-45; DBM-50) recorded the side and rear view throwing and striking movements of each subject (64 fps). Standardized biomechanical procedures were employed during data collection. Each subject was asked to throw a tennis ball as hard or forcefully as possible in a designated direction for five trials. Each subject also was asked to forcefully hit a tennis ball suspended

Table 1
Developmental Levels within Movement Components of Throwing and Striking

Movement Component	Throwing	Striking
*Trunk Action	1. no rotation 2. rotation (spinal or block) 3. differentiated rotation	1. no rotation 2. rotation (spinal or block) 3. differentiated rotation
*Humerus Action	1. oblique humerus 2. aligned but independent 3. lagging humerus	1. oblique humerus 2. aligned but independent 3. lagging humerus
*Forearm Action	1. no forearm lag 2. forearm lag 3. delayed forearm lag	
Racquet Action		1. no racquet lag 2. racquet lag 3. delayed racquet lag
Stepping Action	1. no step 2. ipsilateral step 3. contralateral step 4. long contralateral step	1. no step 2. ipsilateral step 3. contralateral step 4. long contralateral step

*These movement components for throwing had received longitudinal validation (Roberton, 1978a; Roberton & Langendorfer, 1980)

approximately 15 cm above his own head height with a small lightweight racquet for five trials. The two tasks were presented in an alternating order across the sample to control for possible systematic order or learning effects.

Data Reduction

Standardized data reduction procedures for the component category checklists of throwing and striking (Langendorfer, in press; Roberton, 1977, 1978a, 1982) were used in this study. Side and rear views of each filmed trial were projected simultaneously using the stepped- and slow-motion modes of analyzer projectors. A conical timing device in each view was used to synchronize film frames from each camera. Filmed trials were viewed and assessed independently from other trials.

The Roberton instrument has a high degree of reliability (greater than 90% across-trial consistency) and a reasonable level (80% exact agreement or greater) of inter- and intra-rater objectivity. Two of seven movement components (body part or joint actions) have demonstrated "perfect" developmental validity (i.e., universal, invariant order) in cross-sectional and longitudinal samples of nonhandicapped and handicapped subjects. The Langendorfer (in press) striking instrument has similar levels of reliability and objectivity (i.e., 91% across trial consistency and 79%–100% exact agreement for objectivity). In initial screening tests, several movement components maintain a level of developmental validity for striking similar to those in throwing.

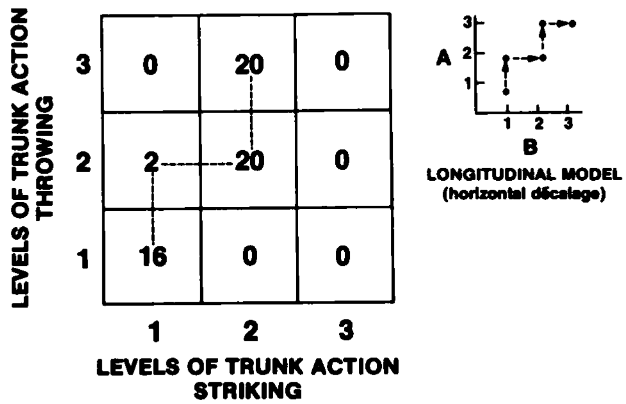

Figure 3—Cross-sectional comparison between levels within trunk action of overarm throwing and striking. Cell categorizations suggested the horizontal *décalage* longitudinal stage model (upper right).

Data treatment

Two analyses were used to assess the structural wholeness or concordance of stage levels across subjects. The first arranged the subjects' modal scores for each movement component on both tasks into 3 × 3 or 4 × 4 contingency tables. These tables were tested against each of Wohlwill's descriptive stage models using a 2 × 2 χ^2 "goodness-of-fit" test. This analysis is "deterministic" (Wohlwill, 1973) since each subject's developmental status on a task is viewed as a rigidly-categorized value. The second analysis involved the calculation of two monotonic coefficients, Goodman and Kruskal's *gamma* and Somers' asymmetric *d* coefficients. Nonparametric coefficients were selected due to the ordinal scale data. Each was selectively applied, depending upon the apparent type of relation. Somers' *d* is more sensitive to deviations for linearity (synchronous stage model), while the *gamma* is more sensitive to nonlinear relations (i.e., asynchronous stage models) (Siegel, 1956; Somers, 1962). In addition, Wohlwill (1973) has suggested that such coefficients can portray the data in more probabilistic terms.

Results

Stage Comparisons

The comparisons between the levels of trunk action used in throwing and striking are portrayed in Figure 3. Sixteen subjects used level 1, a primitive develop-

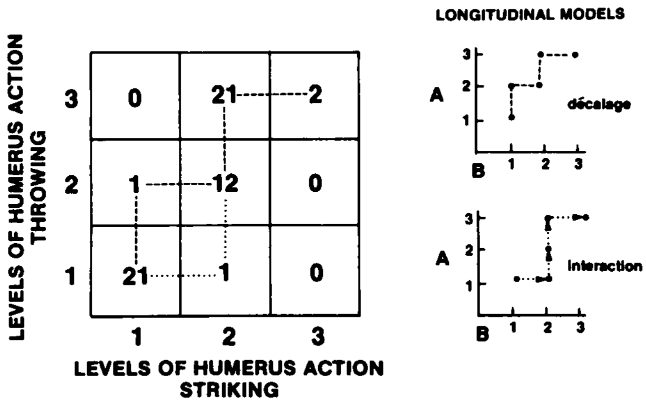

Figure 4—Cross-sectional comparison between levels within humerus action of overarm throwing and striking. Cell categorizations suggested either the horizontal *décalage* or reciprocal interaction stage models (right).

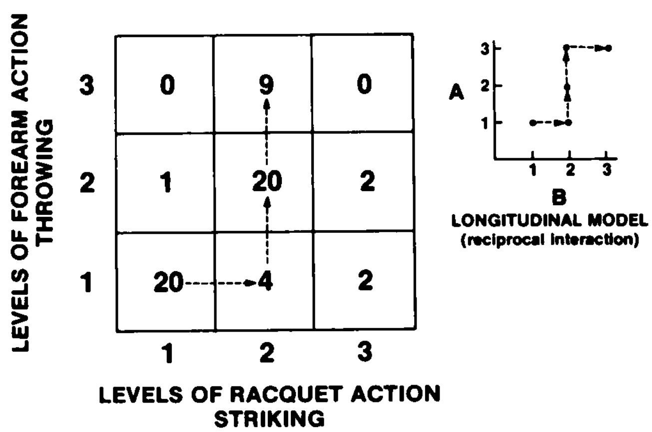

Figure 5—Cross-sectional comparison between levels within the forearm action of overarm throwing and racquet actions of overarm striking. Cell categorizations best predicted the reciprocal interaction longitudinal stage model (upper right).

mental status, in both throwing and striking (i.e., T-1, S-1). Another 20 subjects used Level 2, an intermediate level (block rotation) in both striking and throwing (T-2, S-2). Two subjects, however, showed Level 2 throwing and Level 1 striking (T-2, S-1) while another 20 subjects used Level 3 throwing combined with Level 2 striking (T-3, S-3). The stage model that descriptively matched these results was equivalent to Wohlwill's *décalage* model. According to the post-hoc tests, the data were not significantly different from either the *décalage* or interaction models ($p > .05$) due in part to the presence of only two subjects in the T-2, S-1 cell. However, the monotonic coefficients indicated a perfect monotonic relation between trunk actions of throwing and striking for *gamma* ($g = 1.00$) and slightly lower value ($d = .97$) for the asymmetric coefficient which indicated that the closest fit was to the *décalage* stage model.

Comparisons of actions of the humerus in throwing and striking are shown in Figure 4. As in the trunk action comparisons, the majority of subjects ($n = 35$) used corresponding (i.e., synchronous) humerus action levels in both throwing and striking. A minority of subjects ($n = 23$), however, fell into asynchronous cells. Most of the latter ($n = 21$) fell into the T-3, S-2 cell meaning that subjects who threw the ball with a lagging humerus action (advanced developmental level) struck the ball with an "aligned but independent" action (intermediate developmental level). The presence of only one subject each in the cells T-2, S-1 and T-1, S-2 suggested that the data could have fit either synchronous, *décalage,* reciprocal interaction, or perhaps a combined stage model. The goodness-of-fit test indicated the responses were significantly different only from a synchronous model ($p < .001$), and thus could have fit either a *décalage* or interaction model. The relation among humerus levels produced a *gamma* coefficient equaling 0.997 and a Somers' *d* equaling 0.91.

Finally, when the forearm action of the throw was compared with the racquet action of the overarm strike, most subjects ($n = 42$) continued to demonstrate a high degree of synchrony across tasks (Figure 5). The pattern of the asynchronous responses by 13 subjects, however, suggested a reciprocal interaction was the best longitudinal stage model. Three outliers (i.e., subjects that contradicted the overall pattern) challenged the robustness of a strict deterministic stage model. The goodness-of-fit test indicated that subject responses were significantly different from synchronous and *décalage* patterns ($p < .001$) and thus a reciprocal interaction model was the best fit pattern. Outlier values reduced the monotonic *gamma* value to 0.94 and Somers *d* to 0.78.

Figure 6 displays the intertask comparisons between levels within stepping action for throwing and striking. Sixty percent of the subjects ($n = 35$) were categorized within synchronous cells (i.e., comparable levels of stepping in both throwing and striking). The number of asynchronous classifications (40%) did not differ radically from those observed in the previous three movement component sequences. The pattern of the classifications was important to note. When a subject used Level 1, no stepping action, in accomplishing his throw, he may have used any level from 1 to 3 when performing the striking task. Similarly, when stepping with opposition (Level 3) during a throw, subjects used any of four levels of stepping during striking. The best goodness-of-fit combined the horizontal *décalage* and reciprocal interaction patterns, although the data were still significantly different from that pattern ($p < .05$). The combination of the number of outliers ($n = 5$), the diverse pattern of

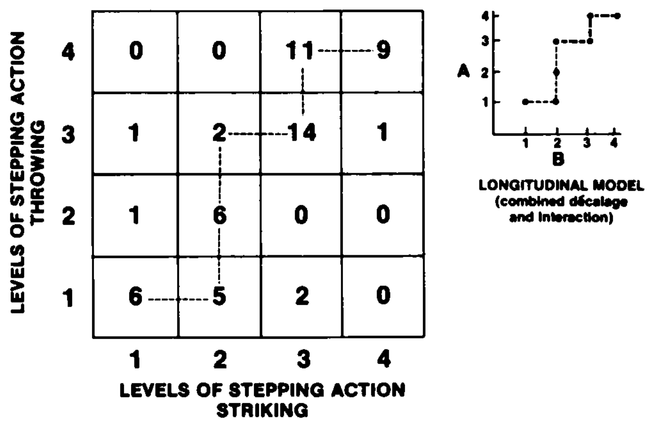

Figure 6—Cross-sectional comparison between levels within stepping action in throwing and striking. Intratask sequences within stepping action of throwing and striking had not shown strong stage qualities. Across-task categorizations indicated weak support for a combined *décalage*-interaction longitudinal stage model (upper right).

those outliers, and the comparatively lower relations (*gamma* = .90; *d* = .73) indicated relatively poor cross-sectional support for horizontal structure across tasks in stepping action.

Discussion

Implications for Motor Stages

Stage theory has been used to predict characteristics associated with change in qualitative sequences over time as well as the generalizability of those changes across task sequences (Pinard & Laurendeau, 1969; Roberton, 1978b). The current study was undertaken to examine the second aspect of stage theory: the existence of commonality among several different motor sequences. Despite the overwhelming support for the concept of specificity in the motor performance, learning, and control literature (Sage, 1984; Schmidt, 1982), the concept of generalizability continues to be referenced in the physical education and human movement literature.

Biomechanical classifications of motor and sport skills (Broer, 1973, 1984; Cooper, Adrian & Glassow, 1982) refer to common movement patterns (i.e., arm patterns: overarm, sidearm, underarm). The motor control literature also cites concepts such as motor schema (Schmidt, 1976; 1982), and coordinative structures as common neuromuscular control mechanisms. (Kelso, 1980; Schmidt, 1982). Such movement commonalities, however, generally have referred to motor skill behavior at one point in time without reference to change. The reference to common movement patterns and motor control structures assumes that the movement of young or inexperienced movers is performed and controlled similarly to older or more experienced movers. The present view suggests a need to expand these concepts into a developmental perspective (i.e., anticipating that movement patterns or control structures change across time).

The results of the current study supported the existence of descriptive commonalities across the changing levels of several motor sequences within the two selected motor tasks, overarm throwing and overarm striking. The cross-sectional data, viewed as a prelongitudinal screening method, supported the need for further longitudinal study of the two skills. The data did suggest that commonalities across levels within motor sequences in different skills cannot be viewed from the perspective of a simple synchronous stage model. The comparisons of the three previously-validated throwing movement component sequences (i.e., trunk, humerus, forearm actions) to striking sequences (trunk, humerus, racquet actions) demonstrated pronounced temporal asynchronies, especially at intermediate and advanced levels of each sequence. There was evidence at the primitive levels, however, that most subjects moved synchronously. Descriptively, developmental commonalities across tasks appear to become more asynchronous as the developmental status becomes more advanced. Thus, developmental status apparently may be characterized as relatively generalizable at primitive and intermediate levels of behavior but more specialized at advanced levels of movement status.

These observations have implications for researchers examining motor control structures for the existence of invariant and variant characteristics. They suggest that consideration of developmental status or learning skill level of subjects may in fact be very important. Younger and inexperienced subjects might manifest stronger invariant characteristics across tasks than older and more experienced subjects.

Analysis of stepping action across throwing and striking was included in the present study because it was of theoretical and measurement interest to determine whether a movement component sequence which had not received intratask support for vertical structure would demonstrate horizontal structure. While additional movement component comparisons were available from the data, stepping action was selected due to its common use in other developmental overarm throwing instruments (Gallahue, 1982; Seefeldt, Reuschlein, & Vogel, 1972; Wild, 1938). Previous prelongitudinal (Langendorfer, in press; Roberton, 1977) and longitudinal investigations (Roberton, 1978a; Roberton & Langendorfer, 1980) demonstrated that stepping action was characterized by poor intratask vertical structure (i.e., not all subjects showed a stable use of the same stepping level across trials or across time) for throwing and striking.

Lack of support for horizontal structure in stepping action across throwing and striking verified the perspective that vertical sequence structure must be present before those sequence levels are likely to generalize across sequences in the form of horizontal structure. In addition, weak horizontal structure for stepping action strengthened the validity of the horizontal structure observed in the three component sequences (i.e., trunk action, humerus action, forearm-racquet action) tested. A complete lack of horizontal structure in stepping action was not observed, just relatively less than the three components with robust vertical structure. Support is provided for the notion that stage theory criteria (i.e., for vertical and horizontal structure) are related within the Piagetian perspective (Wohlwill, 1973).

Integrating Stage Perspectives

The integration of the Piagetian stage theory with motor stage theory provides an important avenue for interpreting observed movement changes within a lifespan developmental perspective. Assuming that movement structures and motor processes exist which are similar to constructs hypothesized in the cognitive domain, the concepts of equilibration (i.e., assimilation and accommodation) can provide powerful means for interpreting and explaining both previously described intratask sequence changes (Halverson & Williams, 1985; Roberton, 1977, 1978a; Roberton & Langendorfer, 1980) and the intertask comparisons in the present study. Rather than assume *a priori* that developmental changes have either a maturational or experiential basis, stage theory, consistent with the most recent lifespan notions of developmental psychology, predicts instead that the interactional dialectic between mover and environment determines the course of movement changes (Roberton, 1984). Stage theory may support a developmental version of coordinative structures and movement schema (Schmidt, 1975) as important constructs in both controlling and changing motor behavior.

Piagetian-like motor schemas can explain observations in the current study. For example, a primitive schema for projecting a ball forward as used by one of the young subjects in the current study may consist of a neuromuscular command which dictates that the trunk remain stable while the arm segments (humerus and forearm action components) act to project the ball forward. When given an implement to accomplish a similar goal of striking an object (ball) forward, the same general schema, enacting a similar motor program, could readily be employed to accomplish the task of striking and projecting the ball. Such similar across task motor behavior is equivalent to a subject categorized in cell T-1; S-1 in the synchronous developmental stage model (Figure 1A).

In order to achieve greater distance or force, the thrower who previously performed in an arm-dominated mode (Step 1-trunk; Step 1-humerus; Step 1-forearm) might accommodate (i.e., adjust his movement schema to meet differing environmental demands) the trunk action to the next higher developmental level (Step 2-rotation). Given similar experiences with striking, the subject could accommodate striking behaviors and shift to a more advanced intermediate level of trunk rotation. However, if the subject has had less experience with striking, he/she might continue to assimilate (i.e., ignore the environmental demands to maintain an existing schema) the striking behavior by continuing use of a primitive model using no trunk action. This asynchrony between throwing and striking behaviors would result in cross-sectional data patterns reminiscent of the *décalage* and reciprocal longitudinal models (Figure 1B and 1C). Longitudinally, a subject may advance developmentally in both throwing and striking either synchronously or asynchronously.

From an interactional developmental perspective; therefore, the hypothesis of a purely synchronous stage model (Figure 1A) to explain movement commonalities across all levels of two sequences is necessarily too simplistic. It would mean that either the change in throwing and striking behaviors indeed was controlled maturationally or that all subjects received identical experiences throughout the course of development in both throwing and striking. Both assumptions are unreasonable in the light of theory and observation.

The present data in trunk action serves as a useful example (see Figure 3). According to the cross-sectional evidence presented in this study, most subjects (n = 20) chose a similar rotation schema for both throwing and striking a ball. Some subjects, however, continued the nonrotation trunk action schema for striking while demonstrating a rotation pattern in throwing (2 subjects in Figure 3 in cell T-2, S-1). Due to the cross-sectional nature of the present sample, whether subjects actually used one or both options across tasks when changing from Level 1 to Level 2 is impossible to predict.

An interesting and potentially important consistency appeared in the intertask comparisons for all three movement components. Only a small percentage of subjects who demonstrated primitive and intermediate levels of movement status in throwing chose a striking pattern asynchronous to throwing. This remarkable consistency across tasks suggests that young and developmentally primitive subjects primarily use assimilation, ignoring environmental and task differences to maintain a consistent movement schema. On the other hand, subjects who were classified at advanced levels of throwing status largely demonstrated asynchronous levels of striking. Regardless of the reason, advanced subjects accommodated to the differing demands of forcefully throwing and striking by choosing different movement schemas. Although assimilation and accommodation both contribute to the equilibration process in changing movement, younger and less advanced subjects appear to assimilate across tasks while older and more advanced subjects are more likely to accommodate.

The evidence for vertical structure in the levels of motor sequences within movement components for several motor skills (i.e. throwing, striking, and hopping) has been robust (Halverson & Williams, 1985; Langendorfer, in press; Roberton, 1978; Roberton & Langendorfer, 1980). Concomitant evidence for "horizontal structure" in motor development has not been nearly so strong (Roberton, 1982). Nevertheless, sufficient evidence was presented within the present study to warrant both continued prelongitudinal screening with other similar tasks (i.e., locomotor skills) and longitudinal validation of the present study using throwing and striking. Wohlwill's observation that in the cognitive developmental literature theoretical stage theories always have paired strong vertical structure with low horizontal structure appears also to apply with motor sequences. Those motor sequences which evidence strong vertical structure appear to be the best candidates for horizontal structure.

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Submitted: September 15, 1985
Accepted: May 23, 1986

This study was completed in conjunction with the requirements for Ph.D. at the University of Wisconsin-Madison under the direction of Dr. Lolas E. Halverson and Dr. Mary Ann Roberton.

The author acknowledges the assistance of a Grant-in-Aid of Research from Sigma Xi, the Scientific Research Society. In addition, preparation of the manuscript was aided by a Research and Creative Activity Appointment from the Division of Research and Sponsored Programs, Kent State University. The conceptual assistance of Dr. Halverson and Dr. Roberton along with the technical assistance of Dr. Kathy Williams, Dr. Ann VanSant and Ms. Karyn Bachman was greatly appreciated. The author thanks Dr. Robert E. Stadulis for his editorial assistance with previous versions of this paper.

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