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A Shift In Component Relationships In The Skill Of One Hand Striking Of Six and Seven Year Old Children: An Exploration of Product and Process

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ABSTRACT

The research is concerned with examining the adjustments six and seven year old children make when the type of implement is varied for the one hand strike, and the effects of those adjustments on outcomes. Additionally, the effects on both process and outcome of varying task goals are examined. The performances of seventeen children striking a ball within a changing but tightly controlled task environment was investigated. The outcome of the skill was measured in distance. The performances were video analysed to detect dynamic changes in task demands (instructional sets). From the video recordings, component production was assessed using an ordinal scale and the resultant data analysed using ACERÔs implementation of the RASCH Latent Trait Scaling model. The interval level scores derived from application of the RASCH model, together with the distance measurements, were analysed using MANOVA techniques to detect group differences. The analysis revealed no significant interactions or effects between the product and process scores, however commonalities emerged for items in relationship to task demand, task implement and commonalities emerged across all four trials. This paper extends current theories and empirical evidence by presenting performance models which illustrate various facets of adjustments to a changing task environment, and by describing the diversity of the adjustments and their implications for professional practice in physical education and sport science.
INTRODUCTION

Fundamental motor skills are considered as prerequisite to the development of more complex, sport specific skills (Gallahue, 1989; Holland 1986; Rose & Heath 1990; Walkley, Holland, Treloar, & Probyn-Smith 1993). Ongoing participation in physical activity and sports is dependent on a myriad of factors. However, “not having fun” was the most frequent reason given by adolescents for dropping out of sport. Upon further probing it was revealed that inadequate levels of competency in the fundamental motor skills and sport specific skills was synonymous with “not having fun” (Clough, McCormack & Trail, 1993; Rose & Heath 1990; Walkley, 1993). The interest in motor skill proficiency is an area of renewed research in Australia (Senate Enquiry into Physical and Sport Education, 1992; Thompson, McCormick, Thomas & Woodcock 1995; Walkley 1993). Results indicate an “abysmal” level of motor skill performance of primary aged children and the consequences include an impact on the participation levels of adolescents in sports. The nature of the assessment of motor skills is important to define when conclusions regarding participation levels rest on the results of such research. How are proficiency levels in motor skills assessed? Aside from the self assessment of motor skills by adolescents, the empirical assessment of the fundamental motor skills has employed a variety of strategies. Probably the most common method of assessment has been the product oriented approach (Davis 1984; Wade 1982).

The product-oriented approach is outcome based and reflects the final or end-product of a performance. Scores are expressed in quantitative terms, for example, the distance a performer hits a ball. This approach generally uses normative criteria with each child’s performance compared with the average performance of children in his or her age group category. The major criticism of product-oriented assessment is that it is based upon the end product rather than the quality of the movement. From the perspective of the teacher it provides limited information for the learner.

The approach most utilised for teaching and learning motor skills is the qualitative analysis because it focuses on the technique of the skill. The process-oriented form of assessment utilises qualitative analysis of movement. Furthermore, process assessment employs criterion referenced instruments providing important assessment and/or evaluative data to base learning and reporting for students. Qualitative analysis generally uses criterion measures to assess whether components of motor skills have been achieved - for example, an essential criterion for successful hitting (striking) is to commence side on to the target. More advanced criteria for the forehand strike include sequential hip and shoulder rotation (Victorian Department of Education 1996).

Assessing developmental sequences of fundamental motor skills qualitatively have been employed during the past twenty years (Kelly, Reuschlein, & Haubenstricker 1990; Oslin, Stroot & Siedentop, 1997; Roberton, 1978; Ulrich, 1985; Walkley et al., 1993). Furthermore the developmental sequences of a range of skills have been analysed adopting either the total-body-configuration approach (Seefeldt & Haubenstricker, 1982), or the component approach (Roberton, 1978). The total body configuration approach employs analysis of the movement pattern as a whole. The component approach involves analysis of separate components or segments of a movement pattern (Oslin, Stroot & Siedentop 1997).

The norm-referenced product-oriented approach has come under scrutiny by Davis (1984) in his review of assessment practices for handicapping conditions. This approach is limited in its use for the practitioner in the teaching situation as it provides little information for the performer in the learning cycle. Currently practitioners assume there is a strong relationship between outcome scores and process scores, however, there is very limited research
addressing this issue. The strength of product based assessment lies in the summative assessment as related to outcomes of learning. It is also useful for the teacher who has limited experiences in qualitative movement analysis.

Measuring the outcome of a skill does not address the technique of the performer which in essence contributes to optimal development of the skill. For example, a strong child who throws with poor technique, will measure higher on outcome measures, but, the developmental level of the skill can be inferior. If instruction is based on outcome measures, the performer with high outcome measures will not be helped despite exhibiting poor process or technique. Once an inefficient movement pattern is developed, changing it is a major challenge for performer and teacher.

The process and product oriented form of assessment dualism is further confounded by extraneous factors. Assessment of motor skills is not only to determine and record a level of performance of the individual, but to determine and record the circumstances under which the performance level was obtained. The relationship between the performer and the environment is necessary and must be accounted for in the assessment of motor skills. Ecological Task Analysis (Davis & Burton 1991) is one form of instructional approach currently taking these additional factors into consideration and is also an assessment framework (Balan & Davis, 1993). Central to this performer-environmental dualism is the task goal, allowing for choices by the performer, manipulation of variables, and the measuring and comparing results by the instructor or researcher.

By employing Ecological Task Analysis (ETA) as a conceptual framework, this study investigates the interrelationship between process and product measures of a motor skill and, furthermore, the implications of the manipulation of the task goal and conditions are explored. This is accomplished by setting the research in the learning environment of the school and measuring the effects produced by the manipulation of the environment, and task goals upon the process and product outcomes of the skill of the forehand strike.

The description of methods and procedures is drawn from a larger study investigating variations in the skill of striking. These variations are: the forehand strike with the hand; the forehand strike with the paddle; the two hand sidearm strike with a teeball bat; and the two hand sidearm strike with a cricket bat. Across all variations of the striking skill, changes in the stability of the environment (ball movement and ball type) and task goal (hit far and hit hard) were manipulated. Only two skills are reported, and those are the closely related skill of dropping the ball and striking it with the hand and then a paddle.

METHOD

Sample

Seventeen children ranging from 81 to 92 months were randomly selected from a local primary school in the northwest region of New South Wales. Students were all from mainstream classes and were included in the testing on the basis of parental permission.

Procedures

The children were withdrawn from class in pairs. Following a demonstration of the skill, each subject had up to three practice trials and then three trials were measured for process and product outcomes.

Task Implements - Hand and Paddle
There were two task implements tested. The hand was used initially as a striking instrument, followed by a wooden paddle. The use of the hand as a striking implement provides a scalar instrument which is consistent with the ecological approach to motor skill testing. In addition a paddle with a handle 10 cm long, with a total length of 36 cm and width of 19.5 cm was employed. This paddle is typical of those employed for striking instruction for primary aged children (Pangrazi & Dauer 1995). Tennis balls were used. Equal bounce of the balls was maintained throughout the testing to ensure the variability of bounce was not a confounding variable.

Task Goal: Instructional Set

Following the demonstration for the handstrike, the subject was instructed to; Drop the ball from waist height and strike it with the preferred hand. Integral to the first two trials was the protocol (instructional set) to “hit the ball out into the (striking) zone as far as you can”. This trial is labelled HSD and stands for Hand Strike Distance. Distance measures were recorded and the trials were videotaped for qualitative analysis. On the third trial, the task demand was changed to "hit the ball as hard as you can". This trial is labelled HSH and stands for HandStrike Hard. On each trial, the research assistant operating the camera near the striking box would cue the performer by saying “Ready, go!” and the performer would attempt to strike the ball.

Following the hand strike trials, the implement was changed to the paddle and the performer was asked to “drop the ball from waist height and strike it with a paddle”. Consistent with protocols for the hand hit, the performer was asked in the first two trials to “hit the ball out into the (striking) zone as far as you can” (PSD = Paddle Strike Distance). Distance measures were recorded and the trials were videotaped for qualitative analysis. On the third trial, the task demand was changed to "hit the ball as hard as you can" (PSH = Paddle Strike Hard). Performer cues were given by the research assistant operating the video recorder.

Regardless of striking implement, a change in task demand or task goal was changed from the second to the third trial. The change in task demand or task goal was prompting for control with power and accuracy. The task demand for the third trial was “Hit the ball as hard as you can" was designed to elicit power from the performer.

Instruments

Striking Zone

The testing area was always in the same location of the playground and included a 50 degree V-Shaped Zone initiated by a one metre square Striking Box and was marked at five metre intervals by domes indicating the parameters of the V shaped area. The domes had two purposes; firstly to indicate the accuracy zone (hit the ball inside the V made by the domes), and secondly, to act as a measurement area as each dome represented a 5 metre interval. A flat tape measure ran down the centre of the testing area. Measures were taken of the final resting place of the ball to the nearest five metre interval.

Recording Instruments

The researcher was recording the final resting place of the ball (distance) from the hitting box and the (accuracy) zone in which it landed. The distance and accuracy were recorded. The camera (Sony Video 8 Camera Recorder Pal/CCD TR305E), mounted on a tripod and utilising a monitor, was operated by a research assistant and recorded the subject hitting the ball. Footage from the recordings were used to assess and code the qualitative process of the performer completing the task of the one hand forehand hit.

Following the implementation of the trials, the recordings were analysed to answer the study questions.
ANALYSIS OF DATA

Product Analysis

The data for three trials were recorded. The product score was recorded as the distance from the striking box to the final resting place of the ball. This was the distance measured in interval measures to the nearest 5 metre interval.

Process Analysis

The forehand strike was analysed using qualitative criteria. Details of the three levels of coding given to each segment of the movement are listed below. Each component of the skill was coded using the following categories. The range of zero represented the most inefficient form of the skill and two represented the most efficient form of the skill with one being a transition between the two ends of the efficiency spectrum. The term 'efficiency' is preferable to 'mature' or 'experienced' as both latter terms have inherent implications and expectations which may not be applicable to all subjects.

The forehand strike utilising the hand as a striking implement was analysed using the following criteria. These criteria are based on the Victorian Fundamental Motor Skill Manual (1996). Furthermore, expansion of criteria was provided using the developmental sequences for striking (Seefeldt & Haubenstricker 1982). The three trials were analysed using the following three-tier criteria designed to differentiate between levels of efficiency in each component of the skill. Although this instrument has not been validated as such, it is based on instruments with validated criteria.

Forehand Strike
Component 1
Preparatory Phase: 0. feet face target
Foot Position 1. homolateral foot forward
2. contralateral foot forward
Component 2
Preparatory Phase: 0. legs straight
Leg Position 1. knees flexed
2. knees flexed and weight transfer
Component 3
Preparatory Phase: 0. trunk faces target
Body Position 1. trunk faces forty five degrees to target
2. trunk is side on to target
Component 4
Contact Phase: 0. eyes not following the ball throughout strike
Head Position 1. eyes following ball during partial flight/strike
2. eyes fixed throughout flight/strike
Component 5
Contact Phase 0. little to no backswing
Backswing 1. shallow and down backswing
2. horizontal backswing and arm straight
Component 6
Contact Phase 0. up/down motion of arm
Hand/arm motion 1. less than 45 degrees up or down with arm bent 2. horizontal motion/ arm straight.
Component 7
Contact Phase 0. floppy wrist and fingers
Implement to ball 1. wrist or hand floppy
2. contact with open hand - wrist rigid.
Component 8
Contact Phase 0. contact ball on downward flight - away from front foot
Ball contact/bounce 1. contact ball on upward flight - above waist of subject and away from front foot
2. contact made at waist opposite front foot
Component 9
Follow through Phase 0. up/down homolateral motion
Arm motion 1. up/down motion across body
2. horizontal motion across body
Component 10
Follow through Phase 0. no trunk rotation
1. either hip or shoulder rotation
2. marked sequential hip to shoulder rotation during strike

The forehand strike using the paddle was analysed using the same criteria as for the hand strike with one exception. Component seven was changed from coding for the hand and wrist action, to coding for the grip on the striking implement. Component seven for the paddle hit includes the following criteria:

Component 7.
Contact Phase 0. grip with 2 hands
Implement to ball 1. improper grip
2. grip with preferred hand

RESULTS AND DISCUSSION

The outcome (product) of the skill was measured in 5 metre interval distances. The performances (process) were video analysed to detect dynamic changes due to implements and task demands (instructional sets). From the video recordings, component criteria was assessed using an ordinal scale and the resultant data analysed using ACERÕs implementation of the RASCH Latent Trait Scaling model (Quest). The interval level scores derived from application of the RASCH model, together with the distance measurement, were analysed using regression techniques to identify relationships. MANOVA was used with the interval level process scores to detect group differences. Generalisability of these results should be viewed with caution as this study employed a small sample (n=17).

Analysis comprises two distinct stages. The first is the employment of the RASCH Latent Trait Scaling System (Quest). The second stage incorporated the interval level scores of item estimates from the RASCH analysis, together with the interval level scores of distance.

RASCH RESULTS

Model of Fit

Fit Statistics indicate the model is a reasonable fit. The measure of fit relies on the Infit Mean Square and Infit T. The infit mean square for item estimate is close to 1 indicating a good fit
for the model. The reliability of the estimates for both items and cases is the proportion of the observed estimate variance that is considered true (Adams & Khoo 1993 p. 24). The poor reliability of 0 for item estimates indicates there is poor separation between the items. However, case estimates reliability is close to 1 indicating good separation of cases, which are subjects. Internal consistency parameters (Cronbach’s alpha measure) of 0.91 identifies there is a good fit between the data and the Rasch model.

Case Estimates

The infit mean square for the case estimates were close to 1 (0.94 - 1.06), indicating a good fit to the model. The case reliability estimates varied with the instructional set. Hitting for distance with the hand and with the paddle has a reliability of 0.73. When the instructional set was for hitting hard with the hand (HSH), the case estimate reliability was 0.95 and hitting hard with the paddle (PSH) was 0.54. The implications of this variability in case estimates across trials is returned to later in connection with the correlation analysis.

Item Estimates

Item estimates give a measure of ability to move to the given criteria level based on the continuum of relative difficulty. The continuum is measured in logits and ranges from +3 to -2 on the four trials. Maps of item estimates (thresholds) for each trial indicate the ability level that is required for an individual to have a fifty percent chance of successfully performing that item (Adams & Khoo 1993 p.86). Item reliability estimates (.00 - .01) indicate that for all four trials, item separation is poor. The sample size might contribute to the lack of item reliability or alternatively it may be necessary to add additional items to each ends of the scale to increase the range of item-difficulty. It might be the case that the three point ordinal scale is not sufficiently fine grained to detect small differences in the quality of performance and component skills. Alternatively, poor separation may be due to the subject sample being so homogenous that the items failed to discriminate. However, the generally acceptable case estimate reliability is evident from previous researchers use of the items to measure the same underlying construct. The lack of additional points on the scale is the most likely source of the difficulty with the item estimate reliability and moving from a three to a five point scale might increase precision and strengthen the item estimate reliability.

Item Analysis

In viewing the item estimates, components of the skill did not line up in the same order of difficulty across all four trials, however there were some general trends. Commonalities can be reported for item estimates (thresholds) over the four trials.

The most consistently difficult item was to move to criteria 9.2 which is using the striking implement in a 'horizontal motion across the body'. Item 9.2 had a difficulty Logit range of +2.5 to +2. (HSD = +2.5; HSH = +2; PSD = +2.7 and PSH = +2.5). Item 3.2 of 'having the trunk side on to the target' had a difficulty logit range of +1.8 to +1.0. (HSD = +1.5; HSH = +1, PSD = +1.8 and PSH = +1.5). The midrange item of the four trials was item 8.2 'contacting the ball at waist height opposite the front foot' and ranged in logits from +1.8 to +0.8 (HSD = +.5; HSH = +1.8 PSD = .5 and PSH = +.8). One of the easier items included criteria 3.1 'standing at a 45 degree angle to the target' had a similar logit scale across the four trials. The logits ranged from -1.2 to -1.9 (HSD = -1.9; HSH = -1.8; PSD = -1.2 and PSH = -1.2).

Some trends can be categorised according to striking implement. The handstrike had a poor discrimination on item 10.2 'marked sequential hip and shoulder rotation' conversely, the paddle strike identified this as a difficulty for PSD = +2.2 and PSH = +2.
Other trends can be categorised according to task demand. When the task demand was hitting for distance, both item 5.2 and 6.2 were difficult items (HSD = +2.2 and PSD = 3 logits), conversely hitting hard HSH and PSH did not register at all. Item 5.2 was horizontal backswing and arm straight and item 6.2 was horizontal arm straight on contact phase with the ball.

This form of analysis has confirmed the advanced ‘efficient’ components of the developmental phases of the forehand strike as more difficult and that the less ‘efficient’ forms of the same skill are ‘easier to perform’. However, when the striking implement is changed and the task demand is changed, the difficulty of items change. This exploration utilising a small sample, has provided some challenges to the stability of accepted, valid, and reliable criterion referenced motor skill instruments.

RASCH method of analysis is based on a comparison between item results, and therefore, items that have either a perfect score or a zero score are discarded. These are regarded as misfitting items as they fail to perform a discriminating or separating function. Both item four and item seven were eliminated by the analysis as there were perfect scores. Item four, ‘following the ball throughout the flight’ was eliminated during HSD, HSH, and PSH. It was included in PSD. Item seven did not discriminate between the coding for wrist action (HSD and HSH) and grip on the paddle (PSH and PSH). Item seven was eliminated for PSD only.

The correlational analysis based on the case estimates and the product scores indicated the relationship between the product and process scores were not significant. This finding has wide ranging implications for teaching as it indicates that both measures of a motor skill must be taken into account when determining the proficiency levels of children across a range of ages and situations. Theoretically, we assume that either product or process measures are a valid form of assessment in researching the proficiency levels of children. As noted earlier, the reliability in case estimates fluctuated depending on the instructional set. The additional stress to “hit the ball as hard as you can” changed the reliability of the items and illustrates the tenuous nature of the integration of component parts of the skill.

In order to identify whether there are differences as a function of the implement or instructional set, case estimates (from RASCH) were utilised in a 2 (distance vs hard) x 2 (hand, paddle) repeated measures within subject multivariate analysis of variance. There were no significant differences between the hitting implements (hand vs paddle) and there were no significant differences as a function of the instructional set (distance vs hard). There was no interaction between type of implement and instruction.

The central questions of this paper pertain to the nature of the relationship between the product and process measures. The dichotomy between product (outcome) and process (technique) remains. The process approach is limited because some of the important factors or processes are difficult to measure, e.g., the speed of the movement, the coordinative interaction, and furthermore, the component approach to measuring process breaks the skill into a series of subskills and the integrative element is lost. Conversely, the product measures ignore the technique of the task and contribute to the development of movement patterns that will limit potential skill development.

**SUMMARY**

The purpose of this study was to employ current qualitative measures of the component approach to explore the relationship between product and process measures of a motor skill. Furthermore, the dynamic interaction of the performer, environment, and the consequence for outcome of motor skill performance, was recognised by utilising the Ecological Task Analysis Framework. The skill of the one hand side arm strike was used in this study. In order to investigate adjustments in the motor skill performance, product and process scores
where obtained when different striking implements (hand and paddle) and varying task demands (hitting for distance and hitting hard) were introduced.

The Rasch Latent Trait Model (Quest) analysed the applicability of the scale (data fitting the model), the stability of the items across task implements (hand and paddle), and across task demand (distance versus hard). There were item-difficulty commonalities across all trials and changes in item-difficulty across implements and changes in difficulty across task demands. The poor reliability of item estimates highlighted the need for a five-point scale to be employed to boost the discrimination and separation between items representing subparts of the skill. Additionally, the variability of case estimates across two variations of essentially the same skill (implement and task demand) could explained by two possibilities. One is the components of the skill are less capable of being transferred when variations in implement or demand are introduced. Secondly, the age group of these subjects may be at a threshold of the ability to control the hand to a longer lever (paddle) in terms of proximal-distal developmental control patterns.

Additionally, the RASCH model provided item estimates in an interval form for use in analysing the relationship between product and process resulted in no significant differences as a consequence of implement and/or instructional set. The small sample (n=17) was a distinguishing limitation in this study.

The implications of this study for practitioners are the variability of the environment, task demands, and task implements must be accounted for in the measurement of process skills. Practitioners using the criterion norm-referenced motor skill instruments should be mindful of the reliability of the instrument regarding the ability to measure components when minor changes in either implement or demand change the difficulty factor for the performer. Additionally, norm-referenced product scores are sometimes recommended as an alternative for primary teachers who teach physical activity but do not have training in movement analysis. This is not a viable option if there is no relationship between product and process. The findings of this study suggest a simple correlation between the two complex components used to assess proficiency in motor skills is still elusive.

REFERENCES


ITEM ANALYSIS.

Commonalities - across all tasks

<table>
<thead>
<tr>
<th></th>
<th>HSD</th>
<th>HSH</th>
<th>PSD</th>
<th>PSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficult items</td>
<td>Item 9.2 horizontal across the body</td>
<td>+2.5</td>
<td>+2.0</td>
<td>+2.7</td>
</tr>
</tbody>
</table>
Item 3.2 trunk side on to the target
+1.5
+1.0
+1.8
+1.5

Item 8.2 contacting the ball at waist height and opposite the front foot.
+0.5

+1.8
+0.5
+0.5

Easy Items

Item 3.1 Standing at a 45 degree angle to the target.
• 1.9
• 1.8
• 1.2
• 1.2

COMMONALITIES -based on implement

HSD
HSH
PSD
PSH

Item 10.2 Marked sequential hip and shoulder rotation.
COMMONALITIES - based on task demand

HIT FOR DISTANCE HSD HSH PSD PSH

Item 5.2 horizontal backswing and arm straight
+2.2

- 

+3

- 

Item 6.2 horizontal arm straight on contact phase with the ball
+2.2

- 

+2.8

- 

Easy Items
Item 6.1 backswing less than 45 degrees and arm bent
0

- 

• 1.8

- 

Easy Items
Item 5.1 shallow and down backswing

0
Item 1.1 homolateral foot forward

- 2.0
- 1.2
- 2.0
- 1.1

Item 9.1 strike phase up/down motion across body

- 1.5
- 0.7
- 1.5
- 0.8