CHAPTER SEVEN

Analysis of the MAMQ:FR Framework

Introduction

The efficacy of the MAMQ:FR framework is examined further in this chapter. In the first section of this chapter the information describes the modification of the data that permitted its use in the statistical analysis. The second section presents the results of the Rasch analysis. The third section provides a discussion and results of the application of the MAMQ:FR framework to the SOLO model.

DATA TREATMENT

Prior to the provision of details about how the data were treated in preparation for statistical analysis, it is timely to reiterate that the forward rolling action was divided into three sequences, the beginning, middle and end. For each sequence a number of *indicators* were identified. The indicators for the beginning sequence were; hand placement, shoulder/elbow position, number of contact points, and head contact position. The bridging sequence indicator*s* were, arm/shoulder position, and hip/knee position. The end sequence had three indicators; leg movements, feet position and final movements. Each indicator was further sub-divided into a number of *descriptors*. These descriptors were hierarchically ranked from lowest to highest quality.

Coding information of data in preparation for statistical analysis is shown in Table 7.1. To assist in identifying the data, each Indicator Name was given an Indicator Acronym. The acronyms for the beginning sequence were given the precursor, which was the letter "B". Similarly the bridging sequences' precursor was allocated the letter "M", and the letter "E" identified the end sequences. Each indicator was allocated two additional letters, which represented the name of the indicator, thus providing a unique cryptogram.

TABLE 7.1: CODING INFORMATION

Sequence name	Indicator name	Indicator acronym (Cryptogram)	Descriptor	Descriptor abbreviation	Data code
Beginning					
	Hand position	BAH			
			Wide of shoulder width	(w)	0
			Close to shoulder width	(c)	1
			Shoulder width	(sw)	2
	Arm/elbow	BEA			
			Bent back	(bb)	0
			Elbows bent laterally	(sb)	1
			Straight	(st)	2
	Head position	BHT			
			Crown (top) of head)	(cr)	0
			Back of head	(ba)	1
			No contact	(nc)	2
	Contact points	BCP			
			More than Six		0
			Five		1
			Three		2
			Four		3
			Two		4
Bridging					
	Hip/knee	MHK			
			Stay straight	(ss)	0
			Bend then straighten	(bs	1
			Remain bent	(bt)	2
			Straight bend contact	(sbc)	3
	Shoulder/arm	MSA			
			Arms rotate onto forearms	(ae)	0
			Arms rotate with body... may straighten	(ar)	1
			Arms open to “V” shape	(av)	2
			Arms bent, straighten... (little impetus)	(af)	3
			Straight arms 180°+ arc	(as)	4
End					
	Foot placement	EFT			
			Inconsistent	(in)	0
			Away from buttocks	(ab)	1
			Close to buttocks	(cb)	2
	Final leg movements	ELM			
			Legs separated	(ls)	0
			Knees/feet apart	(kfa)	1
			Together	(lt)	2
	Final rotational movements	ERM			
			Roll stopping completely	(rs)	0
			Hands are used to assist rising	(uh)	1
			Roll momentarily halts	(sm)	2
			Balance lost	(lb)	3
			Rising to standing unaided	(ru)	4

As shown in Table 7.1 the Descriptors and the accompanying abbreviations are listed from the top of the column from lowest to highest quality also, the descriptors were allocated a numerical value.. The right hand column headed "Data code", shows that for each indicator, the lowest quality was allocated a zero, with each following descriptor given a sequential numeral, depending on the number of descriptors. For example, for the beginning sequence the descriptors for the indicator, termed, Hand position were allocated the following numerals: wide of shoulder width "0", close to shoulder width "1", and shoulder width "2". This procedure was repeated for each descriptor for the other indicators.

An example of a data set for one participant is outlined in the following Table 7.2.

TABLE 7.2: EXAMPLE OF DATA CODE FOR A SINGLE PARTICIPANT

Indicator acronym	**BAH**	**BEA**	**BHT**	**BCP**	**MHK**	**MSA**	**ELM**	**EFT**	**ERM**
Data code	**0**	**0**	**1**	**1**	**2**	**1**	**1**	**1**	**2**

The first line, in Table 7.2, shows the indicator acronym used for all participants. For example, the code **BAH** indicates the "B" for the **B**eginning sequence and indicator, the letter "A" was used as a reminder the **A**rm was a component of the indicator and "H" is for **H**and position. The second line, labelled descriptor code, provides an example of the range of numbers that are applicable to a single participant. The data for all participants (*N*=117) were treated using the same method. Detailed codes for all participants can be seen in Appendix L for the children's cohort, Appendix M for young adults and Appendix N for older adults.

In summary, data preparation that permitted analysis using the *Quest* statistical package meant allocating a set of numbers (codes) to each individual participant, based upon the descriptors for each indicator. The process incorporated the three sequences, which were differentiated, through the allocation of an alphabetical Indicator Acronym. Each letter following the sequence code approximated the first letters of the indicators.

RASCH ANALYSIS: RESULTS

A description of the analysis of the data for all individuals (*N*=117) is provided in this section, leading to a statistical estimate of the participants' movement quality. Included is an estimate of the difficulty ranking for the items, achieved by comparing these items

with the participants' success rates. The result is the production of fit statistics that aids in the identification of the discriminatory nature of the items.

Item and Case Estimate Results

The contents of this subsection present the results, specifically for the case estimates. The output from *Quest* shown in Table 7.3 includes the item estimates and reliability statistics. The item reliability index provides an indication of the degree to which the range and distribution of item difficulty levels is sufficient to differentiate between participants of near equal movement quality. An overview of *Quest* commands used in the analysis may be found in Bond and Fox (2007) .

TABLE 7.3: SUMMARY OF ITEM ESTIMATES

```
   Quality movements
------------------------------------------------------------------
   Item Estimates (Thresholds)
  all on all (N = 117 L = 9 Probability Level= .50)
------------------------------------------------------------------

   Summary of item Estimates
   =========================

   Mean                            .00
   SD                              .91
   SD (adjusted)                   .77
   Reliability of estimate         .71

   Fit Statistics
   ==============

   Infit Mean Square          Outfit Mean Square

    Mean     1.01             Mean     1.00
    SD        .07             SD        .19


      Infit t                    Outfit t

    Mean      .10             Mean      .13
    SD        .61             SD        .70

   0 items with zero scores
   0 items with perfect scores
==================================================================
```

The reliability of the item estimates was satisfactory at .71 on a 0 to 1 scale. This indicates confidence in the replication of item placement across other samples. That is, if the descriptors for the *indicators* for the forward roll were applied to other groups then the order of item estimates would probably be replicated when applied to other samples

for which they were suitably similar. Item reliability can be interpreted in the same way as Cronbach's alpha (Cronbach & Meehl, 1955), which according to Overton (1999) is the extent to which a test (or score) may be said to measure a theoretical construct or trait.

The fit statistics (infit and outfit mean squares) were close to 1 (1.01 and 1.00), for the unstandardised fit estimates with both the infit and outfit mean squares showing little spread from the ideal. When fit scores are standardised, "the mean square values are transformed so they are distributed like *t*" (Bond & Fox, 2007, p. 43), that is with a mean of .0 and a standard deviation of 1.0. In this case the values of the mean of .10 and .13, indicate that the items are useful for the sample of participants. The note at the end of the table indicating that "no" items were too easy or too difficult also verifies this output information.

The output shown in Table 7.4 includes the case estimates and reliability statistics.

TABLE 7.4: SUMMARY OF CASE ESTIMATES

```
quality movements
------------------------------------------------------------------------
Case Estimates
all on all (N = 117 L = 9 Probability Level= .50)
------------------------------------------------------------------------
Summary of case Estimates
=========================
Mean                          -.12
SD                            1.61
SD (adjusted)                 1.50
Reliability of estimate        .87

Fit Statistics
==============
Infit Mean Square          Outfit Mean Square

    Mean      .99              Mean    1.00
    SD        .54              SD       .62

Infit t                   Outfit t
Mean    -.01              Mean     .15
    SD      1.00              SD       .85

   0 cases with zero scores
   4 cases with perfect scores
========================================================================
```

The analysis output in Table 7.4 shows that the mean person estimate (group average) was close to 0 indicating a well-matched item list. The person movement quality

estimate mean of -.12 is an indicator that, for the individuals involved, the items were slightly difficult to achieve. The standard deviation of 1.61 for person estimates indicated a greater spread of person measures or variation in those measures than with item measures. The reliability of the person movement quality was high at .87. The item-person map showed a good match between items and persons. In addition, the person fit statistics were good. The mean of the infit squares at .99 and the outfit means squares at 1.00 were close to, or the same as Rasch's (1960) expectations of 1.00. Consequently, they produced standardised fit *t* values around zero (-.01 and .15). The spread in the modelled fit scores for persons (infit *t* SD=1.00 and outfit *t* SD=.85) suggests that the person movement quality estimates had error estimates well inside the conventionally acceptable range of -2.0 to +2.0.

The four cases with zero scores showed that the items measure the movement quality of all but four persons (participants). Thus, except for the exceptionally talented gymnast, it is possible to make satisfactory descriptions showing the progress of all persons along the continuum revealed by the qualitative observation schedule. This means, however, that an additional more difficult indicator may need to be included in the repertoire of items. Graham, et al. (1998) referred to the use of apparatus such as rolling on objects, e.g., the balance beam or aerial versions of the forward roll (saltos) as a more advanced skill.

Item Fit

This sub-section describes the results, specifically for item fit statistics. Item infit maps can be used to identify those items with infit mean square values that fall inside and/or outside the interval of .77 and 1.30. This is the interval, suggested by Wright and Stone (1979) within which items should lie if they are jointly to represent a single underlying construct.

In addition, item fit maps incorporate a theoretical idealisation (also called construct or fiction or latent trait) of the data's interrelations, an unachievable state that is mathematically represented as the ideal straight line (the dashed line in middle of the map). "The concept involves observing whether the data are on (near as possible) to this hypothetical line" (Bond & Fox, 2001, p. 28). Answering the question about whether the data does fit with the construct. Table 7.5 shows the *Quest* generated item fit map for the data.

TABLE 7.5: ITEM FIT FOR NINE INDICATORS OF THE FORWARD ROLL

```
quality movements
------------------------------------------------------------------------
Item Fit
all on all (N = 117 L = 9 Probability Level= .50)
------------------------------------------------------------------------
INFIT
 MNSQ         .63        .71        .83       1.00       1.20       1.40
--------------+---------+---------+---------+---------+---------+-------+----
  1 BAH                          .               |    *           .
  2 BEA                          .            *  |                .
  3 BHT                          .               |  *             .
  4 BCP                          .               | *              .
  5 MHK                          .             *  |                .
  6 MSA                          .             *  |                .
  7 EFT                          .                |   *            .
  7 ELM                          .                |  *             .
  9 ERM                          .              * |                .
========================================================================
```

Data within Table 7.5 indicate that there were no infit mean square values less than .77 or greater than 1.30, suggesting that the items are coalescing and are all elements of the same construct, that is, for the varying levels of quality performance of the forward roll. It is noteworthy that, "if items did lie outside the boundary lines (pathway) they can not be interpreted meaningfully with regard to this pathway" (Bond & Fox, 2001 p. 23). Sometimes the steps/item chosen by the researcher are satisfactory for some people but not others, e.g., the choice of items may be developmentally consistent with the majority of people. However, sometimes people are moving in a way that is outside the normal pathway of items. It is apparent that this scenario did not present itself for these data.

Item difficulty

This sub-section presents the results for item difficulty. Output from *Quest* includes an item-person map in which person movement quality and item difficulty relations can be observed. Estimates of fit and error are tabulated along with movement quality and difficulty estimates. Item difficulty is expressed in terms of logits, zero equals average, negative equals easier, and positive equals becoming more difficult. "Person ability is estimated in relation to item difficulty estimates" (Bond & Fox, 2001, p. 33) which for this analysis means the higher the positive values the better the quality of movement.

Figure 7.1 shows the *Quest* generated item person map for the data.

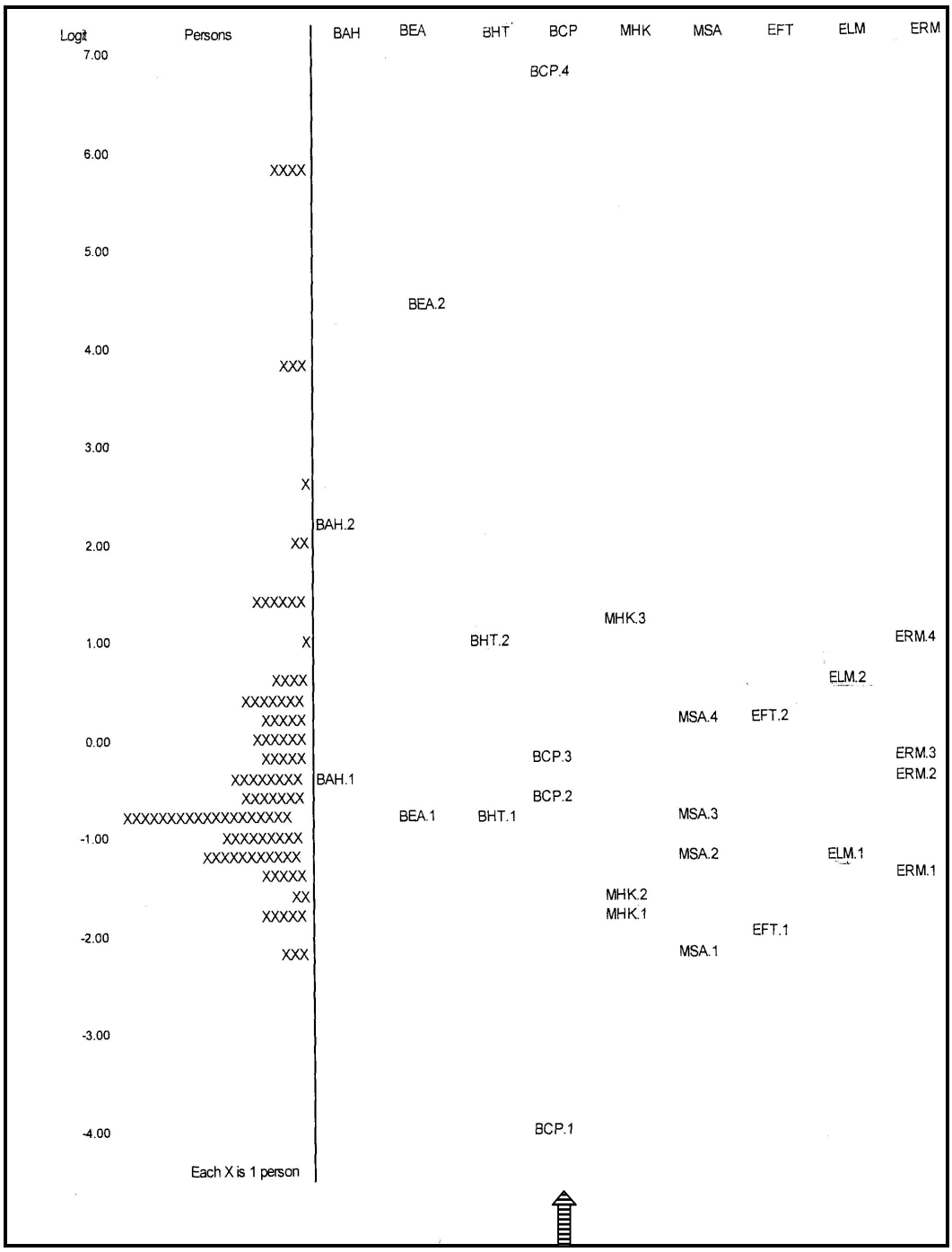

Figure 7.1: Item Person Map

Figure 7.1 shows the hierarchy of item efficiency levels. In interpreting this map the lower levels of quality are indicated by the presence of the number ".1" for each descriptor, e.g., BCP.1. For each increase in movement quality the number increases by one increment, or vice versa, that is, step difficulties are ordered within each item, e.g., BCP.2, BCP.3 and BCP.4.

It is essential that the estimates of person movement quality and item difficulty in the data matrix are meaningful. This can only be achieved if "each and every test item contributes

to the measure of a single attribute" (Bond & Fox, 2001, p. 25). The idea that the recorded performances are a reflection of a single underlying construct, that which the investigator creates to represent the items or observations is necessary for construct validity, that is, "not confusing two or more human attributes into one measure or score" (Bond & Fox, 2001, p. 26). This process was established in the Item Fit section for this investigation.

Note that the measurement unit (logit) is common to both person movement quality and item, and is displayed down the far left hand side of the map. Because it is a logit scale (i.e., an interval scale) the equal distances up and down that scale have equal value. Persons and items are located on the map according to their movement quality and difficulty estimates, respectively. The mean of item difficulties is adopted by default as the zero (0) point. The threshold is the representation of the item difficulty and is the movement quality level that is needed for "a person to have a fifty percent chance of achieving success for the item" (Adams & Khoo, 1993, p. 86). The "Xs" down the centre-left of the map represent the distribution of case (participant) estimates on the logit scale. Each "X" represents the estimate for one participant, which signifies a fifty percent probability the participant will be able to achieve that item (descriptor) at the same position on the logit scale.

Closer scrutiny of the item person map, shown in Figure 7.1, reveals that for each descriptor the steps appear in order of difficulty. The arrow shown at the bottom of Figure 7.1 points to the Indicator Acronym BCP (Beginning Sequence Contact Points [of the head]) and as an example, BCP.1 appears at - 4.0 logits, BCP.2 at - .6 logits, BCP.3 at - .2 logits and BCP.4 at +6.8 logits; the steps between each descriptor present in ascending order of difficulty. BCP.1 was the easiest level (descriptor) to achieve, however, there was greater difficulty experienced by persons in moving from BCP.1 (in terms of logits) to BCP.2, than moving from BCP.2 to BCP.3. In a similar way, judging by the position (an the number of logits) of BCP.4 at the very top of the map, it was much more difficult to move from BCP.3 to BCP.4.

Based on data shown in Figure 7.1, a pictorial representation for all sequence descriptors is presented in the following Figure 7.2.

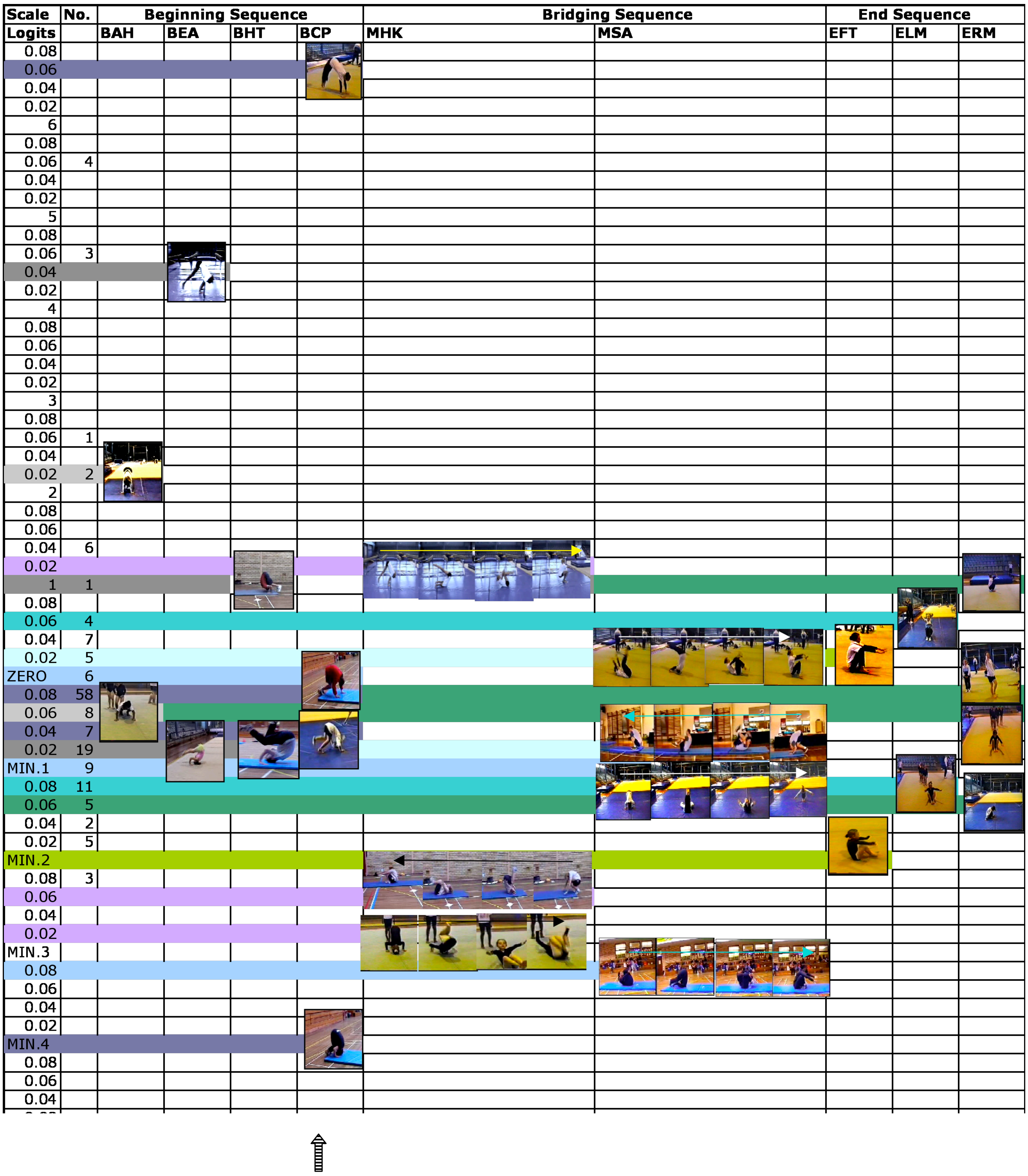

Figure 7.2: Illustration Of The Logit Differences In Pictorial Format

Figure 7.2 shows part of the item person map (featuring items), using illustrations as a substitute for the descriptor code acronyms. Each picture was placed on the map in the same position as its corresponding code.

In summary, the statistical output from Quest, specifically, the item fit map has been overlaid with a number of illustrations, which are placed on the map in exactly the same position as their numerical equivalent and provide a valuable alternative way of making the data accessible to a wide range of individuals who may prefer to rely on visual data to interpret the statistical information.

Conclusion

The use of *Quest* provided statistical verification that the indicators and descriptors were coalescing. The quantitative analysis of the data using the *Quest* (Adams & Khoo, 1993) partial credit model demonstrated that through the employment of a single scale, a view of the data pertaining to the measure of item difficulty, and an individual's ability to achieve an item was possible. This result leads to a degree of confidence that the use of the MAMQ:FR assessment tool can be applied to a broad developmental range of participants.

A NEW THEORETICAL PARADIGM

The statistical analysis of the MAMQ:FR using the *Quest* statistical package provided more than reasonable support for the notion that the items represent a single underlying construct. Both items and persons were shown to act in a predictable manner. Consequently, the analysis of the forward roll using the MAMQ:FR is worthy of further detailed analysis.

Based on the acceptable levels of the fit statistics, this section describes a theoretical paradigm that reviews the use of the MAMQ:FR. This task was undertaken from a perspective based upon the Structure of Observed Learning Outcomes (SOLO) model, involving both cycles and levels, within the sensorimotor mode of learning.

There are three subsections in this section. Firstly, a description of the criteria used to analyse the forward roll in SOLO terms, wherein the question regarding the presence of SOLO cycles and levels within the MAMQ:FR, specifically from a sequences perspective, is addressed through an examination of the data. The sequences perspective

presents a view of a skill that is based on the "component approach", advocated by authors, such as Roberton and Halverson (1977). The second subsection provides a description of an instrument, the SOLO Observation Checklist (SOC) that permits an holistic analysis of the forward roll. This reflects the "total body configuration approach" to skill learning supported by authors such as Haubenstricker, Branta and Seefeldt (1983). The third subsection provides examples of the performance of three individuals who have been assessed for SOLO cycles and levels using the SOC.

The MAMQ:FR Sequences from a SOLO Perspective

This subsection provides information about how SOLO learning cycles and levels were determined, for the forward roll, through the application of the MAMQ:FR indicators and descriptors.

The use of the MAMQ:FR required the performance to be recorded and played back using a "slow motion" facility. In addition the use of a "stop-frame" facility was a valuable tool.

The MAMQ:FR was designed to examine the quality of the forward roll using three hypothetical sequences – beginning, bridging, and end. A SOLO analysis employing the descriptors for each sequence was undertaken for all participants (N=117). The processes used to achieve a SOLO cycle and level, using sequences, are outlined in Figure 7.3.

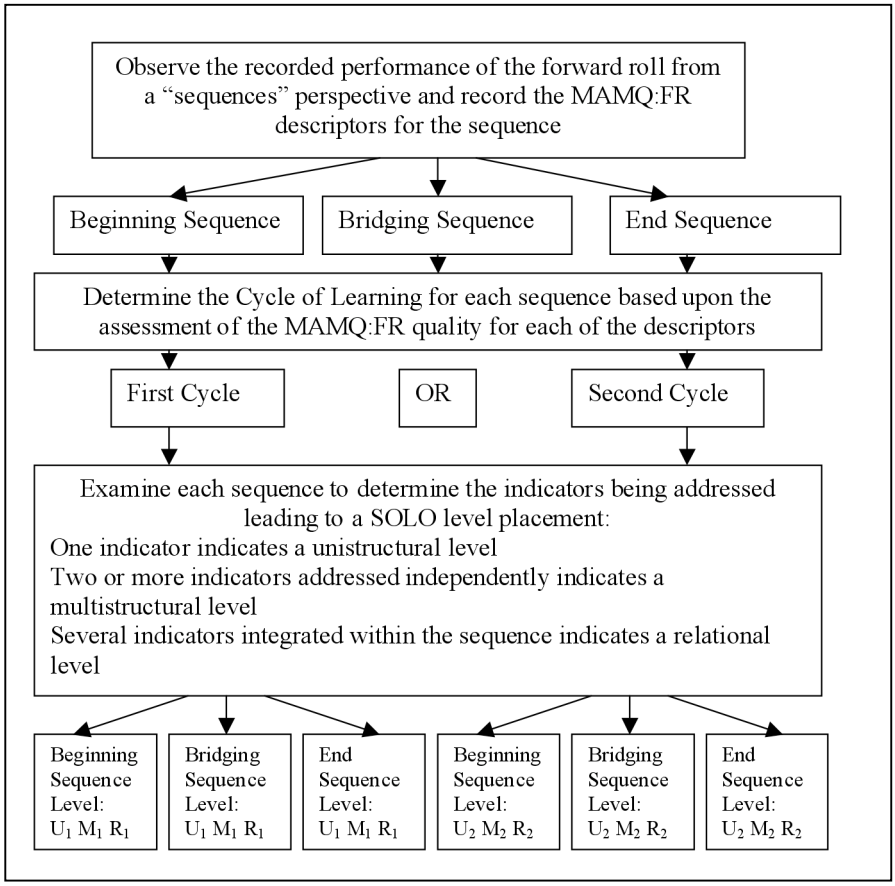

Figure 7.3: Process for determining MAMQ:FR SOLO Cycles and Levels

As shown in Figure 7.3, the SOLO analysis from a sequences perspective commences with the MAMQ:FR framework's descriptors for each indicator. This step is required in order to determine the quality of the observed performance. In applying the framework's descriptors, whether by a novice or an experienced movement analyst, the initial assessment of the forward roll requires familiarity with the indicators and descriptors outlined in the MAMQ:FR framework.

SOLO Cycles

Analysis of the pre-recorded performance of the roll was undertaken using slow motion and frame-by-frame playback facility. During observation of the recorded data, the quality of movement for each indicator was noted through the application of the appropriate MAMQ:FR descriptors. The results of this process were used to determine the SOLO cycle of learning, in the following manner.

Performances with the majority of descriptors observed to be primarily of low quality are Cycle 1. Some performances were observed to elicit descriptors that had some low quality and some medium quality aspects. As the quality of the performance improved, as indicated by descriptors of increasing quality, the individual progresses towards a Cycle 2

performance. The point at which an individual reaches Cycle 2 was determined by noting whether descriptors for each indicator were moving towards, or at, the higher end of the quality continuum. Important to this transition was the observation that the performer had demonstrated that they had learned the components of the forward roll, as exemplified by the quality of the descriptors, and were now at the beginning of the process of attending to the level of quality of one of the indicators; the beginnings of greater control, style and some degree of flair.

SOLO levels

Individuals demonstrating a particular level of quality for the performance, also show progress in learning the skill. For example, learned components for the beginning sequence include raising their arms, keeping their back "straight", bending their knees rather than leaning forward and so on.

Once those learned aspects of the each sequence were identified, and after having allocated the performance to a particular cycle, based on the quality of the descriptors, the next step was to take note of the indicator(s) being specifically addressed by the participant.

Descriptions of each of the characteristics of the SOLO levels are provided in the following paragraphs. The application of this information was used to determine the SOLO level. Descriptions commence with the three levels for Cycle 1 – unistructural, multistructural and relational, then a similar structure is provided for the levels within Cycle 2.

Cycle 1 levels

$\mathbf{U_1}$: A unistructural response is characterised by a single indicator undergoing a change in descriptor quality. That is, the performer is attending to one indicator, which becomes a single focus for the forward roll. In Cycle 1 unistructural responses demonstrate descriptors of poor quality, movements lack fluidity, there are extraneous movements, and control is poor.

$\mathbf{M_1}$: For a response to be coded as multistructural, several descriptors are addressed, however, they are being addressed independently, with little or no connection between them. The performer makes bodily adjustments without really taking into account the movement consequences of each change in limb or body position. In a Cycle 1 multistructural level performance no attention is paid to stylistic elements. The

performance would demonstrate a range of descriptors, mainly poor quality but also some medium quality descriptors.

R_1: A relational response in Cycle 1 is achieved if the performance of the roll shows that the indicators are being integrated, and the movements are performed in a reasonably controlled manner, yet still lacking finesse and style.

To proceed beyond the first cycle of learning, the performer must have demonstrated a relational response for Cycle 1. Consistency between performances would be demonstrated and all components of the skill are being performed with increasing levels of quality.

A Cycle 2 performance would show an emphasis on style, increasing control and precision. The term, style, implies moving in a manner determined by the ethos of gymnastic institutions, such as the Federation Internationale De Gymnastique (2002). Control refers to the amount of extraneous movements observed, i.e., the number of movement errors. Large numbers of errors imply poor control and conversely, better control is evident as the number of errors declines. Style requires control, however, it refers to the overall appearance of the performance, which can also be termed "flair". For example, facial gestures, pointing the toes and fingers, flow of the movements, the amount of body tension and amplitude.

The concepts of both style and control are supported by biomechanical principles (George, 1980) and the Australian Gymnastics Federation (2002) guidelines. Both these qualities; style and control are also mentioned by Biggs and Collis (Biggs & Collis, 1982, p. 215).

Cycle 2 levels

U_2: A unistructural level Cycle 2 performance is characterised by controlled movements as evidenced by higher quality descriptors (i.e., better than R_1) and the individual is observed addressing, a single indicator. The performance would show learning that permitted integration of all aspects of the skill, however, observation would also reveal that the performer is refining one specific aspect of the performance, specifically a single indicator. For example, the number of points of contact in the beginning sequence.

M_2: In a multistructural level in Cycle 2 performance two or more indicators would be addressed. However, whilst "concentrating" on a number of aspects of the skill, in an

attempt to learn what to do to improve the performance, some loss of "good-form" would be observed, even though the overall performance would appear controlled, and stylish.

R_2: For a relational level performance in Cycle 2 all the indicators would be represented by the highest descriptor quality. Each movement is flowing, controlled and stylistic. Movement errors may not be obvious to the assessor. Furthermore, a Cycle 2 performance demonstrates consistency in any repeat performance and there is evidence of a permanent change in movement behaviour.

Samples of descriptions upon which SOLO analysis were based appear in Appendix O, and results for the SOLO analysis of all participants (*N*=117) using the MAMQ:FR may be found in Appendix P.

In summary, all individuals were coded from a sequences perspective using SOLO. Table 7.6 provides an overview for each SOLO level and cycle of the forward roll.

TABLE 7.6: NUMBER OF PARTICIPANTS IN EACH SOLO CYCLE AND LEVEL FOR EACH SEQUENCE OF THE FORWARD ROLL

	Beginning Sequence						Bridging Sequence						End Sequence					
SOLO Level and Cycle	U_1	M_1	R_1	U_2	M_2	R_2	U_1	M_1	R_1	U_2	M_2	R_2	U_1	M_1	R_1	U_2	M_2	R_2
Children	14	14	2	5	4	9	23	6	0	5	6	8	17	11	2	3	6	9
Young Adults	1	2	2	4	10	5	3	0	2	11	4	4	3	1	2	11	3	4
Older Adults	11	14	5	7	6	2	13	14	3	7	6	2	19	11	0	11	3	1

Table 7.6 provides a summary of the UMR codes for each cohort of the SOLO analysis, using the component approach within the beginning, bridging and end sequences.

The SOLO Observational Checklist (SOC)

This subsection provides information about how SOLO learning cycles and levels were determined, for the forward roll, through the application of the SOLO Observation checklist (SOC). This checklist was based upon the MAMQ:FR, however, its application permits a SOLO determination for the forward roll when viewed from a total body perspective.

In order to achieve this purpose the separate divisions within the roll have been retained for presentation purposes, however, the separate divisions used in the MAMQ:FR, formerly termed beginning, bridging and end have been renamed and become the *Start*, *Rotation* and *Finish*.

This checklist is best applied in conjunction with pre-recorded visual data, played back at a speed that permits scrutiny of each descriptor. The SOC shown in Table 7.7 has been divided into Part A and Part B to facilitate explanation.

TABLE 7.7: SOLO OBSERVATIONAL CHECKLIST FOR THE FORWARD ROLL

Subject Number..... Recording Location..... Time:.....

Part A

Indicators	Measure of Quality Continuum (Modified descriptors)							
(Temporal order)	Low Quality (Cycle 1) ⟶		Medium quality (Cycle transition)				⟶ High Quality (Cycle 2)	
Start								
Hand position	>20cm wide Or elbows bend out	❒	Less than 20cm		❒		Shoulder width	❒
Head contact	Superior surface contact	❒	Dorsal surface touches		❒		Off the surface	❒
Contacts (inc. head)	Five or more	❒	Three	❒ Four	❒		Two	❒
Leg push	None or weak	❒	Uneven		❒		Even	❒
Rotation								
Control	Lacking control	❒	Some control	❒			Total control	❒
Arm action	Elbows remain flexed	❒	Abducted	❒			Arms extended (shoulder width)	❒
Legs	Remain extended	❒	Remain flexed	❒	Extended then flex in second half of rotation			❒
Finish								
Rising	Lacking control	❒	Some loss of balance		❒		Totally smooth	❒
Feet	Anterior to buttocks >10cm	❒	Slightly anterior to buttocks		❒		Almost inferior to buttocks	❒
Any part of Legs	Abducted wider than 20cm	❒	Abducted less than 20cm		❒		Anatomically neutral	❒

Part B

Overall Focus:	Single Indicator	❒	or Two or more		❒	or Multiple	❒

Demonstrated aspects of learning:
Other comments:
SOLO:

As shown in Part A, of Table 7.7 the list of Indicators on the left hand side is presented in temporal order. As for the MAMQ:FR, using the SOC commences with the Hand position; the position of the hands is determined with reference to the Measure of Quality (Modified descriptor). For example, the Hand position of the performer may best be delineated by the descriptor ">20cm wide Or elbows bent out", indicating that the hands are placed more than 20cm wider than shoulder width and/or the shoulder joint is rotated (pronated) which allows the elbows to be flexed laterally. As the observation of the performance continues, the assessor "ticks" the most appropriate Modified descriptor box for each Indicator.

In Part B, the items listed commence with the "Overall Focus", permits the inclusion of the assessor's impression relating to the indicator(s) the individual is observed to be focusing upon during the roll. That is, whether the performer appears to be addressing (with the aim of improving), one, two or more, or simultaneously several indicators.

The next item listed in Part B, "Demonstrated aspects of learning" includes notes about those parts of the roll the performer has demonstrated to have learned. For example, it may be observed, that the performer may have learned to "place the hands shoulder width apart at commencement of the roll, or avoided head contact and so on." Recording this information serves as a reminder to the assessor.

Following on, "Other comments" may include additional remarks about any particular descriptor. The placement of numeral after the check box to which the comment applies, aids this process. Examples may include, "1: no leg push ... body is moved past centre of gravity to allow rotation" or for another individual "1: elbows bent laterally, 2: slight bounce, 3: inconsistent – legs crossed, 4: only minimal loss of balance".

The final checklist item in Part B, "SOLO" can now be completed. Using information and data collated from the SOC checklist, and taking note of the SOLO cycle and level descriptions outlined earlier in this section, the performer's SOLO cycle and level is determined from a whole body perspective.

Exemplars of Determining SOLO Levels using the SOC

This subsection provides, by way of example, descriptions of three individual performances of the forward roll. The first example is of a Cycle 1 unistructural level (U_1) performance. The second example is a Cycle 2 multistructural level (M_2), and the third example is a Cycle 2 relational level (R_2).

The illustrations for each example, as noted earlier in this subsection, are presented as three separate divisions – the start, rotation and finish, however, they are viewed as part of a continuum. For each example, Part A of the SOC is presented for each division. Part B follows, under the subheading "Overall Focus" which presents the SOLO cycle and level. At the end of each example, an overall SOC checklist is also provided. This procedure is repeated the two other examples. Addition samples of SOC checklists can be found in Appendix Q.

Example 1: Cycle 1 Unistructural level –Aimee

Aimee, at the time of data collection was a seven-year-old female and she attended a recreational gymnastics program once per week for four months prior to the data being gathered.

Start

Figure 7.4. shows Aimee during the Start of the roll.

Figure 7.4: Aspects of the Start

SOC Results for the Start

Hand Position	>20cm wide Or elbows bent out		Less than 20 cm		Shoulder width
Head Contact	Superior surface touching		Dorsal surface touching		Off the surface
Contacts (inc Head)	Five or more		Three	Four	Two
Leg push	None or weak	1	Uneven		Even

When view at "normal speed", Aimee's movements are noted to be inefficient, she was unable to integrate the body components to achieve a desired start position, which would allow a flowing movement. Note that the number "1" appears alongside Leg push, which indicates a qualifying comment is made in Part B of SOC. In this example the numeral "1" indicated that the Leg push was even, but the application of force was weak.

Rotation

Figure 7.5 shows Aimee during the Rotation of the roll.

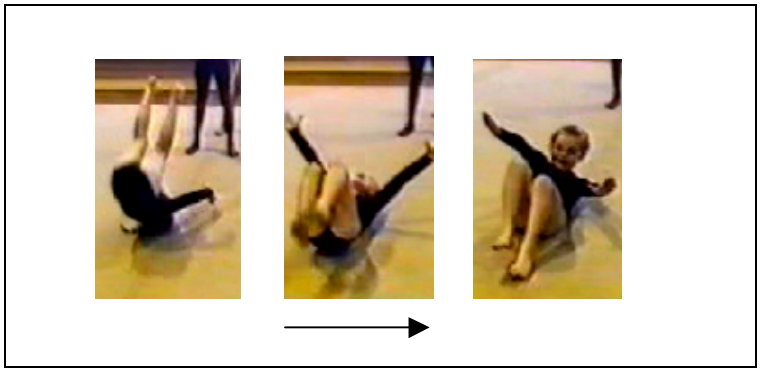

Figure 7.5: Aspects of Rotation: Aimee

SOC Results for the Rotation

Control	Lacking control	Some control	Total control
Arm action	Elbows remain flexed	Abducted	Arms extended (shoulder width)
Legs	Remain extended	Remain flexed	Extended then flex in second half rotation

Real time viewing showed that Aimee demonstrated limited control over her movements during rotation. Slow motion and frame-by-frame viewing revealed that the legs extended from an initial flexed position, her trunk simply rotated around the body's centre of

gravity, she landed on the surface with a "flat back," then "bounced" slightly, her arms remained straight but abducted, and her knees were slightly flexed. At the conclusion of the rotation, she lost momentum and rolling ceased.

Leg extension indicated she was not concerned with, or was unable to control the leg action, and she was unaware that if the legs remained in the extended position the roll would cease once the feet contacted the surface. Aimee did, however, focus on avoiding placing her hands on the surface. The avoidance of hand contact is emphasised in gymnastics because making contact with the surface means a point score deduction in competition. Aimee was concentrating solely on the hand/arm position (i.e., keeping her arms extended) to the exclusion of other aspects of the roll at this point.

The other aspects of the rotation, such as head and leg action received scant attention. The rotation was a result of the body "following on" under the influence of rotational forces and gravity.

Finish

Figure 7.6 shows Aimee during the Finish of the roll.

Figure 7.6: Aspects of the Finish: Aimee

SOC Analysis for the Finish

Rising	Lacking control	Some loss of balance	Totally smooth
Feet	Anterior to buttocks	Slightly anterior to buttocks	Inferior to buttocks
Legs	Abducted more than 20cm	Abducted less than 20cm	Anatomically neutral

Analysis showed the position of the feet was uneven, with one foot placed in front of the other. Aimee leaned towards her left-hand-side, her arms were straight and abducted. Aimee was unable to rise to a standing position without assistance from the arms, hands and the relocation of the legs on the surface. She turned her upper body in the opposite

direction to that of the roll. Aimee crawled on her hands and knees, then stood, took a step backward and then raised arms above the head.

The pictures shown in Figure 7.6 indicate that Aimee was unable to maintain a rolling action, and included some "unusual" actions, e.g., turns 180°, took a long period of time to rise to a standing position and had difficulty maintaining balance at the end of the rotation. Aimee attempted to keep her hands from contacting the surface (unsuccessfully), and at the conclusion of the performance raised her arms above her head, which indicate that she is attempting to fulfil coaching instructions.

Overall Focus: Aimee

Part B of the SOC takes into account all the information provided in Part A to make a determination of the SOLO cycle and level. Throughout the performance Aimee demonstrated low quality descriptors. Low quality is indicative of a first SOLO cycle.

Observation revealed that throughout the roll her main focus was on a single indicator – her arm action. This was evidenced during the Start through the careful placement of her hands on the surface. During the Rotation she avoided hand-contact, and during the Finish, although she was unsuccessful at avoiding hand-contact, she raised her arms whilst attempting to regain a standing position

SOC Analysis for Part B

Overall Focus:	Single Indicator or Two or more or Multiple
Demonstrated aspects of learning:	Placement of the hands. Rest is just getting "over." Developmental factors evident in leg action
Other comments:	Lacked force in leg push.
SOLO:	U_1

Aimee's performance was coded Cycle 1, unistructural level. This determination was based upon the procedures described and reported in this section ... she was focused on a single indicator.

In summary, Table 7.8 shows the completed SOC for Aimee.

TABLE 7.8: SOC FOR AIMEE

No 3. Recording: Gym 1		**Time: 0.10**						
Indicators		**Measure of Quality Continuum (Modified descriptors)**						
(Temporal order)	**Low Quality (Cycle 1) ⟶**		**Medium quality (Cycle transition)**				**⟶ High Quality (Cycle 2)**	
Start								
Hand position	>20cm wide Or elbows bend out	☒	Less than 20cm		❐		Shoulder width	❐
Head contact	Superior surface touching	☒	Dorsal surface touching		❐		Off the surface	❐
Contacts (inc. head)	Five or more	☒	Three	❐	Four ❐		Two	❐
Leg push	None or weak	☒1	Uneven	❐			Even	❐
Rotation								
Control	Lacking control	☒	Some control	❐			Total control	❐
Arm action	Elbows remain flexed	❐	Abducted	☒			Arms extended (shoulder width)	❐
Legs	Remain extended	☒	Remain flexed	❐			Extended then flex in second half of rotation	❐
Finish								
Rising	Lacking control	☒	Some loss of balance		❐		Totally smooth	❐
Feet	Anterior to buttocks	☒	Slightly anterior to buttocks		❐		Inferior to buttocks	❐
Legs	Abducted more than 20cm	☒	Abducted less than 20cm		❐		Anatomically neutral	❐
Overall Focus:	**Single Indicator**	☒	**or Two or more**		❐		**or Multiple**	❐

Demonstrated aspects of learning: Placement of the hands. Rest is just getting over. Developmental factors evident in leg action
Other comments: 1 lacked force.
SOLO: U1

The SOC for Aimee shown in Table 7.8 provided an overall viewpoint that enabled the determination of her SOLO cycle and level, which to reiterate was Cycle 1, unistructural level (U_1).

Example 2: Cycle 2 Multistructural level – Ewen

Ewen was aged nineteen years, and enrolled in a teaching degree at Location C at the time these data were recorded. Ewen's previous experiences with the performance of the forward roll were limited to physical education lessons at school.

Start

Figure 7.7 shows Ewen during the start of the roll.

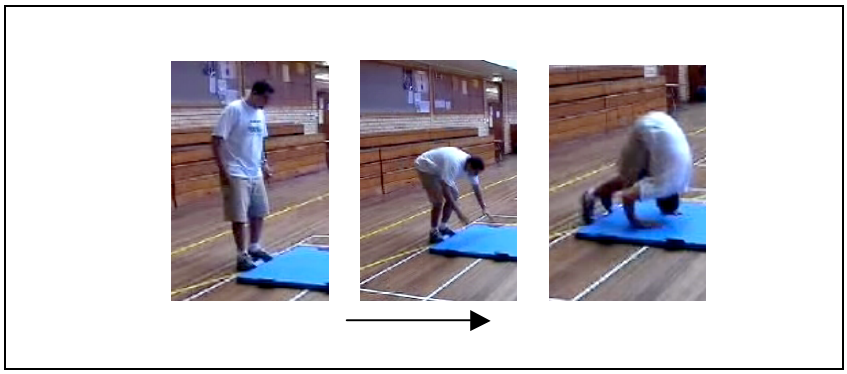

Figure 7.7: Aspects of the Start: Ewen

SOC Results for the Start

Hand Position	>20cm wide Or elbows bent out	Less than 20 cm	Shoulder width
Head Contact	Superior surface touching	Dorsal surface touching	Off the surface
Contacts (inc Head)	Five or more	Three Four	Two
Leg push	None or weak	Uneven	Even

Observations of the recorded data revealed Ewen's arms were flexed at the elbow and he stood with his legs and feet slightly apart. Hip flexion commenced, then the shoulders forward flexed and the knees flexed, and he continued to move towards the surface. The elbows flexed just prior to hands making contact with the surface, close to shoulder width apart. The spine was flexed, as were his hips and knees. There were four contact points, specifically, both hands and feet. The dorsal surface of Ewen's head lightly contacted the surface, however, little body weight was taken on this part of the body, as the arms provided support. Thus there was sufficient rigidity provided by the arms to allow the neck to be flexed (i.e., he tucks his chin). This action also indicated that he was sufficiently coordinated for him to achieve a rotation position. Specifically, he placed his hands on the surface, and the arms supported the body weight, then after a short pause he "pushed off" with both legs.

Ewen was capable of integrating the body components to achieve a desired start position, which allowed a flowing movement. However, there was an apparent lack of stylistic elements in the performance.

Rotation

Figure 7.8 shows Ewen during the rotation of the roll.

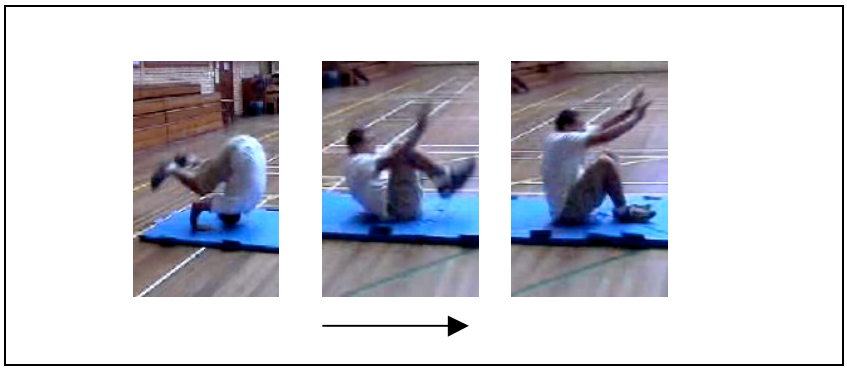

Figure 7.8: Aspects of Rotation: Ewen

SOC Analysis for the Rotation

Control	Lacking control	Some control	Total control
Arm action	Elbows remain flexed	Abducted	Arms extended (shoulder width)
Legs	Remain extended	Remain flexed	Extended then flex in second half rotation

Analysis revealed that at the commencement of rotation there was some knee extension, providing a weak thrust, but sufficient to allow rotation. As rotation commenced his hips became the highest point of the body. Most of his body weight was applied downward when the shoulder line contacted the surface, permitting a head-neck-shoulder sequence of progressive weight bearing. His legs and hips, which were separated laterally,

extended slightly, and flexed early in the rotation. There was smooth transition from the Start into the Rotation. The body remained slightly tucked his arms provided rotational assistance to maintain momentum.

Movements were lacking dynamic qualities, but he was able to perform several movements sequentially, such as: just touching the surface with the head, rolling along a curved back, straightening and flexing the legs and straightening the arms, the latter two with some degree of finesse.

Finish

Figure 7.9 shows Ewen during the Finish of the roll.

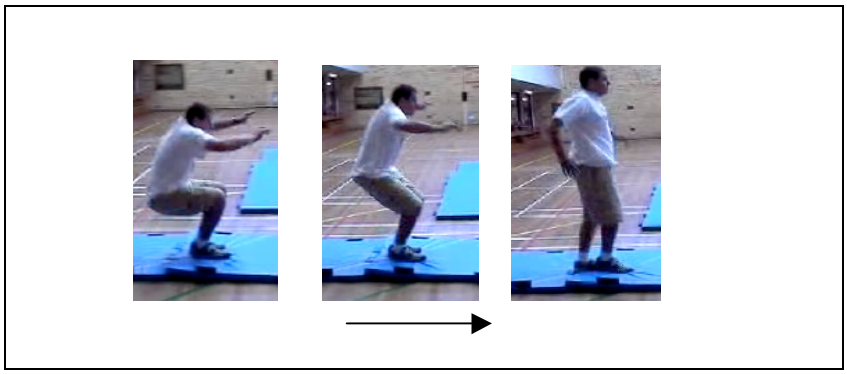

Figure 7.9: Aspects of the Finish: Ewen

SOC Results for the Finish

Rising	Lacking control	Some loss of balance	Totally smooth
Feet	Anterior to buttocks	Slightly anterior to buttocks	Inferior to buttocks
Legs	Abducted more than 20cm	Abducted less than 20cm	Anatomically neutral

Viewed in real time there was no pause in the total movement sequence, as Ewen rose to stand, even though his feet were placed away from the buttocks. Rising to stand was facilitated through the use of the arms, leg extension and the maintenance of sufficient velocity during the rotation. His straight arms forward flexed, his left arm abducted, which was followed by abduction of the right arm. His shoulders forward flexed and elbows extended. At this point his knees were flexed at 90°, and were extending. Ewen reached a standing position and then lost balance taking a short step backwards. This action was accompanied by awkward movements of the arms, which demonstrated an attempt to compensate for the loss of balance.

Overall Focus: Ewen

The majority of the modified descriptors for Ewen were in the middle and upper end of the quality continuum. His focus was on three indicators, which observation revealed to be Head position, Arm action, and Legs. In general movements were indicative of a

progression towards a second SOLO cycle, with one medium quality and two high quality descriptors.

SOC Analysis for Part B

Overall Focus: Single Indicator or Two or more or Multiple
Demonstrated aspects of learning: Hand placement, keeps head off surface, extends arms
Other comments:
SOLO: M_2

Ewen's performance was coded Cycle 2, multistructural level. He was focused on a three indicators, however, the movements that comprise each indicator were observed to be operating independently of each other.

In summary, Table 7.9 shows the SOC for Ewen.

TABLE 7.9: SOC FOR EWEN

Young Adults Subject Number 10. Recording: Gym 4 Time: 2:30

Indicators	Measure of Quality Continuum (Modified descriptors)							
(Temporal order)	Low Quality (Cycle 1) ⟶		Medium quality (Cycle transition)				⟶ High Quality (Cycle 2)	
Start								
Hand position	>20cm wide Or elbows bend out	❒	< 20cm wide of shoulders		❒		Shoulder width	☒
Head contact	Superior surface contact	❒	Dorsal surface touches		❒		Off the surface	☒
Contacts	Five or more	❒	Three	❒ Four	☒		Two	❒
Leg push	None or Weak	❒	Uneven		❒		Even	☒
Rotation								
Control	Lacking control	❒	Some control	❒			Total control	☒
Arm action	Elbows remain flexed	❒	Abducted	❒			Arms extended (shoulder width)	☒
Legs	Remain extended	❒	Remain flexed	☒	Extended then flex in second half of rotation			❒
Finish								
Rising	Lacking control	❒	Some loss of balance		☒		Totally smooth	❒
Feet	Anterior to buttocks >30cm	☒	Slightly anterior to buttocks		❒		Almost inferior to buttocks	❒
Any part of Legs	Abducted > 20cm	☒	Abducted < 20cm		❒		Anatomically neutral	❒
Overall Focus:	Single Indicator	❒	or Two or more		☒		or Multiple	❒

Demonstrated aspects of learning: Hand placement, keeps head off surface, extends arms
Other comments:
SOLO: M2

The SOC for Ewen shown in Table 7.9 provided an overall viewpoint that enabled the determination of her SOLO cycle and level, namely Cycle 2, multistructural level (M_2).

Example 3: Cycle 2 Relational level – Claire

Claire was also introduced earlier in this thesis, as a 12-year-old female who attended gymnastics practice sessions twice per week at Location B.

Start

Figure 7.10 shows Claire during the Start of the roll.

Figure 7.10: Aspects of the Start: Claire

SOC Results for the Start

Hand Position	>20cm wide Or elbows bent out	Less than 20 cm	Shoulder width
Head Contact	Superior surface touching	Dorsal surface touching	Off the surface
Contacts (inc Head)	Five or more	Three Four	Two
Leg push	None or weak	Uneven	Even

Observations in real time showed that Claire was stationary at the start of the performance. Her legs and arms were extended, and her feet together (the anatomically neutral position). Claire flexed her knees in preparation for leaving the surface and arms forward flex 90° at the shoulders.

In a controlled descent Claire's feet left the surface, just prior to her hands making contact. Her arms are straight and the hands touched the surface simultaneously. There were two body contact points indicating a "flight phase". A flight phase is synonymous with superior skill. The moment her fingers touched the surface, the hips were raised above horizontal. To provide propulsion, the legs extended at the knees then her ankles plantar flexed simultaneously. Her body weight was supported by straight arms, which were shoulder width apart.

Rotation

Figure 7.11 shows three pictures from the rotation of the roll.

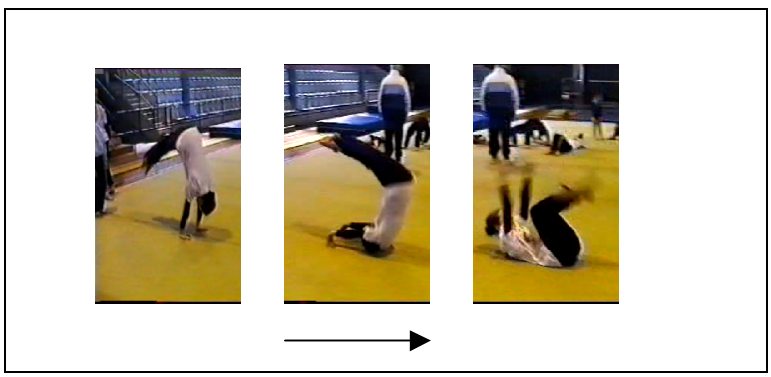

Figure 7.11: Aspects of Rotation: Claire

SOC Results for the Rotation

Control	Lacking control	Some control	Total control
Arm action	Elbows remain flexed	Abducted	Arms extended (shoulder width)
Legs	Remain extended	Remain flexed	Extended then flex in second half rotation

When viewed in real time Claire demonstrated total control over the rotation, her shoulder line was the point of contact, and the legs were extended. Rotation was controlled and the head was ventro-flexed immediately prior to the shoulders making contact with the surface. Arms and legs remained extended as Claire rolled along her slightly curved back from shoulders to hips. Momentum was maintained with demonstrated control, the back was slightly rounded, arms remained shoulder width apart and the knees flexed. Her head and hands left the surface when the upper body was approximately 45° to the surface. Her feet were together and the legs remained extended until late in the rotation. There was an observed deliberate "pause" at the mid point of the rotation demonstrating high levels of control and individual flair.

For the Rotation, the precise timing of movements and the inter-relationship of various body components were evident. She had complete control of the rotation.

Finish

Figure 7.12 shows Claire during the Finish of the roll.

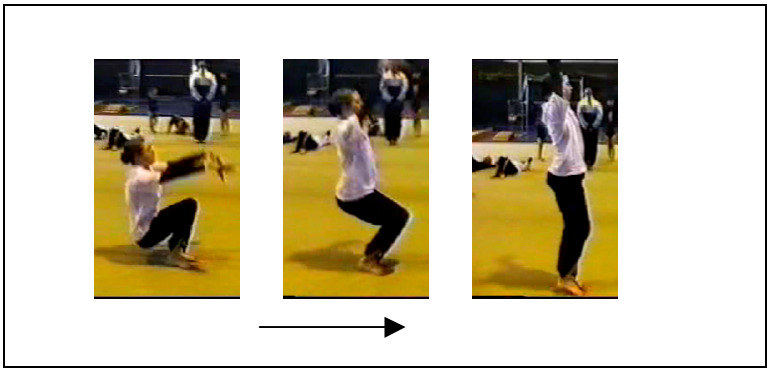

Figure 7.12: Aspects of the Finish: Claire

SOC Results for the Finish

Rising	Lacking control	Some loss of balance	Totally smooth
Feet	Anterior to buttocks	Slightly anterior to buttocks	Inferior to buttocks
Legs	Abducted more than 20cm	Abducted less than 20cm	Anatomically neutral

Viewing the recorded data showed that at the conclusion of rotation the extended arms continued to forward flex at the shoulder to a position above the head. This is the finishing position taught to gymnasts as part of "presenting". The trunk was vertical and the legs extended. Claire rose to a standing position maintaining good form and balance,

and her eyes were focused horizontally. Arm and leg actions were in unison and she was concerned with the maintenance of good form.

Overall Focus: Claire

Claire's performance demonstrated all high quality indicators. Movements were stylish, controlled and flowing. Claire was able to integrate all the body components; all movements occurred simultaneously and she maintained good shape and form. Movements were carried out with deliberate attention to style and accuracy, indicating a performance of high quality.

SOC Analysis for Part B

Overall Focus: Single Indicator or Two or more or Multiple
Demonstrated aspects of learning: Style, precision and control of all modified descriptors
Other comments: 1: Flight phase.
SOLO: R_2

Claire's performance indicates a SOLO Cycle 2, relational level performance. This high quality performance demonstrated the integration of all indicators and included, variety in speed, dynamics and amplitude.

Claire demonstrated a "flight phase" when neither the feet nor the hands were in contact with the surface. In the Rotation timing of elements were precise, the velocity of rotation could be consciously varied for the body/limb components. The finish was characterised by the timing of elements of the rise to standing position, which was under total control, stylish, and dynamic.

Table 7.10 shows the SOC for Claire.

TABLE 7.10: SOC FOR CLAIRE

Children Subject Number 35. Recording: Gym 1Time: 9:59

Indicators	Measure of Quality Continuum (Modified descriptors)							
(Temporal order)	Low Quality (Cycle 1) →		Medium quality (Cycle transition)			→	High Quality (Cycle 2)	
Start								
Hand position	>20cm wide Or elbows bend out	❒	< 20cm wide of shoulders		❒		Shoulder width	☒
Head contact	Superior surface contact	❒	Dorsal surface touches		❒		Off the surface	☒
Contacts	Five or more	❒	Three	❒ Four	❒		Two	☒1
Leg push	None or Weak	❒	Uneven	❒			Even	☒
Rotation								
Control	Lacking control	❒	Some control	❒			Total control	☒
Arm action	Elbows remain flexed	❒	Abducted	❒			Arms extended (shoulder width)	☒
Legs	Remain extended	❒	Remain flexed	❒			Extended then flex in second half of rotation	☒
Finish								
Rising	Lacking control	❒	Some loss of balance		❒		Totally smooth	☒
Feet	Anterior to buttocks >30cm	❒	Slightly anterior to buttocks		❒		Inferior to buttocks	☒
Any part of Legs	Abducted > 20cm	❒	Abducted < 20cm		❒		Anatomically neutral	☒
Overall Focus:	Single Indicator	❒	or Two or more		❒		or Multiple	☒

Demonstrated aspects of learning: Style, precision, and control for all modified descriptors
Other comments: 1 Flight phase.
SOLO: R2

An examination of the SOC for Claire shown in Figure 7.10 shows that all the high quality descriptors were "checked". These factors along with the "Overall focus: combine to indicate that her performance met the criteria for Cycle 2, relational level (R_2).

In summary, all individuals were coded from a whole body approach using SOC to determine the SOLO cycles and levels. Table 7.11 provides an overview the number of participants for each SOLO level and cycle, when the SOC was applied to their performance of the forward roll.

TABLE 7.11: NUMBER OF PARTICIPANTS IN EACH SOLO CYCLE AND LEVEL USING SOC

SOC: Level and Cycle	U_1	M_1	R_1	U_2	M_2	R_2
Children	15	12	2	6	5	8
Young Adults	3	0	2	7	6	5
Older Adults	12	16	2	7	6	2

The overview of UMR codes for each cohort shown in Table 7.11 provides a SOLO analysis using the whole body approach. SOLO cycles and levels for all participants coded using SOC may be found in Appendix R.

Conclusion

The SOLO model of Biggs and Collis (1980) provided the basis upon which learning cycles and levels could be determined. In order to identify the SOLO cycle and level, within the sensorimotor mode of learning, an examination of both the quality of the performance and the amount of learning that an individual demonstrated was required.

Through the application of the MAMQ:FR framework's indicators and descriptors, SOLO cycles and levels were determined for individuals performing the forward roll from a sequences perspective. Each sequence of the forward roll was allocated a SOLO cycle and level. However, to gain a broader determination of the SOLO cycles and levels an additional instrument was designed, termed, the SOLO Observation Checklist (SOC). Using SOC permitted a SOLO analysis from a total body perspective.

When SOC was applied to the entire sample a more holistic assessment of the forward roll was forthcoming. This instrument utilised the most discriminating indicators of movement quality for the forward roll from the MAMQ:FR. The result was that SOLO cycles and levels were applied to the forward roll as a complete skill.

RELIABILITY

This section describes the measures undertaken to ensure the reliability of the results for SOLO coding. Measures need to be employed to ensure the consistency of the results through reliable coding of data. Consistency refers to internal reliability and relates to the extent to which data analysis and interpretation are constant (Wiersma, 1991). To achieve consistency a number of strategies may be employed, including multiple researchers, peer examination and the mechanical recording of data (LeCompte & Goetz, 1982). Tuckman (1988) suggested two methods of ensuring internal reliability, these are termed intracoder and intercoder reliability.

Intracoder reliability

The aim of coding and subsequently recoding the data, from a SOLO perspective, was twofold. Initially, to refine the processes, after establishing the criteria pertaining to the learning cycles and levels. Secondly, to determine the extent to which SOLO coding could be replicated.

Recoding was undertaken on numerous separate occasions over a period of several years. The time period between recoding episodes, ranged from one to six months. The former episodes were conducted primarily to improve upon observational skills for coding the movements in each sequence of the roll as well as finding the focus point for the SOLO lens. The latter episodes, which included those with longer time periods between, were aimed at minimising the probability that individual codes could be recalled, and thus influencing the objectivity of the coder, from one recoding period to the next.

Twenty, randomly selected participants, from across all cohorts, were recoded during the final recoding session. The process involved recoding each sequence – beginning, bridging and end of the forward roll, singly for the selected participants, thus sixty individual codes were recorded. Variations between the recodes from the original coding were all within the one SOLO level of each other, and no individuals were relocated from SOLO learning Cycle 1 into Cycle 2 or vice versa. Intracoder reliability was .90 based on the sixty sequence recodes. Fifty-four recodes were in agreement whilst 6 differed on one

sequence by one SOLO level. That is there were no cases where the recoding of the data resulted in more than a one different sequence.

Intercoder reliability

Intercoder reliability checks were performed using the SOLO Observation Checklist. This task was performed independently by a trained physical education expert and experienced researcher. For the purpose of internal reliability, twenty, randomly selected participants, from across all cohorts, were coded using the SOC. The resulting intercoder reliability using this instrument was .80 (16 agreements out of 20). The four disagreements centred on differences between U_2 (one focus) and M_2 (a number of foci) in Cycle 2. However, following a discussion these differences of agreement were ameliorated. The clarification of the coding around these two levels was then applied to the entire sample.

Data Recording: Reliability

The recording of data onto videotape, offered the opportunity to preserve all data unobstructed (LeCompte & Preissle, 1993), thereby adding to internal reliability. All data were transferred, at a later date to CD-ROM, which permitted the removal of extraneous images that were not relevant to this study.

Conclusion

The underpinning foundations of the SOLO analysis were subject to data intracoder and intercoder reliability checks. Results of these checks indicate a high degree of conformity, especially, for the intracoder aspect. An improvement in intracoder reliability was noted over the period of time taken to complete this study. These improved results were achieved due to repeated practice and honing of observational skills.

CHAPTER CONCLUSION

The use of the quantitative methods such as Rasch and the *Quest* statistical package reinforced the findings relating to the characteristics of the forward roll from a qualitative perspective. There were no unexpected patterns in the responses evident from a statistical standpoint. In addition, an underlying construct was confirmed, meaning that the instrument measured varying levels of the quality of the performance for the forward roll.

In addition to the quantitative analysis of the MAMQ:FR, this instrument was also examined using the principles based upon the SOLO theoretical model. The purpose was to determine whether SOLO cycles and levels could be described in terms of the

MAMQ:FR indicators and descriptors, for the forward roll. Moreover, a checklist, the SOC, was devised that applied SOLO cycles and levels to the performance of the forward roll as a whole. Examples of SOLO coding using this checklist were provided through the descriptions of the performances of three individuals, Aimee, Ewen, and Claire.

Generally, with regard to the observation of performances of the forward roll, the absence of numerous extraneous distracting movements, evident in higher quality performances, permitted classification of a performance to be made more rapidly than poorer quality performances within the second cycle.

Re-coding of SOLO data over several sessions created a closer match between the levels within each cycle of learning for each sequence when applying the MAMQ:FR. Practise and repeated coding of the data meant that a more skilful assessment was achieved. The improved accuracy in assessment was evident following the intercoder reliability checks.

The application of the MAMQ:FR and SOC has permitted the allocation of SOLO cycles and levels to the performance of the forward roll. In response to the fourth research question, compelling evidence has been provided to conclude that the SOLO model is an appropriate tool for describing various qualities of the forward roll. Finally, the characteristics of the SOLO cycles levels of response have been described for the sensorimotor mode of learning "across the lifespan".