EVIDENCE FOR THE EXISTENCE OF A MOVEMENT SIGNATURE IN SPORT

Wayne Maschette and Noel Lythgo
Centre of Physical Activity Across the Lifespan (COPAAL),
School of Exercise Science, ACU National, Victoria, Melbourne, Australia

The purpose of this study was to investigate whether consistent kinematic characteristics exist that enable perceptual categorisation and recognition of movement. Two forms of point-light presentation were employed, a person wearing black clothing in a blackened environment with the joints marked by reflective tape (RT) and a second presentation where the body and background were removed completely and the joints represented by a blue dot (BD1 or BD2). The results of experiment 1 showed the blue dot presentation elicited more correct answers than the RT presentation ($p = .005$). The blackened background showed some environmental cues in addition to the point-light data, which may have had a distraction effect. Consequently a second experiment was conducted to confirm the differences in the two methods and control for any possible order of presentation. The results showed the BD presentation was superior for recognition of consistent kinematic characteristics in randomised presentations ($p = .000$).

KEY WORDS: point-light, perception, movement signature.

INTRODUCTION: Movement organization is a multilevel concept within which variability is prevalent. Understanding of variability can be investigated using an applied biomechanical perspective where the consequences of variability are the focus. Factors that affect kinematic outcomes can then be related to biomechanical function where the performance is the relevant issue. Furthermore, performance can be related to an individual and thereby can be recognised by its intra-individual variability but within broad parameters. As an example, handwriting is used to identify people and legally bind them to contracts in most parts of the world. Interestingly, handwriting is a manipulative skill that involves limited movement of parts of the body to produce a performance outcome. This performance outcome then becomes the written signature by which a person is identified with inter-individual variability ensuring that it is distinguishable from many other signatures. On analysis, it is not only the outcome (i.e. written signature) that has a set of recognisable characteristics but also the performance production itself will contain elements that distinguish it as handwriting. Moreover, from a global perspective, different types of movements possess performance production characteristics, that when observed as a whole are common only for that task. Furthermore, when a single task is performed, observers know whether the performance is elite or non-elite based upon Intra-movement variability.

It can be concluded that all movements possess distinctive performance production characteristics that are a movement signature. These movement signatures enable us to distinguish the many types of movement that a person may choose to perform. Walking for example can easily be distinguished from skipping or hopping as each movement contains distinctive kinematic characteristics that enable the observer to separate movements. Although these parameters of the intra-movement variability may be broad, it seems reasonable to suggest that there is a non-linear change from one movement signature to a new movement signature. In this context, a person may be walking and then abruptly change into a skip with the transition being unrelated to the final movement signature. Some performance characteristics are the relative timing of the movement of one body segment in comparison to another, the velocity that each segment moves relative to another and the sequence of initiation of the components (Magill, 2001; Schmidt & Lee, 1999; Schmidt & Wrisberg, 2000). It can be assumed that some or all of these characteristics are used to positively identify the movement signature. Interestingly, the parameters of the movement signature are so broad that within each movement signature every person applies their personal movement characteristics but the overall action is performed within boundaries that make the movement signature recognisable. Walking is thereby distinguishable from running, and at elite levels of walking competitions rules are set to ensure the person is walking and not running.

Perception of movement uses vision to compare movement production characteristics to classify the skill. Familiarity with particular motor patterns by either performing or observing motor skills is more likely to have developed increased perceptual proficiency to distinguish movement signatures by the individual. Intra-individual movement variability does, similar to a written signature, offers clues to identity. Many of us share general characteristics, but physical differences make a difference in the way we move (Webb, 2003). The authors believe inter-movement variability should be considered to be a movement signature by which we classify movement. Personal idiosyncrasies that lead to intra-individual movement variability are normal and therefore each person will possess a unique movement signature for all the different tasks performed.

To test the possibility that it is the kinematic data that is used to distinguish movement signatures, some researchers have masked the body shape during performance in an attempt to check whether the identification of the movement signature may become more difficult for the individual. Known as the point-light (PL) technique, the performing individual is dressed in black with a black background and reflective markers are placed on the joints. This technique provides the observer with a series of illuminated markers moving in a particular sequence and the observers are asked to either recognise the skill or the person performing the skill. The research has some interesting outcomes that are reported here.

The PL technique has been used to study the visual perception of human motion (Johansson, 1973; Cutting & Kolzowski,1977; Williams,1988; Brownlow, Dixon, Egbert & Radcliffe,1997). This technique masks the body shape and illuminates a few key points on a moving human body. It has been reported that these few key illuminations are enough for an accurate perception of gait patterns such as walking or running (Johansson, 1973). Furthermore, Cutting & Kolzowski (1977) reported that the illumination of key joints was enough for people to recognise a friends' walking gait. This finding reinforces the fact that while movement has a recognisable signature, intra-individual variability of that movement signature is recognisable to others.

For this study it was decided to use the point-light technique to investigate whether a group of Exercise Science students could recognise fundamental motor skills projected onto a large screen in a lecture theatre.

METHOD: In a pilot study this investigation used two forms of the PL technique, traditional reflective tape in a darkened background and blue dots on a white background. A total of fifteen fundamental motor skills (skipping, hopping, forward roll, etc) were filmed in a darkened room with the major joints marked with reflective tape. In the first form of point-light technique, it was easy to see the reflective tape marked joints move in a particular sequence, at a given speed and with a particular force. Some background features were also visible but not clearly so, such as the demonstrator's face and equipment such as a mat. The second form of the point-light technique was digitised via a Peak Motus Motion Analysis System where all the background was eliminated. This form of the point-light technique left a series of blue dots where the markers were positioned and had a plain white background. These images were transferred to digital video via the Peak Motus system and recorded on a CD-ROM for ease of playing.

A Sony video projector (Model VPL CX5) was used both in the pilot and second study to project the video onto a large screen. A typical university lecture theatre was used with the participants distributed in a manner which separated them from others.

In the pilot study, 18 participants were shown a normal PL reflective tape protocol (RT) with a darkened background and the joints highlighted by reflective markers. In total, 15 fundamental motor skills were shown using the typical PL reflective tape protocol and the responses recorded. Immediately following the PL reflective tape protocol, the 15 fundamental motor tasks were randomised and shown as moving blue dots on a white background which were created by using the reflective marker positions from the previous PL protocol. A second randomised series of blue dots was shown as the third sequence.

In the second experiment, two sets of video clips showing the typical PL reflective tape

protocol with a darkened background were recorded on a CD-ROM. Additionally, two sets of video clips showing only blue dots were also recorded on the same CD-ROM. A random sequence of the 15 skills was used as RT1 and the same sequence used as Blue Dots 1. A second random sequence of the markers (RT 2) and blue dots (Blue Dots 2) was also stored on the CD-ROM. Based upon the results of the pilot test, a second experiment with 70 students was used to test the assumption that a movement signature existed. To control for the type of PL technique used, four groups were established and tested under the following conditions:
Group 1: RT1 and Dots1 (n= 17)
Group 2: RT1 and RT2 (n = 15)
Group 3: Dots1 and RT1 (n = 22)
Group 4: Dots1 and Dots2 (n = 16)
It was reasoned that the number of correct response from the reflective tape point-light technique would not equal the number of correct responses from the point-light blue dots technique. This meant that the order effect was apparent with the dots without a background superior to the reflective tape procedure as was found in the pilot test.
After completing the necessary consent forms, each participant was given a score sheet to record their responses and was instructed on how the test procedure would be performed. The score sheet contained a list of the fifteen numbers alongside which the name of the motor skill was to be written. The task consisted of the participant watching one trial of the video clip and then writing the answer on the score sheet.
The participants were year 1 University students who in their previous semester had been enrolled in a class Foundations of Motor Development and Behaviour. In this class fundamental motor skills were explained and the textbook set for the class was used to select the fifteen fundamental motor skills.

RESULTS AND DISCUSSION: The pilot study was used to test whether the participants could recognise the fundamental motor skill kinematic characteristics when each skill was presented as a series of illuminated markers on a darkened background in comparison to the same skills being presented as a series of moving blue dots on a white background. A summary of the comparisons are presented in Table 1 where the 18 people responded to 15 fundamental motor skill videos as traditional RT technique or as blue dots projected onto a large screen in a lecture theatre. The percentage of correct responses was calculated for each condition. The increasing percentage of correct answers across the conditions is evident with the blue dots showing a better rate than the RT technique. It was considered that one possibility for the lower scores on the RT technique was that it was the first condition shown and therefore the other responses indicate a learning effect. A second possibility however, was that the RT condition contained extra information (outline of body shape, face, background equipment) that may have been distractions to the recognition of the consistent kinematic characteristics contained in the videos.

Table 1 Pilot Test Summary of Correct Responses for the three conditions.

	RT protocol	Blue Dots 1	Blue Dots 2
Correct responses	211	227	243
Total possible correct responses	270	270	270
% Correct responses	78	84	90

A repeated measures ANOVA was used to test whether there was any difference between viewing the traditional RT protocol in comparison to the blue dots protocol. Significant differences were found between the RT and Blue Dots 2 ($p = .005$); Blue Dots1 and Blue Dots2 ($p = .023$) but not between RT and Blue Dots 1 ($p = 0.96$). These findings led the authors to again question whether it was a learning or distractions effect. Projected into a sports situation, the question must be asked whether there are distractions to the learning of kinematic characteristics during the demonstrations?

The second study was designed to test whether the learning effect was the major contributor to the improved scores on subsequent trials. The pilot test data was used to construct four conditions: RT 1 vs Dots 1; RT1 vs RT 2; Dots 1 Vs RT 1; Dots 1 vs Dots 2. The summary of the correct responses is presented in table 2. It should be noted that four separate groups of participants were involved in this study. Interestingly, the dots procedure seemed to be more relevant in allowing the movement signature to be recognized. The paired samples t-test supported this assumption with no significant differences when RT1 vs RT 2 ($p = .617$); Dots 1 Vs RT 1($p = .329$); Dots 1 vs Dots 2 ($p = .188$). But the RT1 Vs Dots1 was significant. The % correct responses shown in table 2 clearly show that the participants were recognizing the movement signature consistent kinematics more readily when no background distractions were available.

Table 2 Summary of Correct Responses for the four comparisons.

	Group 1		Group 2		Group 3		Group 4	
	RT1	*Dots 1*	*RT1*	*RT2*	*Dots 1*	*RT1*	*Dots 1*	*Dots 2*
Correct responses	186	231	161	165	296	293	232	235
Total possible correct responses	255	255	225	225	330	330	240	240
% Correct responses	73%	91%	72%	73%	90%	89%	97%	98%

CONCLUSION: This study found evidence of a movement signature. The presentation of consistent kinematic information allowed fundamental movement patterns to be identified. From an applied biomechanics perspective, this information could provide a method to better understand perturbations in the movement signature. These perturbations may help identify mechanical problems resulting from injury, fatigue, poor technique, or equipment failure (eg strapping).

The recognition of the movement signature was found to be affected by additional information embedded in the movement. A possible explanation for this outcome may be the observer was distracted by factors such as the body outline and facial features, thereby losing focus on the movement signature. This suggests sports practitioners should eliminate as many of the background distractions as possible to enable observers to focus on key kinematic information in a movement signature.

REFERENCES:

Brownlow, S., Dixon, A.R., Egbert, C.A, Radcliffe, R.D. (1997). Perception of movement and dancer characteristics from point-light displays of dance. Psychological Record, 47(3), 411-421.

Cutting, J.E., Kozlowski, L.T. (1977). Recognizing friends by their walk: Gait perception without familiarity cues. Bulletin of the Psychonomic Society, 9(5), 353-356.

Imwold, C.H., Hoffman, S.J. (1983). Visual recognition of a gymnastics skill by experienced and inexperienced instructors. Research Quarterly for Exercise & Sport, 54(2), 149-155.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. Perception & Psychophysics, 14, 201-211.

Magill, R.A. (2001). Motor Learning: Concepts and Applications (6th Ed.). Dubuque, IA: Brown.

Schmidt, R.A., & Wrisberg ,C.A. (2000). Motor Learning and Performance: A problem based learning approach. Champaign, IL: Human Kinetics.

Schmidt, R.A., & Lee, T.D. (1998). Motor control and learning: A behavioral emphasis (3rd Ed.). Champaign, IL: Human Kinetics.

Webb, A. (2003). Walk offers clues to identity. BBC News Worldwide, http://news.bbc.co.uk/2/hi/technology/2712995.stm.

Williams J.G. (1988). Perception of a throwing action from point-light demonstrations. Perceptual & Motor Skills, 67(1), 273-4.