


How should we interpret movement variability in athletes?

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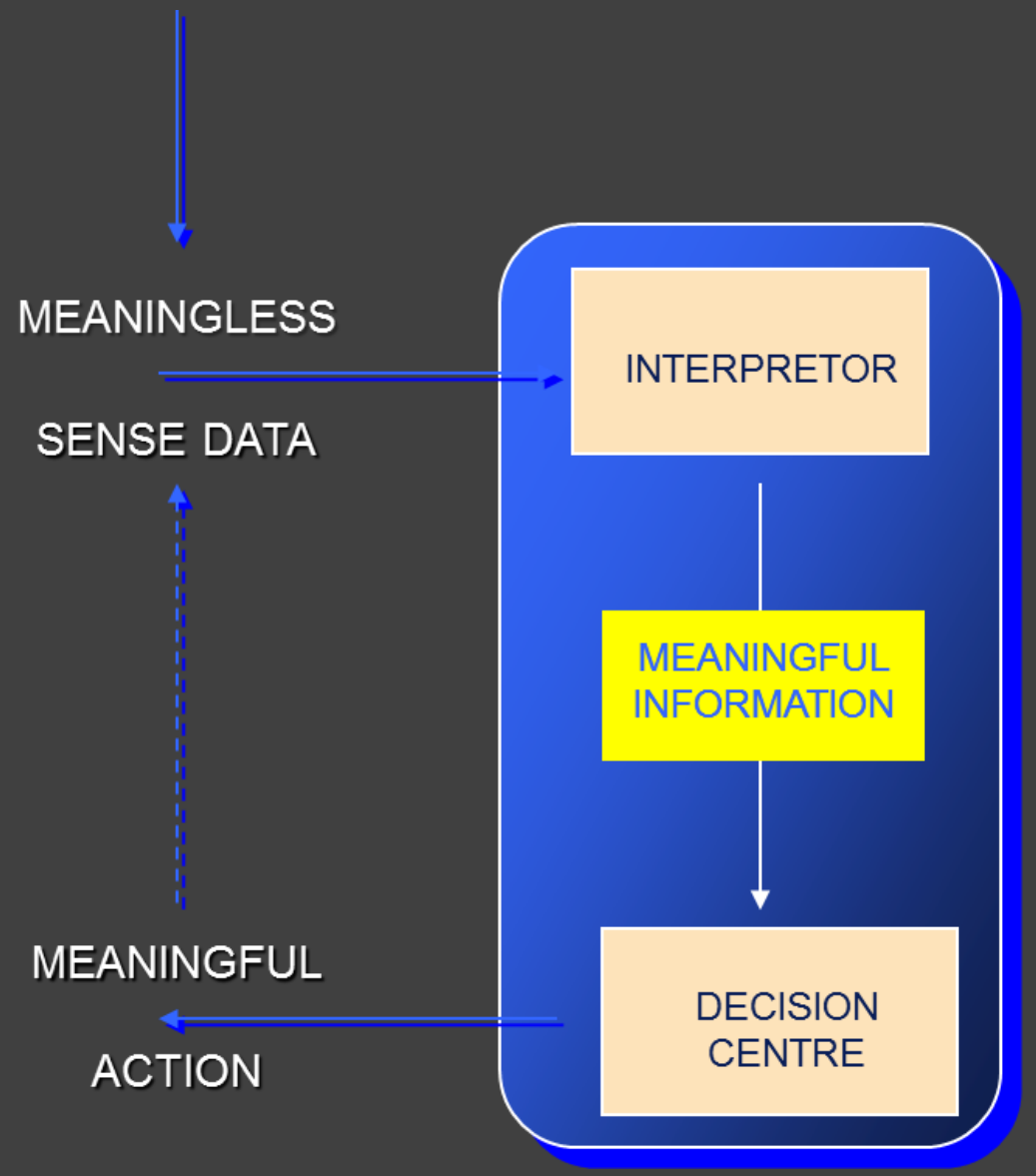
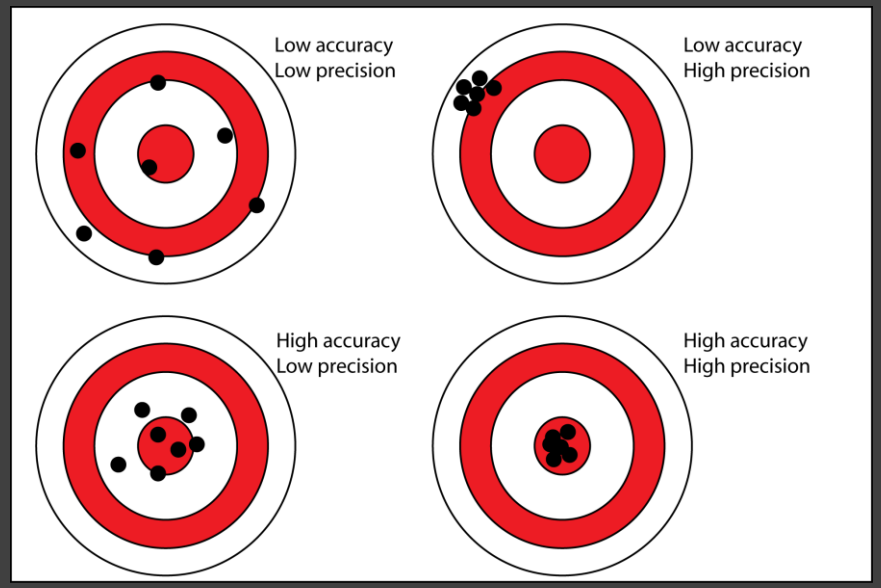
Traditional motor learning model: Information processing



Influence on interpretations of movement variability



Interpretation of movement variability

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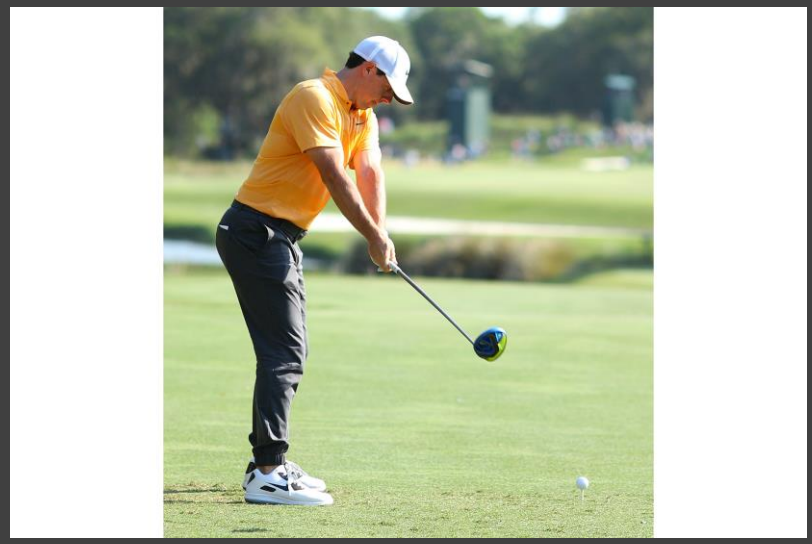
Sources of movement variability

1. Measurement errors
2. Execution errors



1. Non-functional biological variability
2. Functional biological variability
   ‘Adaptive movement variability’

Adaptive movement variability

- Traditional view:
  - Noise
  - Aim to eliminate
- Functional movement variability
  - Reduce overuse injury risk
  - Flexibility/adaptability
  - Compensation/synergy

Arutyunyan et al. **(1969)**

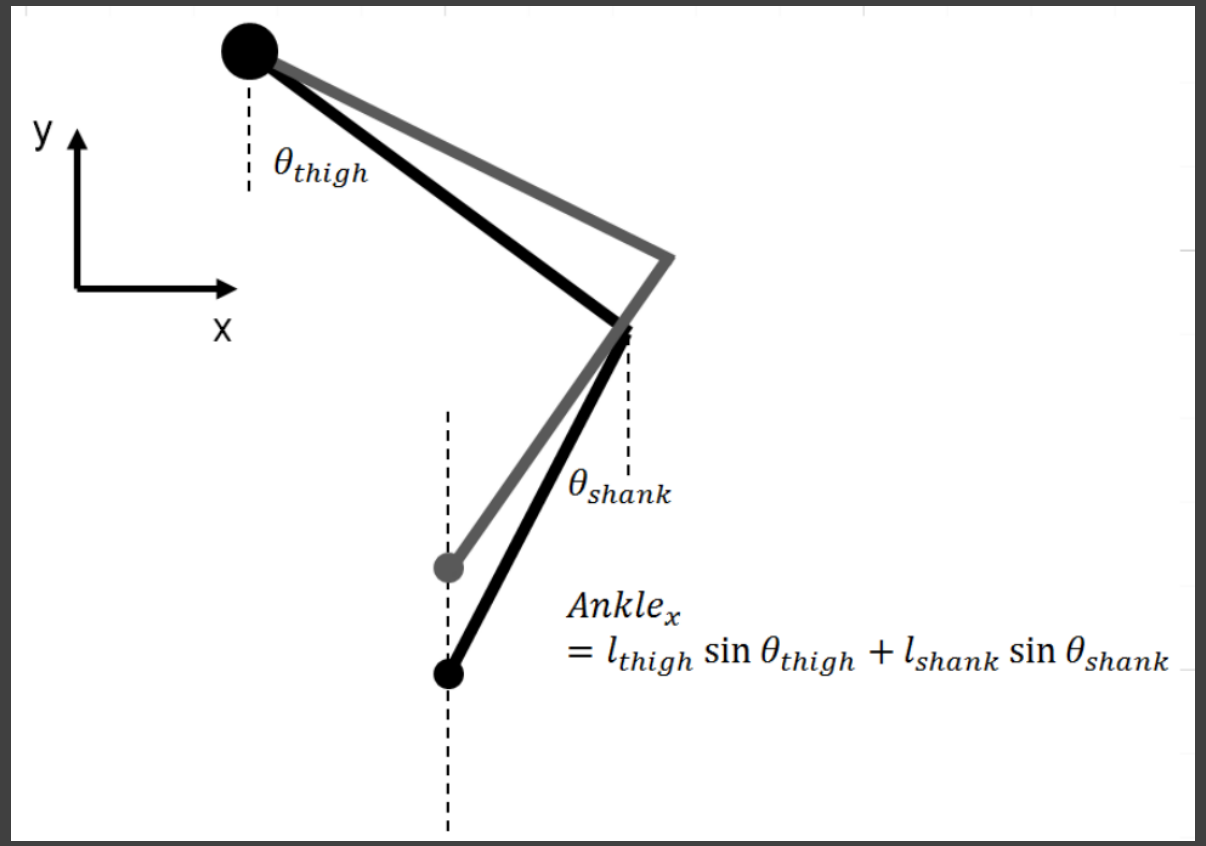
Bernstein: “Repetition without repetition”

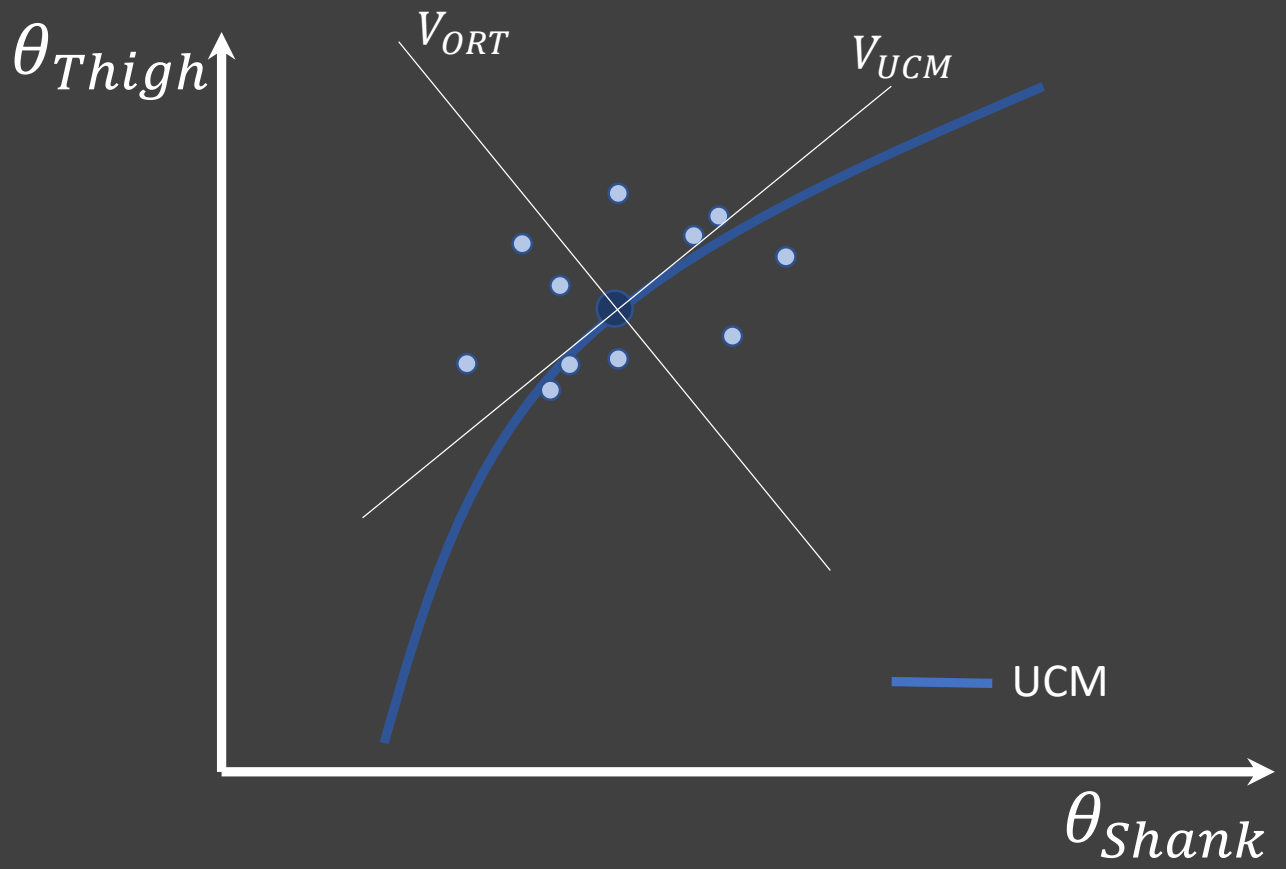
Adaptive movement variability in golf

- Several studies suggest lower variability in more skilled athletes
  - McTeigue et al. (1994) – pelvis and thorax rotation
  - Barclay and McIlroy (1990) – upper extremity muscle activity
  - Neal et al. (1990) – temporal and joint kinematics
  - Bradshaw et al. (2009) – kinematics at discrete points in the swing
- Even the highly skilled players exhibit movement variability though
- These studies and others have focussed on the *magnitude*, rather than the *structure* of the variability

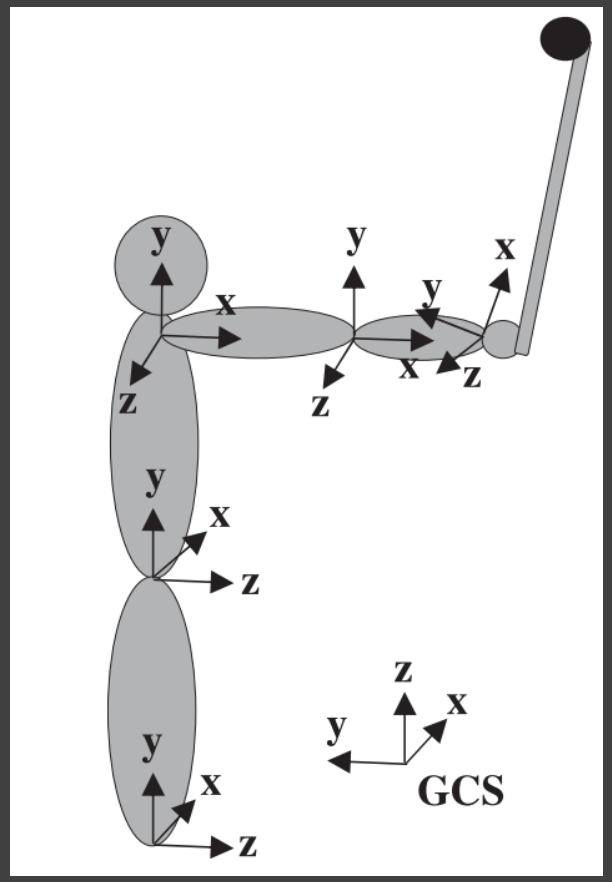
Structure of variability - Synergy/compensation

Uncontrolled manifold analysis

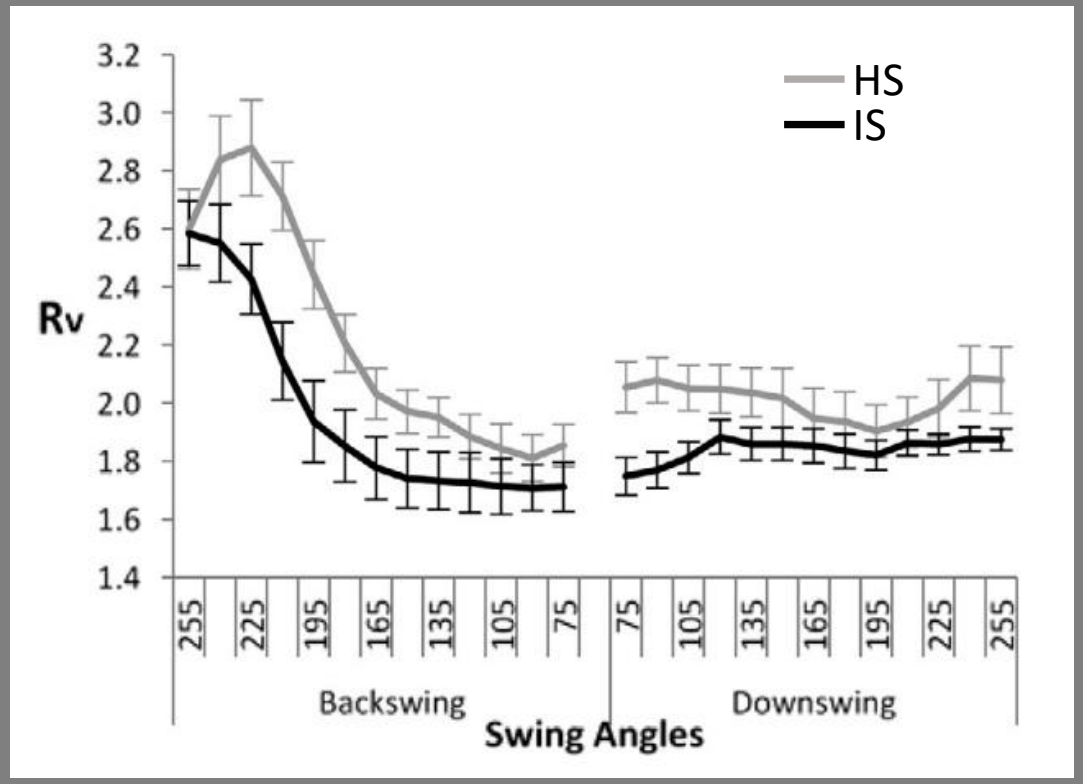




Morrison et al (2016)



Magnitude of variability



Behav Res (2018) 50:620–629
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Quantifying synergies in two-versus-one situations in team sports: An example from Rugby Union

P. Passos [1] · J. Milho [2,3] · C. Button [4]

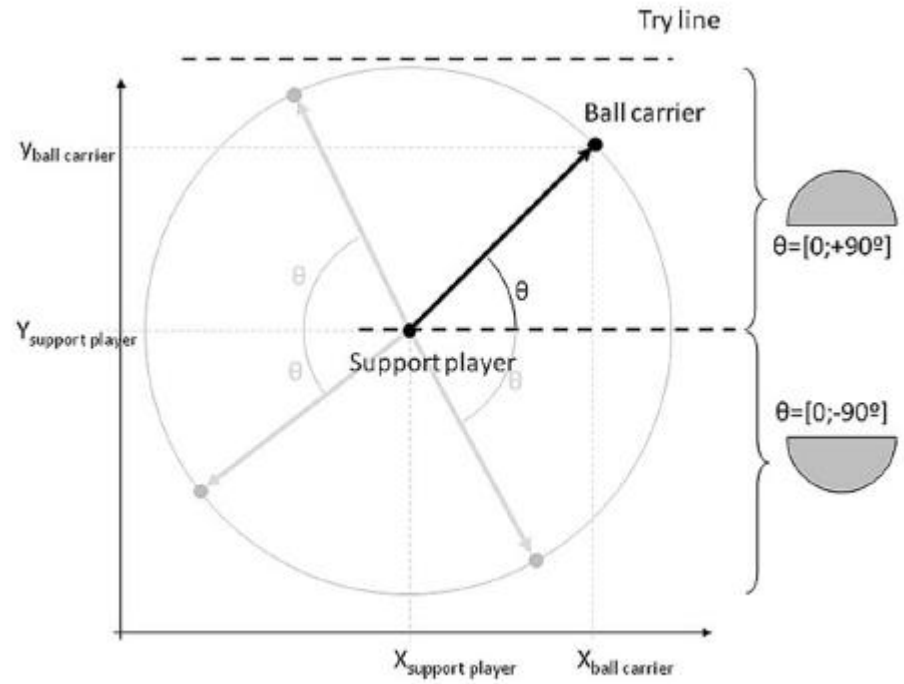


Fig. 1 Diagram depicting the calculation of inter-player angle (θ)

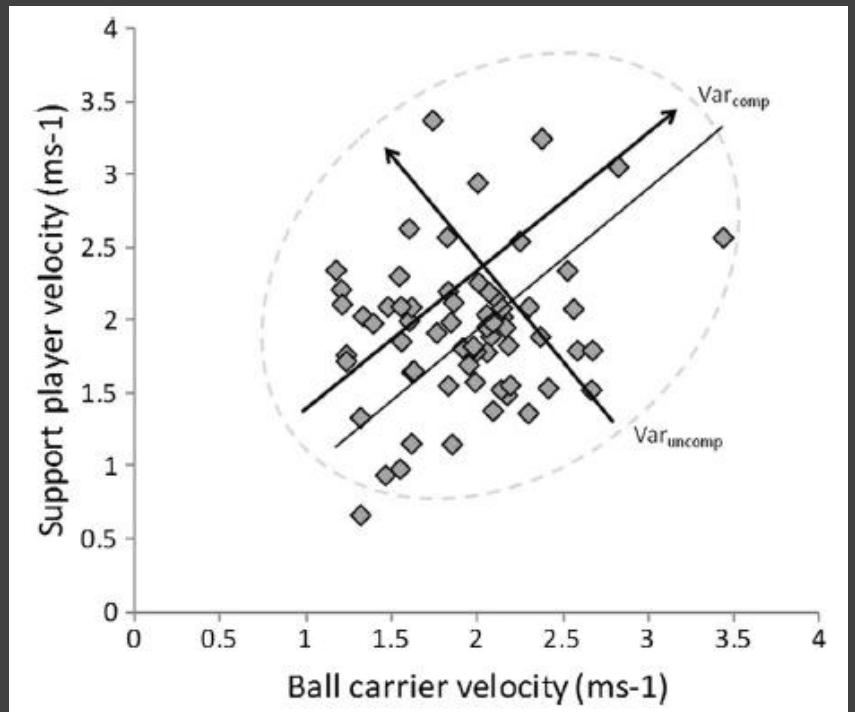
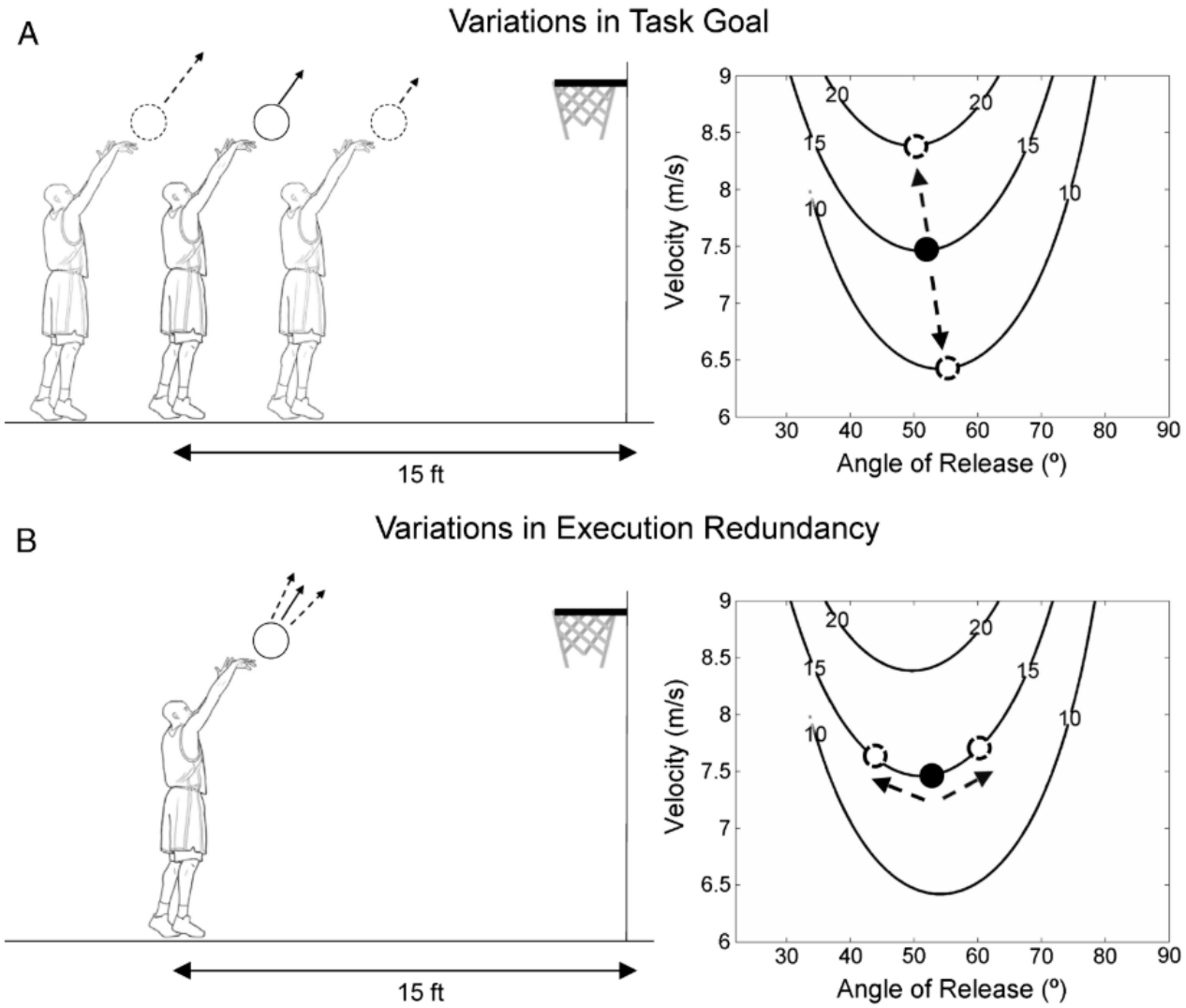


Fig. 2 Running line velocities subspace (an example from trial data)

Implications for practice environments

- Does this evidence mean that practice schedules/environments need to include variability to facilitate learning?
- Variability introduced by an external agent normally at least an order of magnitude greater than the inherent movement variability (Ranganathan and Newell, 2013)
- Key issue!



Ranganathan and Newell (2013)

‘Extreme’ example
Differential Learning

- Contrast to deliberate practice
  - Never practice the same movement more than ‘*three* times’
- Introduce *random* variations into the movement

Appendix 1

Starting positions for the differencial learning group.

Lesson 1:
The skates parallel to the left with hips to the front.
Three point start.
With two hands on the ice with the skates in a V-shape.
The skates parallel to the right with hands and arms moved backwards.
The skates leaning on the outside with the right arm in front.
The arms beside the body and make a jump before the start.
The skates in a V-shape with the arms in front.
The left skate in front and look downwards.
All the weight on the hind leg with the hips to the back.
The hips to the back with one step to the right before the start.
Make a 180° turn before the start.

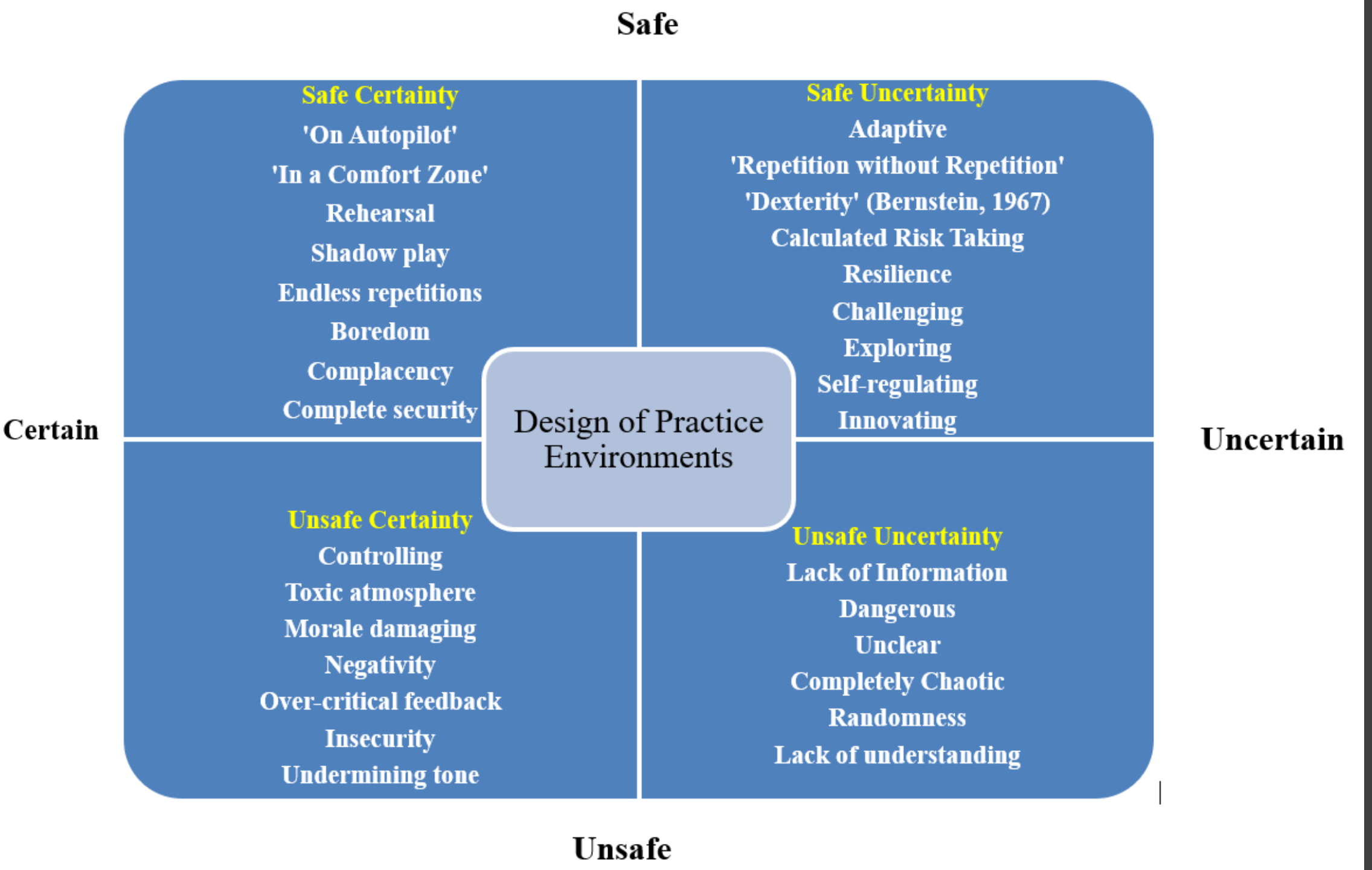
Lesson 2:
Approach skating on the left leg.
Straight knees with the skates leaning on the inside.
The hips to the front and back straight up.
Weight on the front leg and look to the end of the track.
Step to the left before the start.
The right leg in front with right arm in front.
Skates parallel to the track with upper body horizontal.
The right hand on the ice.
Make very small steps.
Put your skates as perpendicular to the track as possible while performing running action.
Make an initial large step.
Regarding arm movement, only make use of the forearms.
Do not move the arms.
First step parallel to the track.

Lesson 3:
Knees bent and weight in the centre.
Take big steps.
Left foot in front with right arm behind.
Make wide steps.
Make narrow steps.
Take the first step very small.
Skates parallel to the left with hips to the front.
The left hand on the ice with right foot behind.
The right foot and left arm in front.
The skates parallel to the right with knees bent deep.
Both arms in the air.
Tap one skate with the other before the start.
Perform a pirouette before the start.
Touch a skate with one hand before the start.
Feet close together.

Differential Learning Skating start (Savelsbergh et al., 2010)

Manipulating constraints to introduce variability

Manipulating constraints to introduce *uncertainty*


Safe
Safe Certainty
'On Autopilot'
'In a Comfort Zone'
Rehearsal
Shadow play
Endless repetitions
Boredom
Complacency
Complete security
Safe Uncertainty
Adaptive
'Repetition without Repetition'
'Dexterity' (Bernstein, 1967)
Calculated Risk Taking
Resilience
Challenging
Exploring
Self-regulating
Innovating
Certain
Design of Practice Environments
Uncertain
Unsafe Certainty
Controlling
Toxic atmosphere
Morale damaging
Negativity
Over-critical feedback
Insecurity
Undermining tone
Unsafe Uncertainty
Lack of Information
Dangerous
Unclear
Completely Chaotic
Randomness
Lack of understanding
Unsafe

Take home messages

- Variability is inherent in human movement
- Variability in outcome and performance should not be interpreted the same way
- Adaptive movement variability can be functional
- There are important implications for practice environments

Thank you

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