Learning to Sprint:
The Art of Coaching Meets the Science of Motor Learning

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OBJECTIVES

- Discuss a technical model for sprinting from a dynamic systems perspective
- Discuss an error model for sprinting from a dynamic systems perspective
- Discuss a constrain-based coaching model with emphasis placed on instruction/feedback and practice design

01

Linear Speed: Technical Model

- Coordination
- Absolute Speed

Technical Model: Coordination

co·or·di·na·tion:

Patterning of head, body, and limb movements relative to the patterning of environmental objects and events (Turvey, 1990)

Coordination: Dynamic Systems

- Describes the control of coordinated movement that emphasizes the role of information in the environment and dynamic properties of the body/limbs
- Views the process of human motor control as a complex system that behaves like any complex biological or physical system
- Concerned with identifying laws (natural and physical) that govern changes in human coordination patterns

Coordination: Dynamic Systems

- Attractor State (Motor Program Equivalent):
  - A *preferred behavioral state* that is said to be *stable* or homeostatic
  - Occurs and can change in response to *constraints* within the human system, environment and/or task
- Self-Organization:
  - Spontaneous expression of a motor skill in response to specific tasks, environment conditions and biological capabilities (Attractor State)

Dynamic Systems: Sprint Considerations

- Biological:
  - Anatomy and Genetics
  - Mobility, Stability, Strength, Speed-Strength, and Speed
- Task:
  - High speed linear running
  - Decision making and reaction
- Environment:
  - Surface: Field, Court, or Track
  - Gravity as a constant

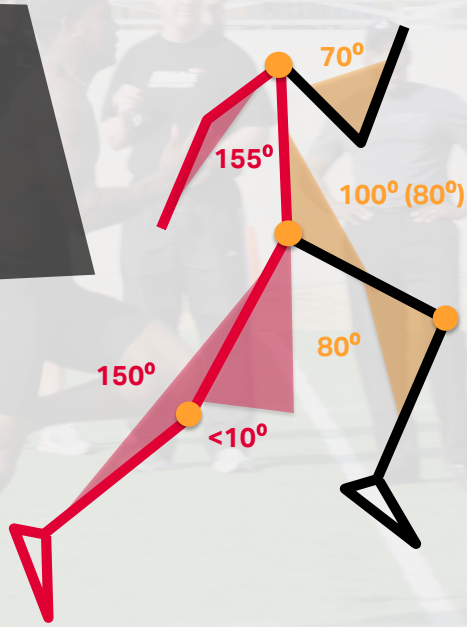
Technical Model: Absolute Speed


Technical Goal 1
Synchronize front and backside leg action with arm action in an effort to maximize the peak hip flexion achieved in the front leg


Technical Goal 2
Contact the ground as close to the center of mass as possible in an effort to minimize breaking forces and maximize vertical force

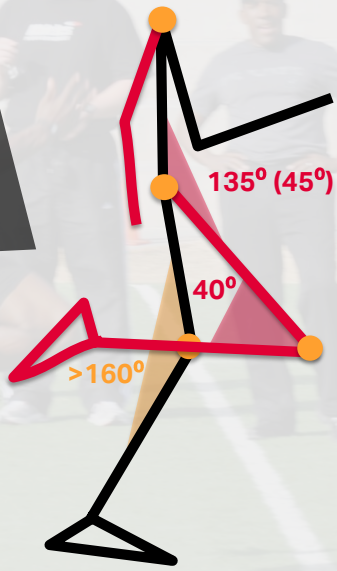
Critical Position 1: Take-Off
Stance Hip Extension: <10°
Stance Knee Extension: 150°
Recovery Knee Flexion: 80°
Recovery Hip Flexion: 80°

Arm Action:
Back Arm: 155°
Front Arm: 70-80°



Mann, 2011

Critical Position 2: Figure-4
Stance Hip Extension: < 20°
Stance Knee Extension: > 160°
Recovery Knee Flexion: 40°
Recovery Hip Flexion: 45°



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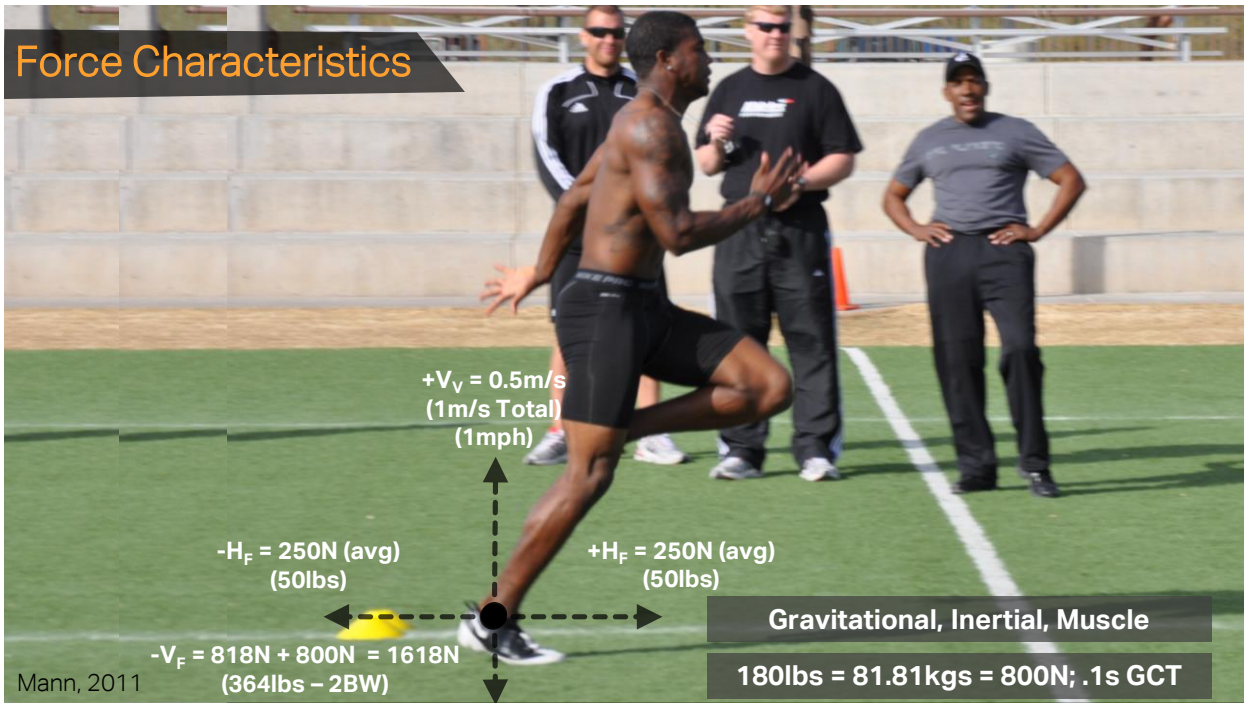
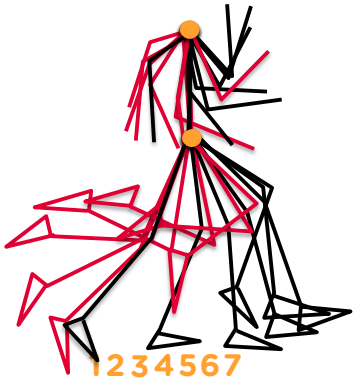
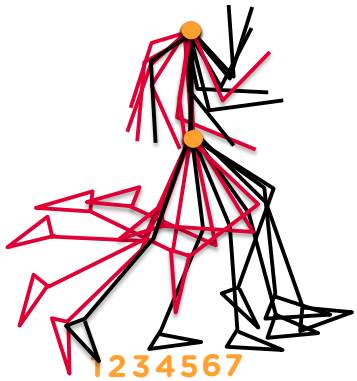






Characteristics:

- Frequency: 4.4-5 contacts/sec
- Length: 2.8-2.9yds
- Grd. Time: .087-.11s
- Flt. Time: .123-.127s

Mann, 2011

02

Linear Speed: Error Model

- Attractor States
- Absolute Speed

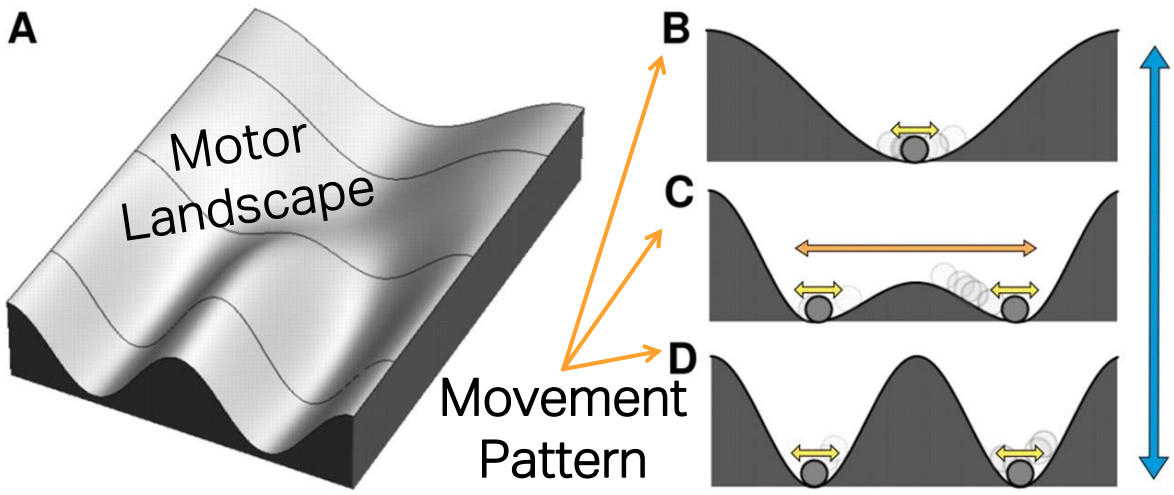
Error Model: Attractor States

Attractor States

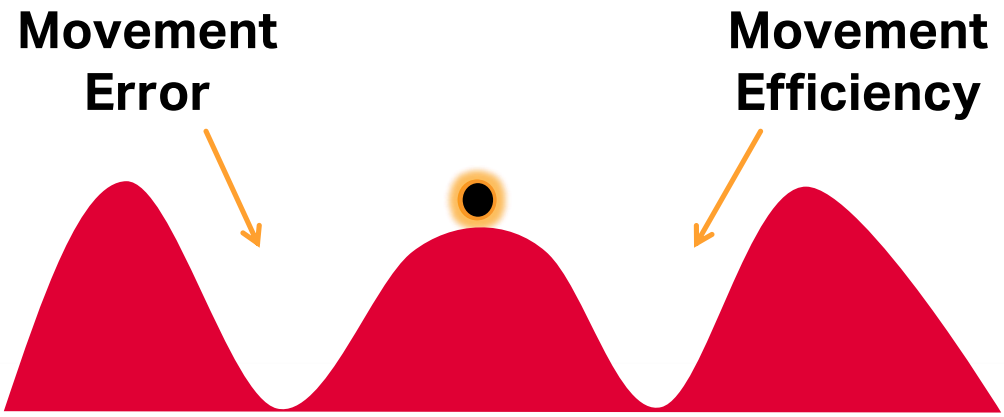
- Attractor:
  - A stable state of the motor control system that leads to behavior according to preferred coordination patterns

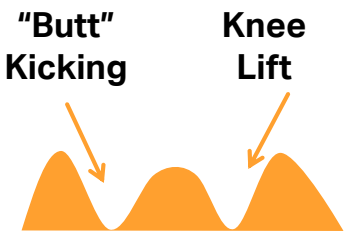
- Characteristics of an attractor:
  - Identified by order parameters (e.g., relative phase)
  - Control parameters (e.g., speed) influence order parameters
  - Minimum trial-to-trial performance variability
  - Stability – Retains present state despite perturbation
  - Energy efficient

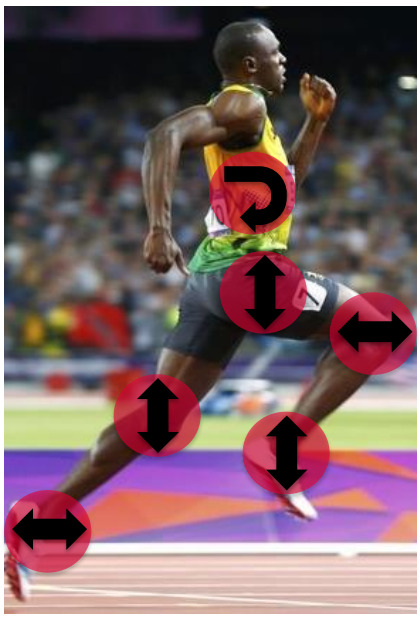
Attractor States

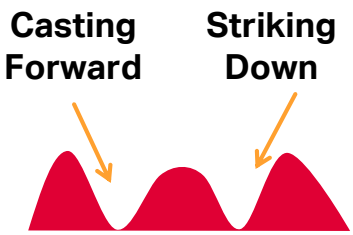


Attractors and Movement





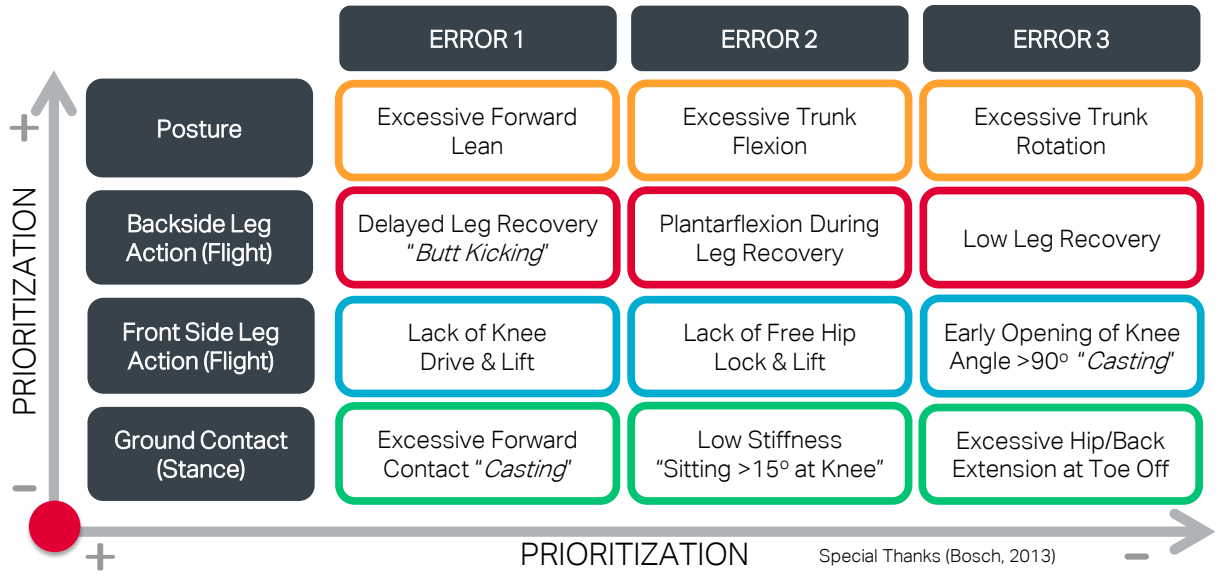




Error Model: Absolute Speed

Movement Error Model

Absolute Speed Error Model



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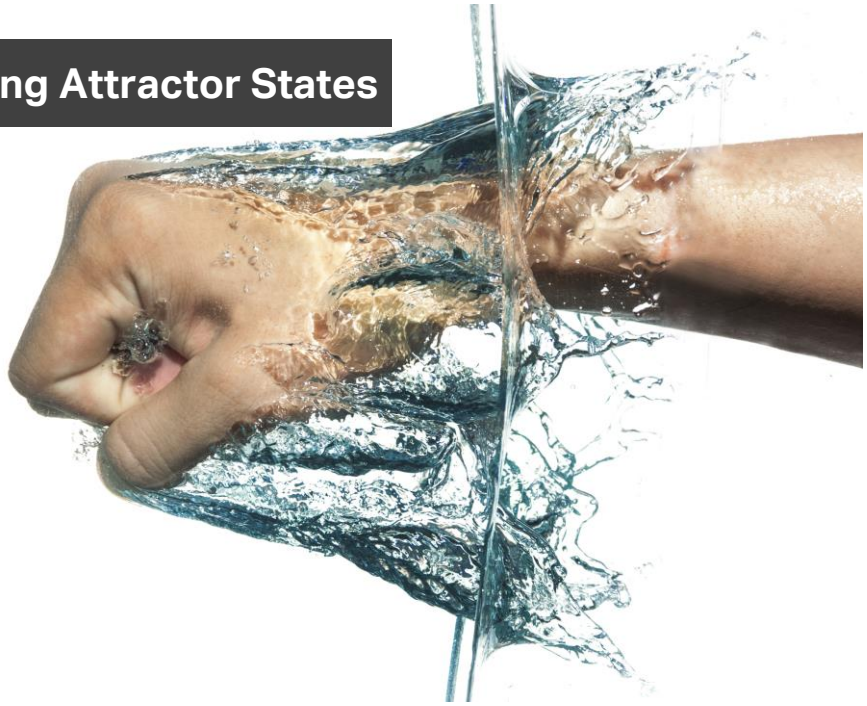
Linear Speed: Coaching Model

- Influencing Attractor States
- Instruction/Feedback
- Practice Design

Coaching: Influencing Attractor States



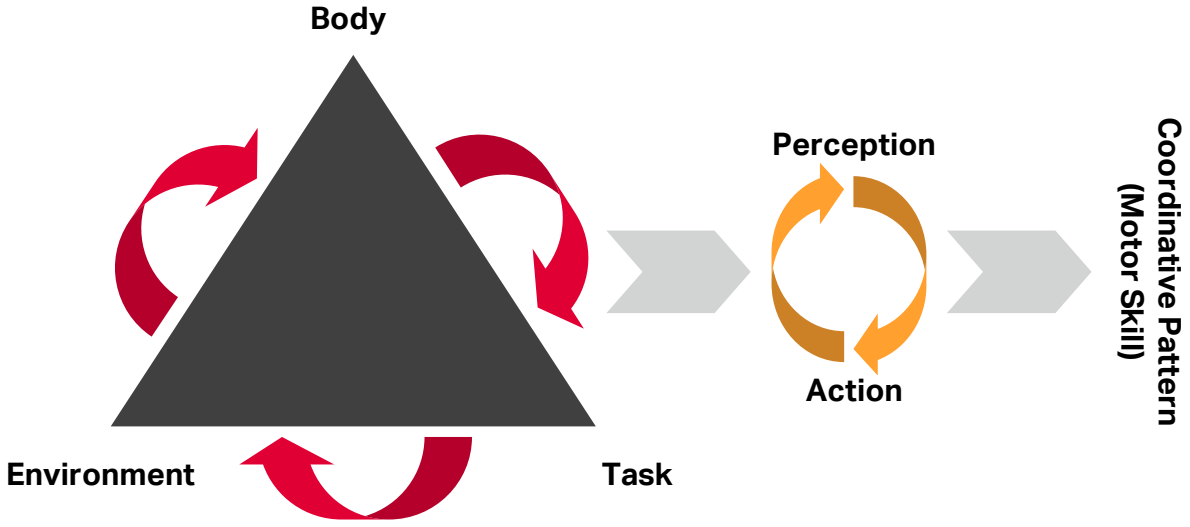
Influencing Attractor States

- The use of variability is critical to guide the motor system from a non-functional "stable state" to a functional "stable state"
- Drills can be designed to constrain or restrict an error, which allows for the possibility of a new movement pattern

Influencing Attractors

"Errors must become unstable for efficiency to emerge"

Self-Organization (Constraint-Based) Model



"The optimal pattern of coordination is determined by the interaction among constraints specified by the person, the environment, and the task" (Newell, 1986)

Adapted From: Davids, K., Button, C., and Bennett, S., 2008

Body Constraints

Position — Athletes ability to attain proper stability and mobility relative to the movements being performed

Pattern — Athletes ability to coordinate the limbs of the body relative to task and environment constraints

Power — Athletes ability to express the appropriate strength qualities relative to the movements being performed

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Task Constraints

Spatial — Manipulate the amount of space the movement can be performed in (e.g. Hurdle Distances)

Temporal — Manipulate the amount of time the movement can be performed in (e.g. jump mat or athletes racing)

Rules/ Equipment — Change the rules to constrain choices and/or introduce equipment to constrain the movement options

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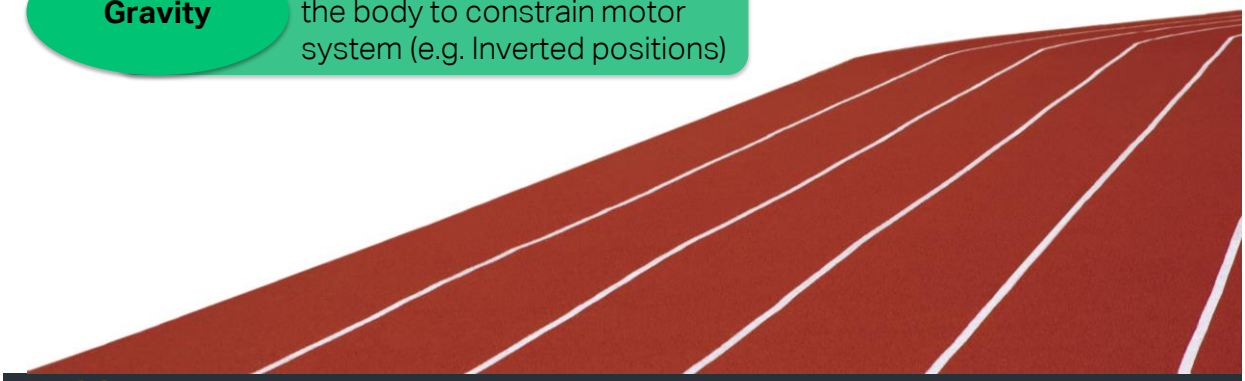
Environmental Constraints

Ground — Manipulate the surface to constrain motor system (e.g. sand, grass, and track)

Gravity — Manipulate the orientation of the body to constrain motor system (e.g. Inverted positions)



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Coaching: Instruction/Feedback

Verbal Instruction

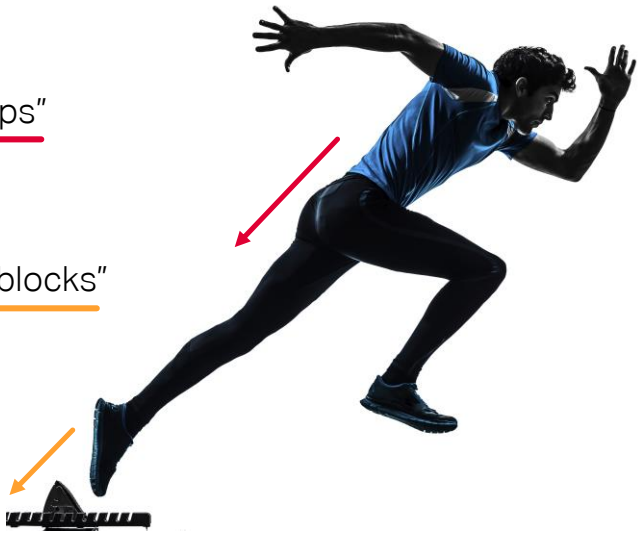
- Provide 1-2 focus cues to build awareness
- Limit unnecessary information ("Over-Coaching")
- Start and finish instruction with what you want versus what you don't want
- Focus attention externally on the outcomes opposed to internally on the body process

Verbal Instruction: Cueing

- Internal Cueing: Focused on "Body Movement"
  - Joint reference: "Squeeze your shoulder blades"
  - Muscle reference: "Squeeze your glutes"
- External Cueing: Focused on "Movement Outcome"
  - Environment reference: "Explode off the ground"
  - Outcome reference: "Jump as high as you can"

Internal vs. External Cueing Applied to Sprinting

- **Internal**
  - "Explode through your hips"
- **External:**
  - "Explode off the ground/blocks"

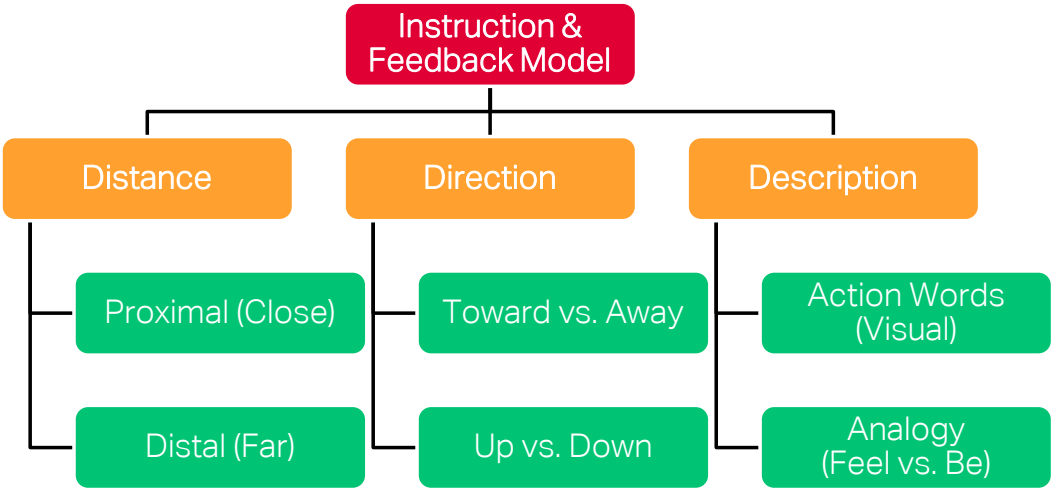


16 Years of research has shown that internal focus constrains the motor system, while external focus allows the motor system to self-organize efficiently to improve performance

(Wulf, 2012)

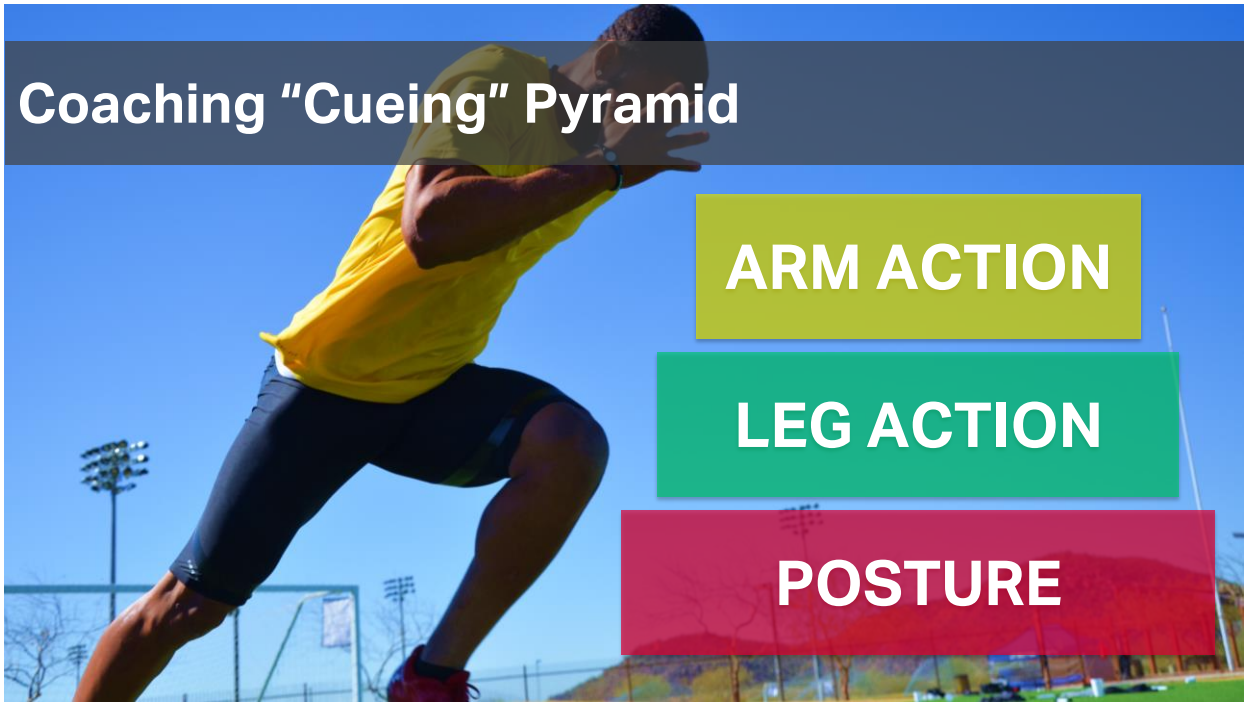
Instructional Coaching Model

"Cues should be mapped to desired biomechanics based on prioritized error"



Winkelman, 2014

Cueing Model: Absolute Speed


Coaching "Cueing" Pyramid
ARM ACTION
LEG ACTION
POSTURE


Posture
"Stand tall"
"Lean into the wind"
"Drive belt buckle forward"


Leg Action: Front
"High heels"..."Step over"
"Snap laces to the sky"
"Knees up"..."Explode glass"


Leg Action: Back
"Drive down through ground"
"Snap the ground away"
"Spin the earth"


Leg Action: Arms
"Hammer back"
"Snap down and back"
"Throw...*insert word*...back"


Putting It All Together
"Fight gravity and stay tall"
"Cycle action"..."Scissor"
"Stay on top of cyclical action"

In Sum:

- Instruction should guide not prescribe
- Provide feedback on outcomes over process
- Say the most with the least
- Ask a question before you provide an answer
- What you want vs. what you don't want

Coaching: Practice Design

Practice Design

- Goal
  - Optimize learning and retention in an effort to reach maximum transfer to the sporting environment

- Key Terms
  - Practice Variability
  - Contextual Interference
  - Differential Learning

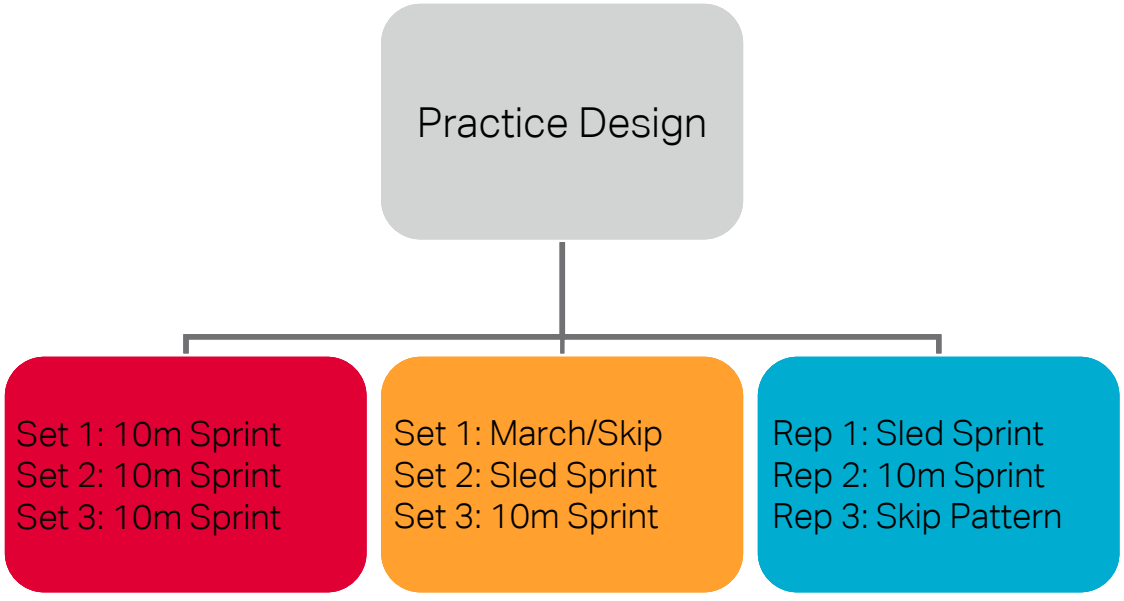
Practice Design

- Practice Variability:
  - The variety of movement and context characteristics a person experiences while practicing a skill

- Contextual Interference (CI):
  - The memory and performance disruption that results from performing multiple skills or variations within the context of practice

- Contextual Interference Effect (Battig, 1979):
  - Learning benefit from performing multiple skills in a high CI practice schedule (i.e. Random), rather than skills in a low CI practice schedule (i.e. Blocked)

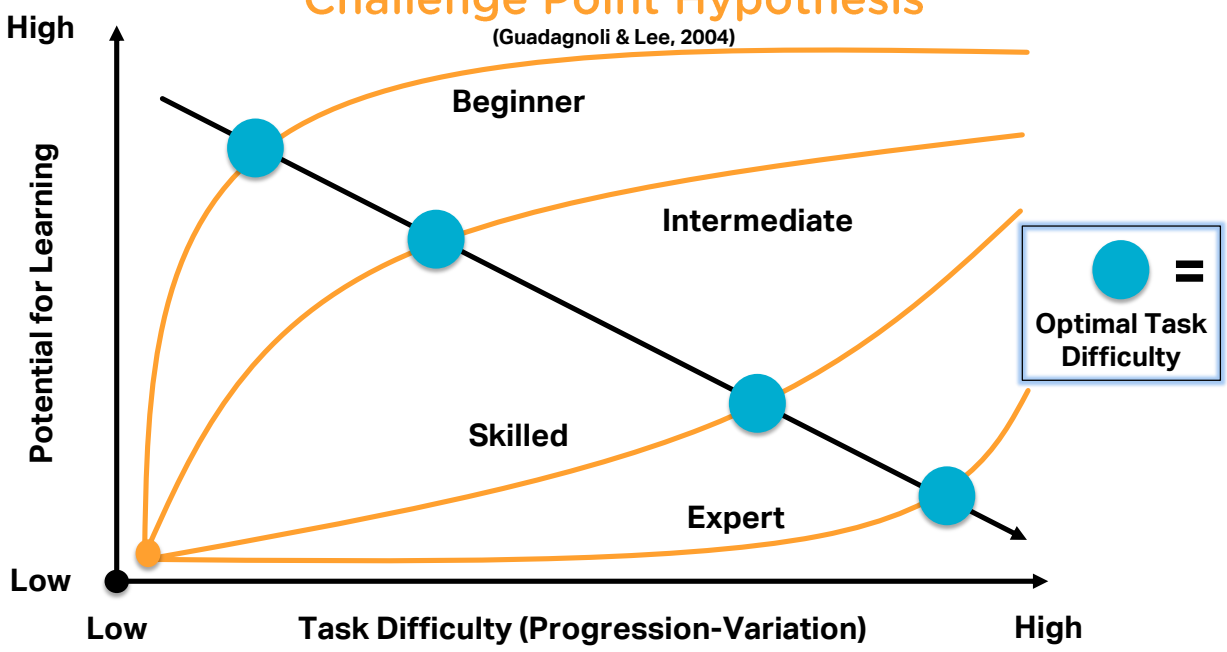
Contextual Interference Applied



Differential Learning

- Schöllhorn introduced differential training to improve skill acquisition
- Differential training:
  - "noise" (random irrelevant movements) is introduced during practice of a target skill
- Differential training induces continuous changes in movement executions by avoiding repetitions, removing corrective instructions and emphasizing discovery practice
  - Positive benefits of differential training (e.g. shot putting, soccer skills, basketball, hurdles, speed skating, and skiing)

Challenge Point Hypothesis



Fitts and Posner 3-Stage Model

COGNITIVE STAGE	ASSOCIATIVE STAGE	AUTONOMOUS STAGE
• Identify Objectives	• Associate with Cues	• Subconscious/Auto
• Self-talk/Questioning	• Refining/Consistent	• Multiple Tasks
• ↑ Errors/Variability	• ↓ Errors/Variability	• ↓↓↓ Errors/Variability
• Instruction/Feedback	• Identify/Correct Errors	• ↑↑ Identify/Correct Error

Practice Timeline

(Fitts and Posner, 1967, Davids et al., 2008, and Magill, 2011)

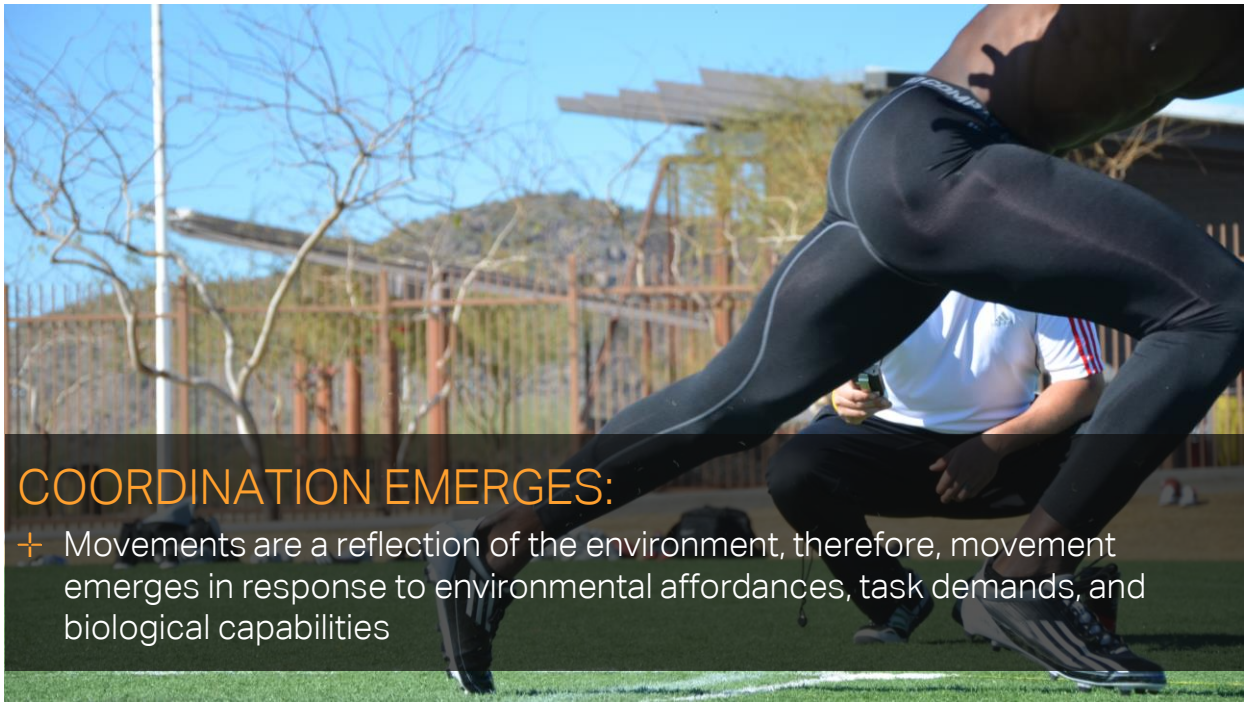
In Sum:

- Drills create context for athlete understanding
- Drills should create affordances that allow optimal technical changes to emerge
- Drills should be self-limiting, which allows errors to become variable to change

"Let the drill do the talking and the athlete do the walking"

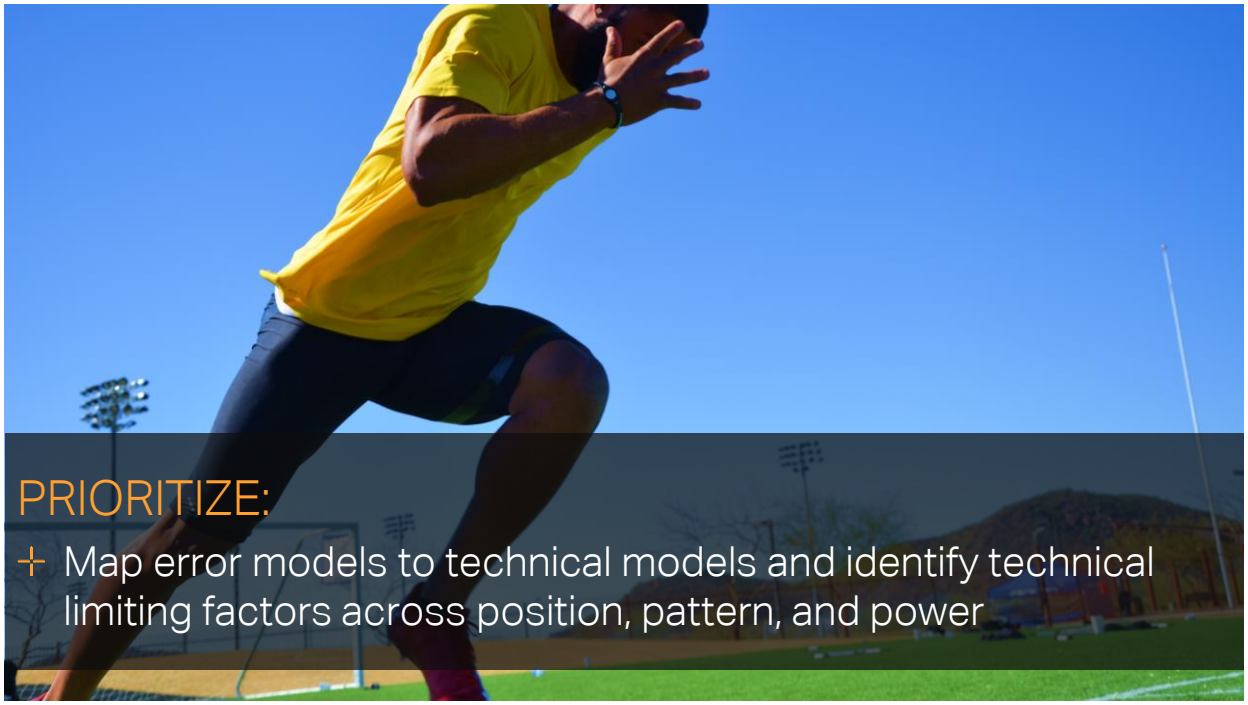
04

Linear Speed: Conclusions



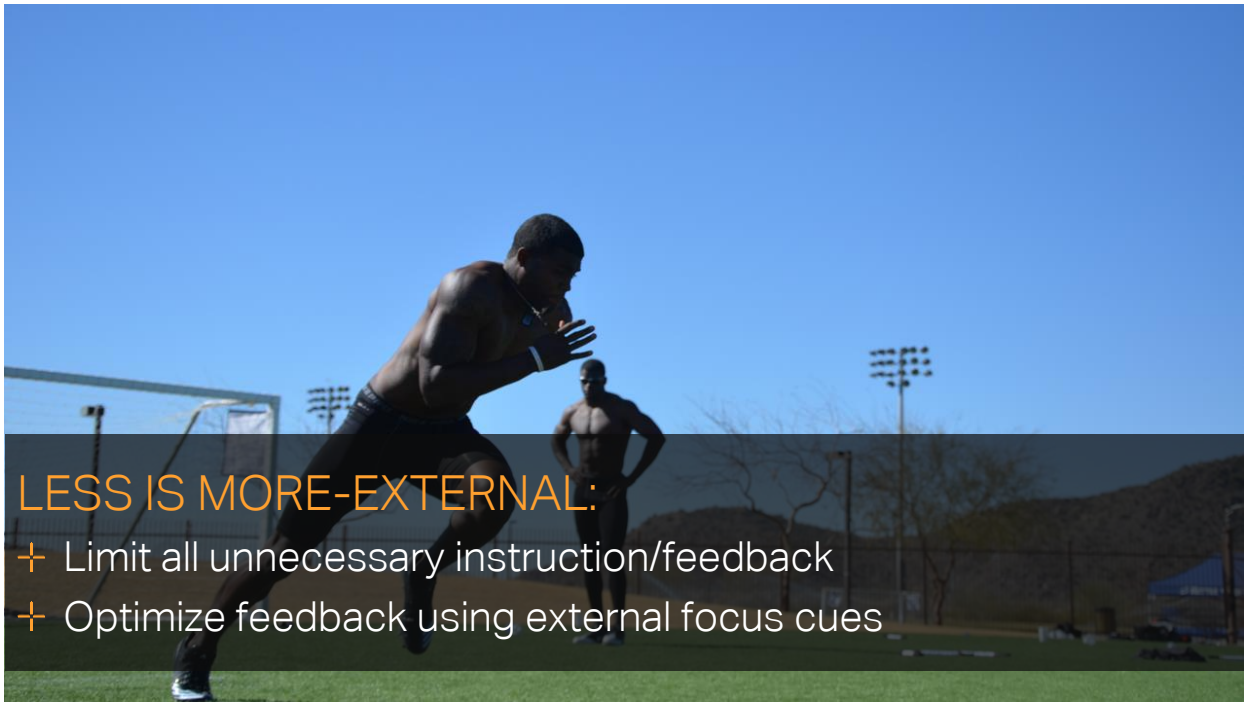
COORDINATION EMERGES:

- Movements are a reflection of the environment, therefore, movement emerges in response to environmental affordances, task demands, and biological capabilities



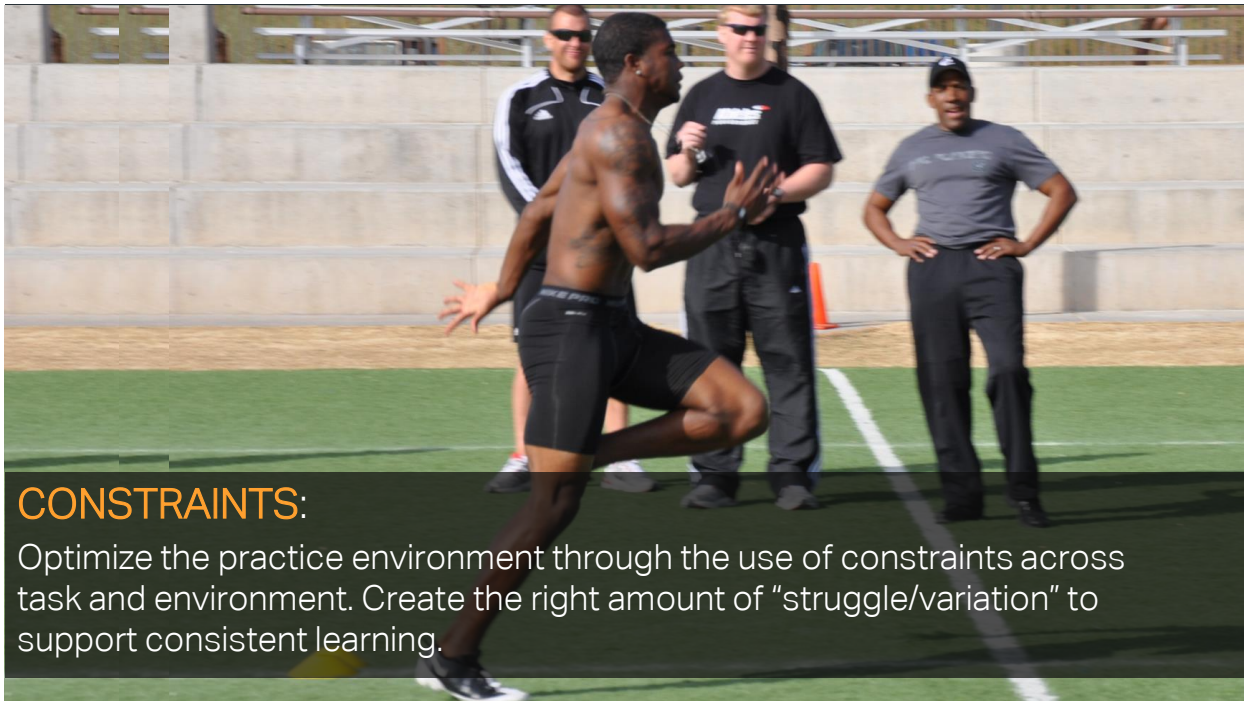
PRIORITIZE:

- Map error models to technical models and identify technical limiting factors across position, pattern, and power



LESS IS MORE-EXTERNAL:

- Limit all unnecessary instruction/feedback
- Optimize feedback using external focus cues



CONSTRAINTS:

Optimize the practice environment through the use of constraints across task and environment. Create the right amount of "struggle/variation" to support consistent learning.

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