Practice Variability & Contextual Interference
Variability in practice conditions is important for learning motor skills.
PRACTICE VARIABILITY

- Refers to the variety of movement and context characteristics the learner experiences while practicing a skill.
  - Key predictor according to motor program theory (Schmidt) of successful future performance
  - Dynamic pattern theory stresses the learner’s needs to explore and discover which increases there potential to perform.
Practice variability hypothesis

- Learning is the greatest when one performs the skill in a variety of ways and/or contexts rather than one way and/or one context.
BENEFITS OF PRACTICE VARIABILITY

- Increases the capacity to perform the skill in a future test situation
Variability Hypothesis Support

- Shea & Kohl studies compared constant to variable practice conditions in producing force.
- Shoenfeld et al basketball freethrow study comparing constant to variable practice conditions.
- These studies and others results involving retention and transfer tests confirmed the variability hypothesis.
Shea & Kohl (1990, 1991) Studies

- **Goal:** Participants applied 175N of force to press a handle.

- **Method**
  - **Constant group:** 289 trials reproducing the 175N force
  - **Varied group:** 4 different forces (125, 150, 200 & 225 N)

- **Retention Test**
  - **Varied group** performed more accurately than the constant group.
Shoenfelt, Maue, McDowell, & Woolard (2002) Study

Purpose: Accuracy of basketball free throws

Methods:

- Constant group
  - Free Throw shooting on the line
- Variable practice group 1
  - Front and back of the line
- Variable practice group 2
  - Front, Back, and on the line
- Variable practice group 3
  - Random (left and to right of the key, top of the key, etc)

Retention Test

Constant group increases by 1% whereas the varied groups increased from 2.4% to 10.9% in their accuracy
IRONY OF PRACTICE VARIABILITY

- Practice variability will produce more performance errors during practice or learning.

- But research shows that the learner is more accurate when performing a future novel transfer task (Edwards & Lee, 1985).
Implementing variability

- Step 1: Assess the nature of the skill
  - Is it an open or closed skill?
- Step 2: How is the skill used in real life?
  - How is the skill used in the sport?
- Step 3: Systematically introduce variations in regulatory conditions, non-regulatory conditions, or both.
Implementing Practice Variability

- Regulatory conditions
  - They are needed or critical to the performance
  - Directly influence the pattern of the movement

- Nonregulatory conditions
  - Indirectly influences the pattern of movements
  - May influence one’s degree of success
Examples of regulatory conditions

- Learner’s or clients positions prior to and during performance
- Speed of the ball
- Trajectory of the ball
- Height of the net
- Distance of the shot
- Size and shape of the ball
- Width of balance beam
Examples of non-regulatory conditions

Performer’s fatigue level
Heckling of the fans
Number to attempts in shooting
Shooting with players in the lane or not in the lane
Sunlight
Temperature
Clothing
Performing in front of spectator and not in front of spectators.
HOW SHOULD ONE PRACTICE A CLOSED SKILL?

- Depends on degree of *intertrial variability* of physical context and skill
Practicing a closed skill

- Closed skills that do not involve intertrial variability of regulatory conditions, nonregulatory conditions may be novel.
  - For practice, regulatory conditions should remain constant, but nonregulatory conditions should vary according to expectations for the test situation.
Practicing a Closed Skill

- Closed skills that do involve intertrial variability, both regulatory and nonregulatory are likely to be novel in the test situation.
- For practice, both the regulatory and nonregulatory conditions should be varied.
HOW SHOULD ONE PRACTICE A OPEN SKILL?

- “Practice needs to include experiences with regulatory characteristics that change from one attempt to another.”
  - Each performance of an open skill is unique, certain characteristics are new to the performer.

- The performer needs to modify previously produced movements in order to achieve the goal of the skill.

- In practice, variety of experiences with both regulatory and nonregulatory conditions that change from one attempt to another is needed.
Practice Design
ORGANIZING VARIABLE PRACTICE

- Variable practice can involve more than one skill in a practice session
- One way to solve this practice schedule problem is to understand the concept of *contextual interference*
- *Contextual interference* is the interference that results from practicing various skills within the same context of practice
## Contextual Interference Practices

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CONTEXTUAL INTERFERENCE EFFECT

- High contextual interference results in better learning of the task variation than a low amount
- Low contextual interference inhibits performance in novel performance contexts
Shea & Morgan (1979)

- First study about contextual interference
- Participants practiced on 3 variations of movement patterns of knocking down blocks.
  - One group followed Block practice design
  - One group followed Random practice design
- During practice the random group made more errors but out performed the block practice group on a retention test.
CONTEXTUAL INTERFERENCE EFFECTS OUTSIDE THE LAB

- College women in random practice of three badminton skills outperformed the blocked practice group (Goode & Magill)
  - Significance of this study was it involved beginners.
- Baseball hitters in random practice of three types of pitches outperformed the blocked practice schedule (Hall & Others)
  - Significance if this study was it involved high skilled
- Other studies in basketball, tennis, volleyball and rifle shooting found similar findings.
Physical Therapy Example

- Hanlon (1996) rehab study with hemiparetic arm patients comparing random to block practice schedule.
  - 24 adult patients with chronic hemiparesis caused by a stroke
  - 5 step movement was performed
  - Method
    - Random schedule involved 10 trials per session per day until the participant achieved criterion levels
    - Block schedule involved 10 trials per session per day until the participant achieved criterion levels.
    - NO Practice group (control)
  - Retention tests shows that random groups performed a 5-step sequence skill better than blocked practice group.
Contextual Interference & One’s Judgments

- Judgement about how much they are learning while we practice is referred to as “metacognition” (what we know about what we know).

- Participants who followed random practice schedule more accurately estimated their test performance where as participants who followed a block schedule overestimated their test performance.
Limits of Contextual Interference

- Challenge Point Hypothesis (Guadanoli & Lee, 2004)
  - Random practice will be optimal for skills that are simple and less optimal for skills that are of the highest difficulty.
  - Random practice will be more effective for highly skilled individuals and lower level of contextual interference is more appropriate for beginners.

- Skills that are similar in relative time, random practice is better. Skills that are different in relative time, lower contextual practices may be better.
Amount of Contextual Interference Effect

Low

- Nonrepeated blocks of trials of each task variation
- Serial repetition of short blocks of trials of each task variation

High

- Random repetition of short blocks of trials of each task variation
- Serial order of trials of all task variations
- Random order of all tasks variations
Practitioner’s View

When several variation of the skill must be learned, the best course of action would be to select a practice that is moderate to high in contextual interference.

- If the person does not respond well to this practice, one needs to modify the practice that is lower in the amount of contextual inference until they require the basic movement patterns of the skill variations.
- One should only base the effectiveness of practice on retention or transfer and not on practice performance.
WHY DOES THE CONTEXTUAL INTERFERENCE EFFECT OCCUR?

- Elaboration hypothesis (Morgan, 1979)
  - Random practice engages one in more strategies
  - Performer retains in working memory all the skill variations
  - Performer develops a memory representation of the skill

- Action plan reconstruction hypothesis
  - Random practice requires performers to reconstruct an action plan for each practice trial
  - Performer engages in more problem solving
In Summary

- Two important learner-related characteristics are associated with contextual inference:
  - Higher levels of contextual interference involve greater attention demands during practice than lower levels.
  - People who practice according to blocked schedule then to over estimate how well they are learning during practice.
Practice Specificity

- One of the oldest principle of human learning

- Most practitioners are faced with a common dilemma.....design a practice that best prepares the learner or client to perform in a future “test” or “criterion condition.”
Practice specificity

- Franklin Henry 1960’s basic assumption is that every skill requires special underlying abilities that are independent and task specific and that individuals have varying levels of many motor abilities, that is required to perform successfully.
  - *therefore the conditions in practice and “test” should be similar.*
Different types of specificity

- Sensory and motor specificity
- Context specificity
- Cognitive Processing specificity
Sensory & Motor Specificity

- Learning a motor skill is specific to the sources of sensory/perceptual information available during practice.
  - Let’s say early in practice the performer used visual information primarily to learn a skill.....What would happen to one’s performance on a retention or transfer test that required him or her to performing the skill without visual information?
    - It’s not surprising that the performer did worse.
    - Once it was restored, performances improved.
  - Why was performance affected when vision was removed?
    - People prefer to use the same motor program that they used to learn the task (Proteau’s Hypothesis)
Context Specificity

- During practice we encode information about the skill(s) to perform.
- In a “test” situation we attempt to retrieve the information encoded so we can perform the skill.
- More similar the practice context is to the text context the greater the retention.
- This association between encoding context and retrieval context has become to be know as the encoding specificity principle.
- Practical example:
  - Home field advantage. Playing on one’s home field or arena has many encoding & retrieval contexts that are similar between practice and the “game,” But as many when one playing a does not at home. This may be the reason why playing a home results in more wins.
Wright & Shea’s Encoding Specificity Studies

- In these studies subjected learned 3 or 4 digit sequences of key presses on a keyboard.
  - Each key had a number and were color coded.
  - The subject’s learned the number sequences.
  - But not only did the subject’s learn the numbered sequences (intentional remembering) but also was able to remember the color of the key (incidental remembering).
Intentional & incidental remembering

*Intentional remembering* is where I refer you to exact information about the performance or situation I want you to remember.

*Incidental remembering* refers to information that you remembered that was nonessential parts of the performance or situation.

e.g. I ask you to estimate the speed of your serve in tennis. One can also report the speed (intentional) but also where the ball landed in the serve (incidental).
Importance of Wright & Shea’s Key studies

- People learn more about the context than they are explicitly instructed to learn.
- Incidental parts of the contexts are used by the people as cue to remember the intended parts.
- Home field advantage: Player’s home context includes many more incidental and intended remembering parts than not playing at home.
- Implication from these studies:
  
  *One should include as many features of the test context into the practice context.*
Cognitive Processing Specificity

- Transfer-appropriate processing (TAP)
- Assumption is that each skill requires their own unique cognitive processes that relate to performing that skill.
- Best practice is when the person is learning a skill in practice that requires the same cognitive processing that will be required in “test” situation.
Cognitive Processing Example

- The game of soccer requires fast decision making by the players.
  - The coach designs a “mini type game” situations that requires the player to make the same quick decisions when to pass or kick they would make in the game.
  - Another coach design drills in passing and kicking that are repetitive and sequential but does not require the decision time as compared to how passing and kicking is executed in the game.
Practice variability vs. Practice specificity

These two concepts seemly conflict with each other but:

◆ Practice variability relates to movement characteristics of the skill performed in practice

◆ Practice specificity relates to practice characteristics.

Bottomline. If we apply practice specificity principles to learning a motor skill, the typical result(s) is/are the skill(s) improves in practice but poor adaptability results if it does not include practice variability.
Example

- The basketball coach designed a set of rebound and fast brake drills.
- The basketball coach had his/her player perform many repetitions of the skills above in the drill until they reached a criterion level set by the coach.
- In all the drills the coach was careful to design the drill so that the decisions made, the practice context, and visual information were similar to the game.
- The coach did one last thing. He or she changed how rebounding or the transitions of fast brake occurred on every trial of the drill. This was to assure that the player could adapt their performance to changes within the game.
Summary & Application

- Performing the skill to be learned in a variety of ways maximizes performing it in future test situation or real life situations.
- Assess how the skill is to be performed in real life situations then develop practices that match the context, cognitive processes and sensory information and provide variation in practice.
- Early in learning or relearning a skill start with blocked practice then once they attain a degree of success move them to serial and/or random practice.
Summary & Application

- Practice specificity improves the skill but does not assure one that the performer will be able to perform the skill in a real life or game situation.
- Best practices or learning occurs when one applies practice variability, contextual interference, and practice specificity.
Practice Organization
Rehabilitation Example
Patient (True Story)

- Male
- 45
- Automobile injury (Femur & Lumbar Fractures)
- Closed Head Injury (3 months – Coma)
Assessment

- Rivenead & Gait Assessment
  - Gait
  - Transfer skills
Gait

- Regulatory
  - Heel to toe
  - Narrow base of support
  - Arms in opposition
  - Toe straight and forward (not in or outward)

- Non regulatory
  - Walking surface (carpet, hardwood floor)
  - Weight bearing (treadmill, full weight bearing)
  - Obstacles (around objects of different sizes)
  - Carrying objects while walking
  - Walking paths
  - Assisted or non assisted
Transfer Skills

- Up and down stairs
- Sit to Standing
- Stand to Sit
- Out of bed to standing
- Prone position to standing
How are these skills performed in real life?

In what ways? (practice variability)

In what environmental situations? (context specificity)
Practice Variability

- Walking (Closed)
  - Long Pole (assisted)
  - Walking on treadmill at the same speed
  - Floor grid walking
  - Walking on the same surface in the clinic
  - Walking path the same
  - Walk while carrying a 5 lbs bag

- Walking (Open)
  - Walking at different speeds
  - Walking on different surfaces
  - Walking around objects of different sizes
  - Walking paths vary
  - Walking carrying different weighted objects
  - Unassisted walking
Practice Variability

- Transition Skills (closed)
  - Same surface
  - Same chair height
  - Chair with arm rests
  - 3 step stair
  - Steps the same height
  - Same bed

- Transition Skills (Open)
  - Vary surfaces
  - Vary chair heights
  - Chairs with or without arm rests
  - Stair in hallway and outside
  - Vary softness of bed
Practice Specificity

Gait Situations
- Alone
- Among a crowd
- When it is dark?
- Across a busy intersection?
- At home? Work?

Transitions Situations
- Early in the morning after sleep
- Eating/dining
## Contextual Interference

<table>
<thead>
<tr>
<th>Blocked</th>
<th>Serial</th>
<th>Random</th>
</tr>
</thead>
</table>
| Gait (15 minutes) | Walking on treadmill  
Walking with poles  
Walking unassisted  
Walking Stairs  
Sit to stand  
Stand to sit  
Prone to stand  
Bed to Stand | Stand to Sit  
Walk with Poles  
Walk Stairs  
Pone to Stand  
Walk on Treadmill |
Practice Organization

Physical Education Example
8th Grade Baseball/Softball Unit

- Middle School
- Co-ed Population
- 8th Graders (14-15 years of age)
- Physical Education Teacher
  - Introduce the situations of play
    - Stealing a base
    - Situations (runners on 1 & 3 with 1 out, bases loaded with no outs, runner on first with no outs, runner on 3rd base with 0 or 1 out)
  - Assess Hitting and Fielding*
Hitting

Regulatory Conditions
Stance
Weight Shift
Hips then Shoulder then arm extension
Timing

Non Regulatory Condition
# of balls hit
Type of pitcher
Speed of the pitch
Color of the ball
Bat length
Weather
Location of ball
Players on based or not on based
Count
Fielding

- Regulatory
  - Ready position
  - Seeing the ball come off the bat
  - Transportation of limb
  - Retraction of the glove prior to ball contact
  - Grasp (catch)
  - Look & Set then throw

- Non regulatory
  - Player on based
  - Number of grounders or fly balls
  - Weather
  - Eyewear
  - Location of ball
  - Speed of ball
Situations: Specificity of Practice

- Regulatory conditions
  - Throwing
  - Fielding

- Non regulatory conditions
  - Stealing a base
  - Runners on 1 & 3 based on number of outs
  - Runners on 3 based on number of outs
  - Runner on 1st based on number of outs
  - Type of field
Practice Variability

**Hitting Closed**
- Same speed
- Same location
- Same delivery
- Same Environment
- Same swing

**Hitting Open**
- Vary location of ball
- Vary speed of the ball
- Different pitchers
- Practice under the lights or during the day
Practice Variability

Fielding (Closed)
- Same type of grounder or fly ball
- Same location
- Same Speed
- Same type of catch

Fielding (open)
- Different grounders or fly balls
- Different locations
- Different speeds
- Different type of catch
  - One handed
  - Two handed
  - Underhanded
  - Overhanded
## Practice Specificity

### Situation (closed)
- Same situation over and over with
  - Same speed
  - Same locations
  - Same strategy
  - Same number of outs

### Situation (Open)
- Different situations involving
  - vary locations
  - vary speed
  - vary the strategy
  - vary the outs
## Contextual Interference

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<td>Hitting off a lefty</td>
<td>Day 1 Situations</td>
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<tr>
<td>Catching (15 minutes)</td>
<td>Hitting off a righty</td>
<td>Hitting (lefty)</td>
</tr>
<tr>
<td>Situation (15 minutes)</td>
<td>Fielding a grounder</td>
<td>Fielding (grounders &amp; fly)</td>
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<tr>
<td></td>
<td>Fielding a Fly</td>
<td>Hitting (righty)</td>
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<td></td>
<td>Situations</td>
<td>Situations</td>
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The End