Progressive Gait Training:

Motor Learning Strategies and the Research

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Welcome

Motor Learning

Motor learning is the change in motor skill ability achieved through practice.

(Levac, 2013)

To learn a skill

- acquire and initially perform
- retain over time
- transfer to other settings/tasks

(Vialu, 2017)

Stages of Learning

Acquisition Fluency Generalization Adaptation

(Sues-Delaney, 2017) (Wright, 2009)

Task – movement performed

- Discrete – has beginning and end
- Serial (Complex) – group of discrete skills
- Continuous – no recognizable beginning/end

(Schmidt & Lee, 2011)

Task – environmental context

(Schmidt & Lee, 2011)

Feedback-Related Terms

Most-to-Least

- Full Physical Assistance
- Partial Physical
- Tactile Cue
- Modeling
- Direct Verbal
- Indirect Verbal
- Gesture
- Independent (natural cue)

(Sues-Delaney, 2017)

Most-to-Least

- Full Physical Assistance
- Partial Physical
- Tactile Cue
- Modeling
- Direct Verbal
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- Gesture
- Independent (natural cue)

Least-to-Most

- Independent (natural cue)
- Gesture
- Indirect Verbal
- Direct Verbal
- Modeling
- Tactile Cue
- Partial Physical
- Full Physical Assistance

(Sues-Delaney, 2017) (Fields, 2013)

How can our intervention promote learning?

- Research findings related to practice
- Research findings related to feedback

Practice

- What is practiced?
- When is it practiced?
- How is it practiced?

Practice

- What is practiced?
  - Specificity
  - Salience
- When is it practiced?
- How is it practiced?

Specificity

Practice of a particular skill primarily develops that skill.

Skilled motor practice induces response in that specific brain area.

(Perez, 2004)

Gait practice improves gait speed. Strength training does not.

(Moreau, 2015)

Salience

Of importance or relevance to the person.

"Sufficient motivation and attention are…essential to promoting engagement in the task." (Kleim, 2008)

"Task-specific training should be relevant to the patient/client and to the context." (Hubbard, 2009)

Practice

- What is practiced?
- When is it practiced?
  - Amount and Frequency (How much? How often?)
  - Practice Scheduling
- How is it practiced?

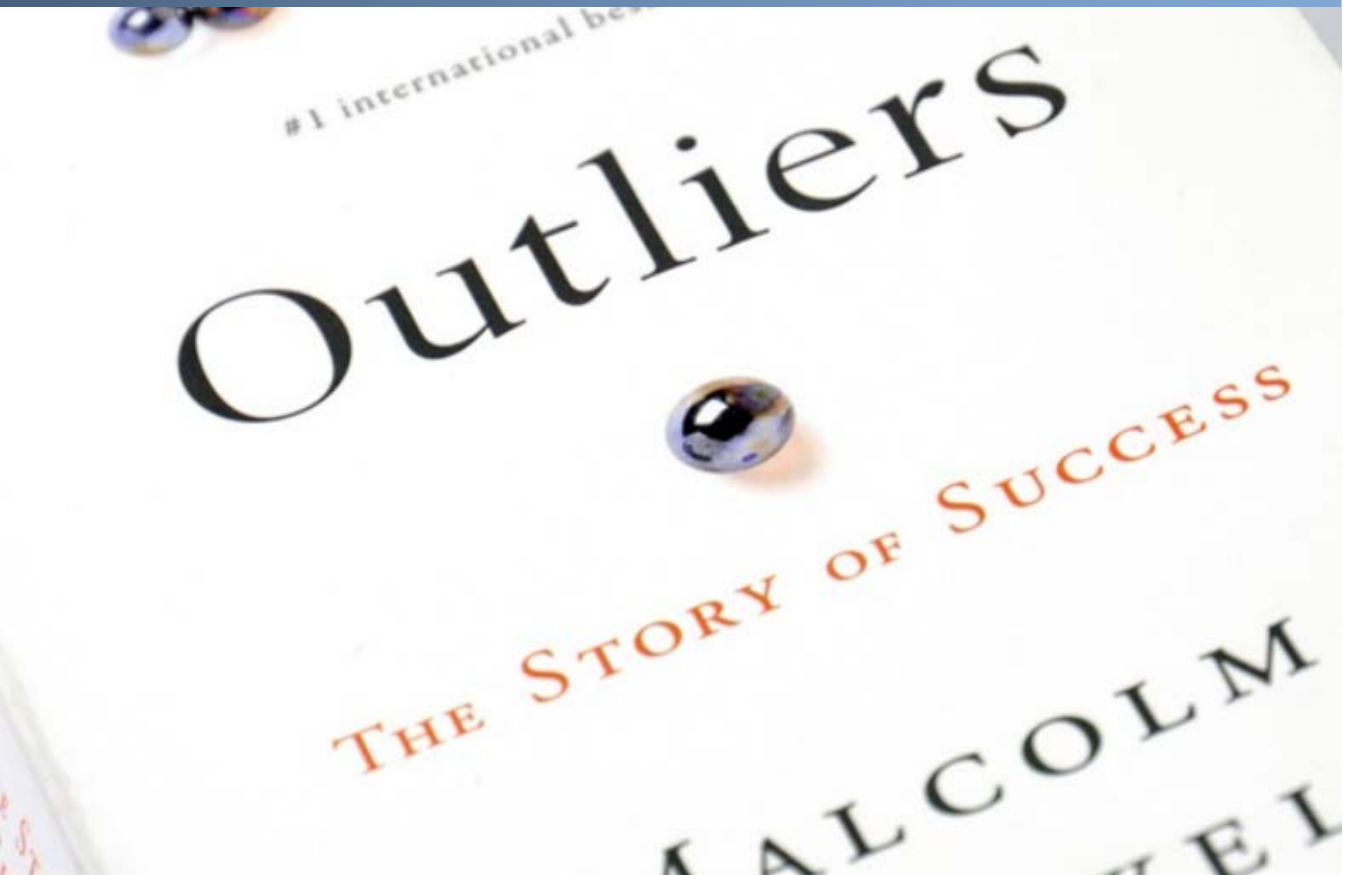
Amount and Frequency

More practice results in more learning.

"The most powerful way we can enhance skill acquisition: *increasing the amount of practice.*"

(Thomson, 2012)
(Thomson, 2005)

Outliers – Malcolm Gladwell



10,000 hours of practice

More than 2 ½ hours a day for 10 years

10,000 hours

Sheer amount or quantity of practice is one thing.

Are there ways to improve skills faster than simply practicing over and over?

How do you learn to walk?

Thousands of steps and dozens of falls per day.

"Immense amounts of time-distributed, variable practice constitute the natural practice regimen for learning to walk."

(Adolph, 2012)

Practice

- What is practiced?
- When is it practiced?
  - Amount and Frequency
  - **Practice Scheduling** (Massed versus Distributed)
- How is it practiced?

Practice Scheduling

How much rest between practice trials?

Massed practice

more time spent in practice (than rest)

Distributed practice

More time spent in rest periods (than in practice)

(Thomson, 2012)
(Thomson, 2005)

Practice Scheduling

Distributed practice results in better motor skill acquisition and retention.

(Donovan & Radosevich, 1999)

Practice Scheduling

For the same amount of actual practice, distributed practice requires more overall time.

(Thomson, 2012)
(Thomson, 2005)

Massed practice may be better for discrete tasks.

(Lee & Genovese, 1988)
(Panchuk, 2013)

Practice

- What is practiced?
- When is it practiced?
- How is it practiced?

Practice

- How is it practiced?
  - Variability
  - Difficulty
  - Part/Whole Practice
  - Transfer-Appropriate

Constant practice

same parameters in practice session

Variable practice

different parameters during a practice

(Vialu, 2017)

Blocked practice

drill one skill for many repetitions (before practicing another)

Random practice

randomly alternate between different skills during practice

(Vialu, 2017)

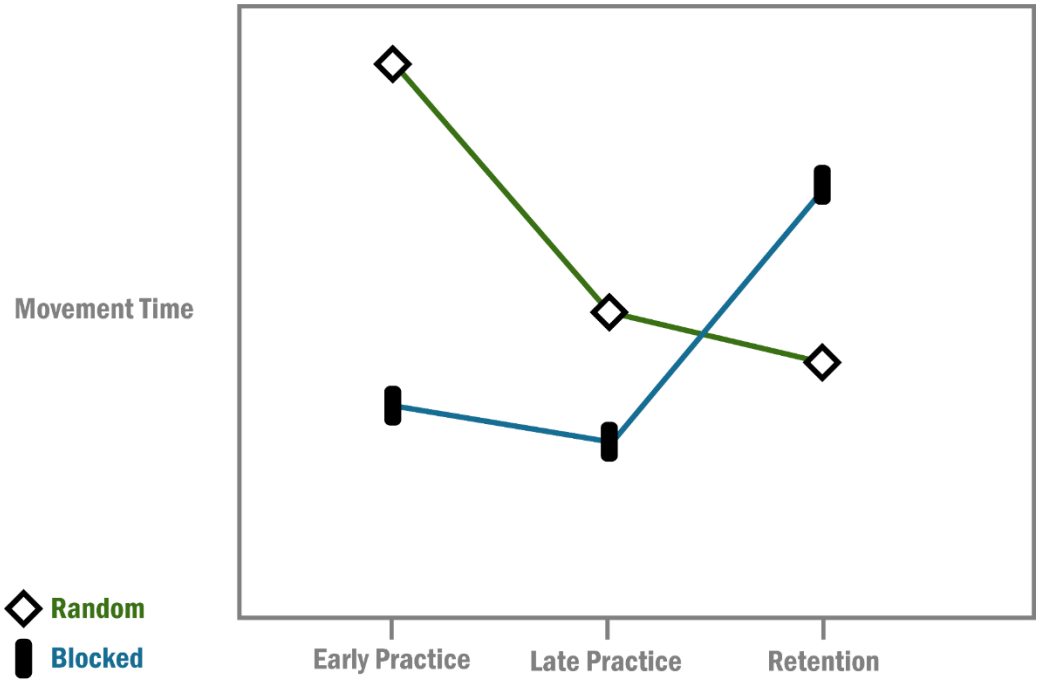
Blocked versus Random

- Acquisition (performance) is better with blocked practice
- Skill retention and transfer is better with random practice

(Thomson, 2005)

(Hanlon, 1996)

Blocked versus Random



(Thomson, 2012)
(Thomson, 2005)

Variable Practice

Variable practice improves transfer of learning: the performance in a new situation is better.

- **More performance error *during practice***
- **Better accuracy when performing a novel transfer task**

Contextual Interference (CI)

CI is the interference that results from practicing various skills within the same context of practice.

(Millslagle, 2014)

CI demands constant reconstruction of performance with slightly different solutions.

(Vialu, 2017)

Contextual Interference (CI)

High contextual interference (task variation) results in better learning.

Low contextual interference *inhibits* performance for novel task demands.

(Prado, 2017)

(Millslagle, 2014)

Can blocked practice improve retention?

For children, the effects of blocked vs random practice is less clear.

(Zwicker, 2009)

“Task variables and stage of learning are important determinants of CI effects…”

(Zipp, 2010)

Contextual Interference (CI)

For simpler tasks: better outcome with random practice.

For complex tasks: advantage of random practice is less.

(Guadagnoli & Lee, 2004)

Contextual Interference (CI)

For beginners, lower level of CI is appropriate.

For skilled individuals, random practice is more effective.

(Guadagnoli & Lee, 2004)

Practice

- How is it practiced?
  - Variability
  - Difficulty
  - Part/Whole Practice
  - Transfer-Appropriate

Difficulty / Problem-solving

The process of problem-solving results in effective learning.

(Repetition of a movement does not.)

(Thomson, 2012)
(Thomson, 2005)

Difficulty / Problem-solving

Factors

- **Skill level of the individual** age, experience, stage of learning
- **Task difficulty** movements required, context of environment
- **Support/feedback** assistance provided, instruction, correction

Challenge Point

"Motor tasks represent different challenges for performers of different abilities."

(Guadagnoli & Lee, 2004)

Challenge Point

Functional task difficulty

Difficulty due to

- **the ability level of the person performing the task**
- **the environmental context**

(Guadagnoli & Lee, 2004)

Challenge Point

Nominal task difficulty: Difficulty due to the characteristics of the task only

(Guadagnoli & Lee, 2004)

Challenge Point

Optimal level of challenge results in learning.

- **Too easy impedes learning**
- **Too hard impedes practice**

Maximize learning, while minimizing detriment to performance during practice

(Guadagnoli & Lee, 2004)

Difficulty / Problem-solving

In order to make progress, you have to be comfortable *with effort.*

The only time you are actually growing is when you're uncomfortable.

Just Manageable Difficulty Level

Challenging the skill development of the individual

But not making it *too* difficult

(Bidabe, 2016)

Practice

- How is it practiced?
  - Variability
  - Difficulty
  - Part/Whole Practice
  - Transfer-Appropriate

Part practice

learn parts of motor skill; then integrate to practice whole task

Whole practice

Learn entire skill as a whole

Part & Whole Practice

Field of Motor Learning

Task Complexity and Organization – Naylor and Briggs

Skill Classification – Schmidt and Wrisberg

Task Complexity

How many components to the task?

Low Complexity

High Complexity

(Naylor and Briggs, 1963)

Task Organization

Are the components inter-related/inter-dependent?

Low Organization **High Organization**

(Naylor and Briggs, 1963)

Task Complexity and Organization

Whole Practice for skill that is low in complexity and high in organization.

Part Practice for skill that is low in organization and high in complexity.

(Naylor and Briggs, 1963)

Part Practice - Example

Stroke patients: balance on hemiparetic limb

Results after balance training:

- **Patients bore weight more symmetrically**
- ***Did not increase*** **"single limb stance" duration time on paretic limb when walking**

(Winstein, 1989)

Part Practice - Advantages

- Simplifies the skill
- Experience early success to increase motivation
- Focus practice on problematic components (without wasting time on those already mastered)

(Eustache, 2016)

Part-Task versus Whole-Task

Consider:

- How complex is the task?
- What is the capability of the learner?
- Is the environment conducive or challenging?

Skill Classification

Task

Is the task discrete, complex, continuous?

Person

Does the task require cognitive involvement? motor involvement?

Environment

Is the environment “closed” or “open”?

(Schmidt & Wrisberg, 2008)

Part-Task versus Whole-Task

Learning parts of a task may be helpful during early stages of learning, but will not facilitate learning skill in context.

Whole-task practice results in better movement quality.

(Zwicker, 2009)

Part-task practice is of most value when combined with practice of whole task.

(Thomson, 2005)

Part-Task versus Whole-Task

- Segmentation (separate into segments to practice; then combine into sequence for further practice)
- Fractionalization (practice components separately, then combine to practice together simultaneously)
- Simplification (reduce the level of difficulty of task)

(Eustache, 2016)

Part-Task versus Whole-Task

Will whole-practice or part-practice be more likely to result in transfer of the whole skill?

"To better verify the empirical validity of recommendations for the use of whole and part practice, more studies are necessary."

(Fontana, 2009)

Practice

- How is it practiced?
  - Variability
  - Difficulty
  - Part/Whole Practice
  - Transfer-Appropriate

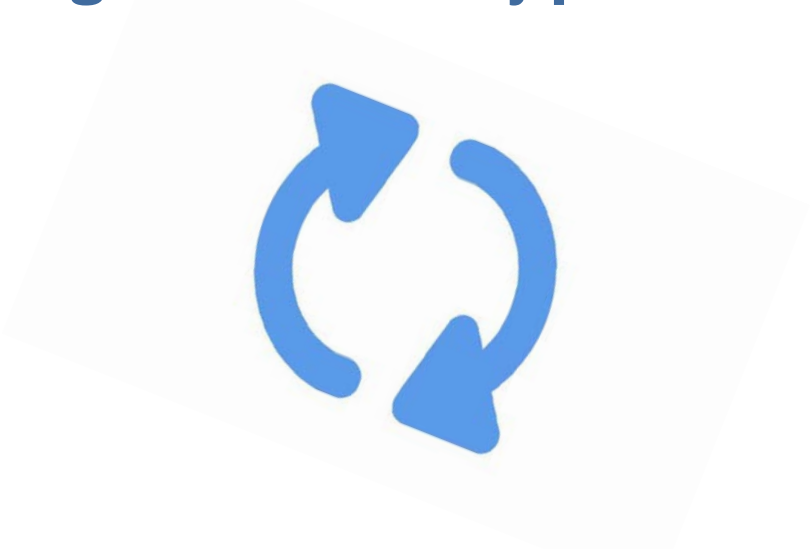
Transfer Appropriate Training

1. Analyze the task
2. Part-practice: practice the needed or missing components
3. Whole-practice: practice whole task
4. Transference of training: practice whole task *in natural contexts where it will be used*

(Thomson, 2005)

Practice / Feedback

Motor learning is enhanced by practice *and by feedback*.



Explicit learning

conscious, involves working memory, can verbally describe

Implicit learning

without awareness, without verbal knowledge

(Kleynen, 2015)

Implicit Learning

is possible regardless of age, intelligence, motor ability.

"Individuals with altered movement dynamics and compromised working memory can benefit from implicit motor learning."

(Steenbergen, 2010)

"Implicit motor learning interventions are recommended for individuals with cerebral palsy."

(van der Kamp, 2017)

Feedback

- **Intrinsic** (learner's own movement-sensory system)
- **Verbal Feedback**
- **Modeling**
- **Physical Guidance**

Feedback-Related Terms

Most-to-Least

Full Physical Assistance
Partial Physical
Tactile Cue
Modeling
Direct Verbal
Indirect Verbal
Gesture
Independent (natural cue)

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Partial Physical
Full Physical Assistance

(Sues-Delaney, 2017) (Fields, 2013)

Intrinsic Feedback

- Inherent in sensory/neuromotor system
- Occurs naturally as part of performing movement
- Not conscious
- *Promotes implicit learning*

Intrinsic Feedback

Therapist can structure task and environment to support movement goals.

(Gentile, 1998)

Verbal instructions and feedback are intentionally restricted.

(Kleynan et al, 2015)

Intrinsic Feedback

Enhance opportunities for task-intrinsic feedback to *promote implicit motor learning*.

External focus of attention (on outcome of task in environment)
Practice the whole skill in its entirety.

(Kleynan et al, 2015)

Extrinsic Feedback

- Augments and supplements intrinsic feedback
  - Verbal (instructions, cues, feedback)
  - Non-verbal (visual/modeling, physical guidance)
- Conscious
- *Promotes explicit learning*

Extrinsic Feedback

Augmented feedback

- "adds on" to the task-intrinsic feedback
- can help to speed the process of learning

How essential is it?

Depends on skill being learned, person learning skill, stage of learning

(Millslagle, 2014)

Extrinsic Feedback

Augmented feedback

- **the *type or content* of feedback and**
- **the *amount and timing* of feedback**

may have different effects on learning.

(Millslagle, 2014)

(Kleynan et al, 2015)

TYPE or CONTENT

Information on....

- process of movement (internal) – feedback/instruction
- outcome of movement (external) – feedback/instruction
- error – to facilitate learning
- success – to reinforce, motivate

AMOUNT / TIMING

Provided....

- consistently versus sporadically
- during, at end, or after the movement
- as a summary
- by reducing it over time
- only beyond a certain margin of error

CONTENT OF FEEDBACK

- Knowledge of Performance (KP)
- Knowledge of Results (KR)
- Internal vs. External Focus
- Errors vs. Correct
- Motivational (Praise)

AMOUNT/TIMING

- Consistent vs. Sporadic
- Immediate vs. Delayed
- Summary
- Faded
- Bandwidth

Knowledge of Performance (KP)

pertains to movement pattern characteristics, kinematic (internal)

(Schmidt, 1991)
(Young, 1992)

Knowledge of Results (KR)

pertains to movement outcome, relative to environmental goal (external)

(Salmoni, 1984)

Which is better? KP or KR

Both forms of feedback are valuable in skill learning.

(Millslagle, 2014)

(Bishop, 2018)

Knowledge of Performance (KP)

Verbal KP feedback about movement characteristics may be helpful when

- **a specific movement is required for a skill and/or**
- **movement is more complex**

(Millslagle, 2014)

Prescriptive KP

Tells exactly what to do correctly; limit error to help learning
Appropriate in early learning

Descriptive KP

Describes the movement; gives allowance for learner's processing
Appropriate once the skill is learned

(Millslagle, 2014)

Knowledge of Results (KR)

"Both KP and KR are important for learning, but more research has been done with the effects of KR on learning."

(Thomson, 2005)

- Feedback on skill outcome/goal achievement
- External only
- Not descriptive of process

Knowledge of Results (KR)

Verbal KR feedback about movement outcome may be helpful

- when task-intrinsic and/or KP feedback not detected or processed well by the learner
- to promote certainty (confirms learner's own assessments)
- to promote active learning (motivational)

(Millslagle, 2014)

CONTENT OF FEEDBACK

Knowledge of Performance (KP)

Knowledge of Results (KR)

Internal vs. External Focus

Errors vs. Correct

Motivational (Praise)

Internal Focus

focus on abstract intrinsic goals

“reach hand out toward your right”

External Focus

Focus on concrete environmental goals

“touch the book”

(Thomson, 2005)

(Chiviacowsky, 2013)

Internal vs. external focus of attention

Internal focus

- results in trying to consciously control one's movements
- may constrain the motor system, interfere with automatic motor control processes

External focus

- motor system naturally self-organizes inherent abilities without interference by conscious control
- may promote automatic control processes, result in more effective performance and learning

(Wulf, 2001)

CONTENT OF FEEDBACK

Knowledge of Performance (KP)

Knowledge of Results (KR)

Internal vs. External Focus

Errors vs. Correct

Motivational (Praise)

Errors versus Correct

Implicit learning
Task-intrinsic feedback

Initial stages of practice: reduce (constrain) the number of errors committed to promote early learning
Implicit learning is non-verbal, not a conscious process

(Capio, 2012)

Errors versus Correct

Explicit Learning
Verbal augmented feedback

Negative

- **Providing error information is more effective for skill improvement**

Positive

- **Providing information about correct performance will be motivating**

(Millslagle, 2014)

CONTENT OF FEEDBACK

Knowledge of Performance (KP)
Knowledge of Results (KR)
Internal vs. External Focus
Errors vs. Correct
Motivational (Praise)

Motivational (Praise)

Children that received additional praise performed better on retention trial.

(Ávila, 2012)

Generic feedback

Implies inherent ability

“you are a great soccer player”

Non-generic Feedback

Implies task as acquirable

“those kicks were great”

(Chiviacowsky, 2014)

Motivational (Praise)

Children who received non-generic feedback during practice outperformed the generic feedback group on a retention test.

(Chiviacowsky, 2014)

CONTENT OF FEEDBACK

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Consistent Feedback

Feedback after every trial is detrimental to learning.

(Salmoni, 1984)

(Hemayattalab, 2010)

Consistent Feedback

Feedback after every trial is detrimental to learning.

(Salmoni, 1984)

(Hemayattalab, 2010)

Promotes reliance on feedback and discourages ability to detect error intrinsically. *(Adults)*

(Vialu, 2017)

Can consistent feedback improve retention?

For children, more feedback results in better learning when task is difficult/complex.

(Sidaway, 2012)
(Rice, 2016)

For children, provide more feedback during initial practice and reduce it more gradually (compared to adults.)

(Sullivan, 2008)

AMOUNT/TIMING

Consistent vs. Sporadic

Immediate vs. Delayed

Summary

Faded

Bandwidth

Timing of Feedback

Concurrent

- Feedback given *during* the movement

Terminal

- Feedback given *at completion* of the movement

Immediate

- Feedback given *directly after* the movement

(Millslagle, 2014)

Timing of Feedback

"Instantaneous KR degrades learning."

- There seems to be a minimum amount of time that must pass before giving feedback.

(Swinnen, 1990)

Delayed: Wait a few seconds before giving feedback.

Delayed Feedback

Can facilitate task-intrinsic processing

Provides information of value to solve problems

(Swinnen, 1990)

(Millslagle, 2014)

KR-delay interval

The time between the end of one practice attempt and the augmented feedback.

Post-KR interval

The interval of time between the augmented feedback and the beginning of the next practice attempt

(Millslagle, 2014)

Post-KR interval

Important

- Learner engages in important planning
- Processes and develops the feedback to determine future plan of action

(Millslagle, 2014)

AMOUNT/TIMING

Consistent vs. Sporadic

Immediate vs. Delayed

Summary

Faded

Bandwidth

Summary Feedback

Provide feedback only after a certain number of trials.

Average feedback consists of an average across trials

(Young, 1992)

Summary Feedback

"Task complexity and performer experience interact in determining optimal summary length." (Guadagnoli, 1996)

Simple skills: provide longer summaries, less often
Complex skills: provide shorter summaries, more often

(Millslagle, 2014)

Faded Feedback

Systematically reduce feedback frequency.

Self-selected feedback:
Provide feedback only when the learner requests it.

(Millslagle, 2014)

Faded Feedback - Example

Give feedback for 50% of the trials.
Give feedback for 25% of the trials.
Give feedback for 12% of the trials.
Give feedback when requested (self-selected or self-controlled.)

(Millslagle, 2014)

Bandwidth

Provide feedback only if performance errors are outside predetermined range of correctness.

- Within the band: feedback given sparingly
- Outside the band: feedback given frequently

No-feedback condition:

- If performance is approximately correct, then no feedback

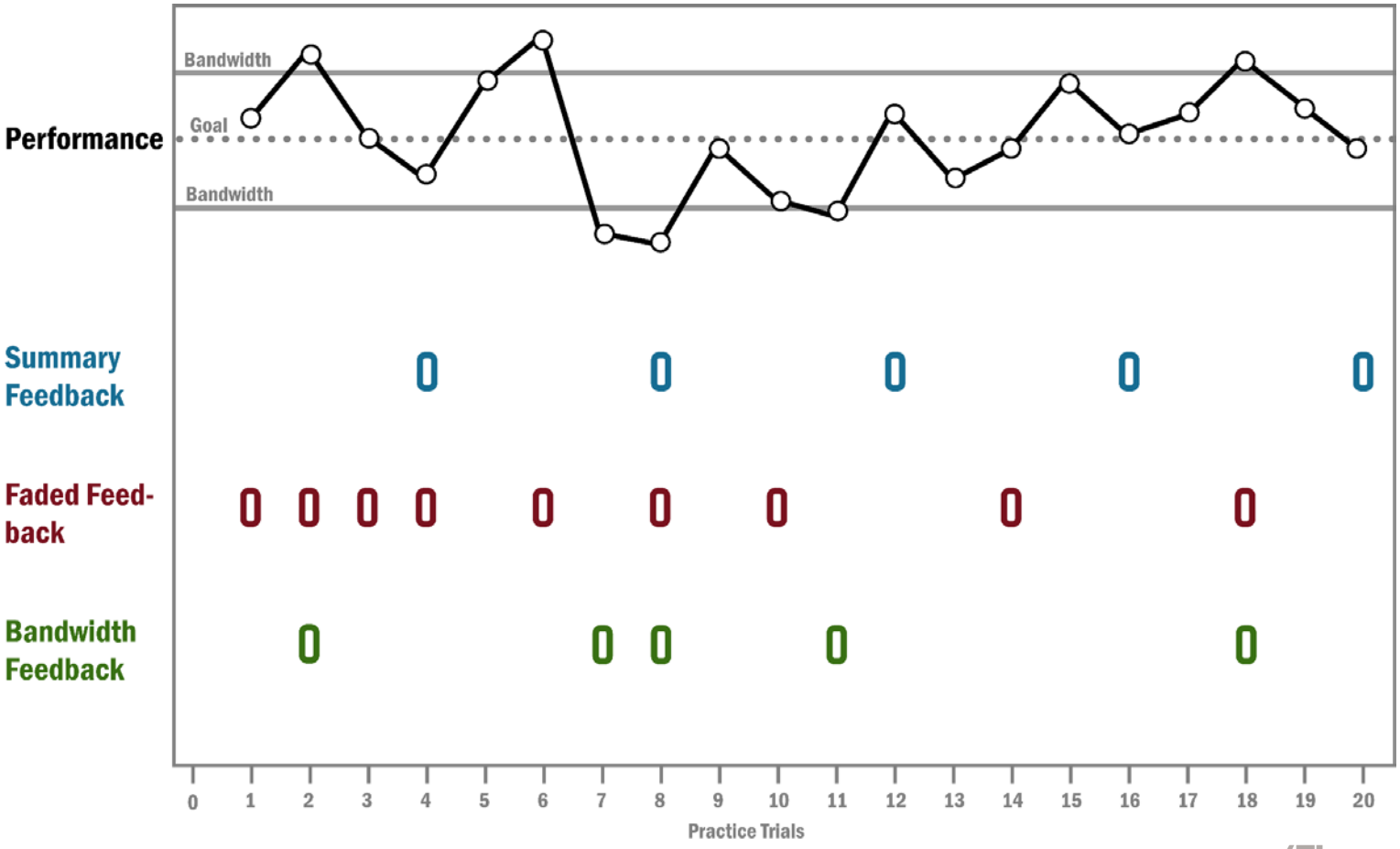
(Millslagle, 2014)

Bandwidth

How much error to allow before providing feedback?

- **Individualize frequency of feedback; consider task difficulty, learner ability, stage of learning.**
- **Regardless of bandwidth size, learner should know that they will receive less (or no) feedback within predetermined band of correctness.**

(Millslagle, 2014)



(Thomson, 2005)

CONTENT OF FEEDBACK

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Feedback

- Intrinsic (learner's own movement-sensory system)
- Verbal Feedback
- **Modeling**
- **Physical Guidance**

Modeling

Observational Learning
A demonstration of movement may provide information that cannot easily be provided verbally.

May be useful for children who have difficulty understanding verbal instructions.

(Thomson, 2005)

Modeling

Helpful

- Replicate a certain specific movement that is needed for goal outcome
- For complex tasks

(Wulf, 2005)

Less helpful

- When an existing movement pattern requires refinement
- When goal outcome not dependent on one way of doing it

(Williams & Hodges, 2005)

Modeling

Provide demonstration on self-selected basis (self-controlled)

- **Self-controlled study group had higher scores in retention.**

(Wulf, 2005)

Modeling - recommendations

Avoid prescribing movement solutions.

Couple the demonstration with focus on the outcome goal.

(Williams & Hodges, 2005)

Peer-modeling

Peer modeling can also be useful.

(Vialu, 2017)

Observe a learning model and hear the feedback provided to that model.

Observe a variety of other models.

(Williams & Hodges, 2005)

Modeling

Demonstration is not necessarily more effective than verbal augmentative feedback.

(Tzetzis, 1999)

(Williams & Hodges, 2005)

Alternating demonstration with physical practice is more effective than either demonstration or physical practice alone.

(Wulf, 2005)

Physical Guidance

Manual guidance

- Correct positioning to enable the action

Physical support

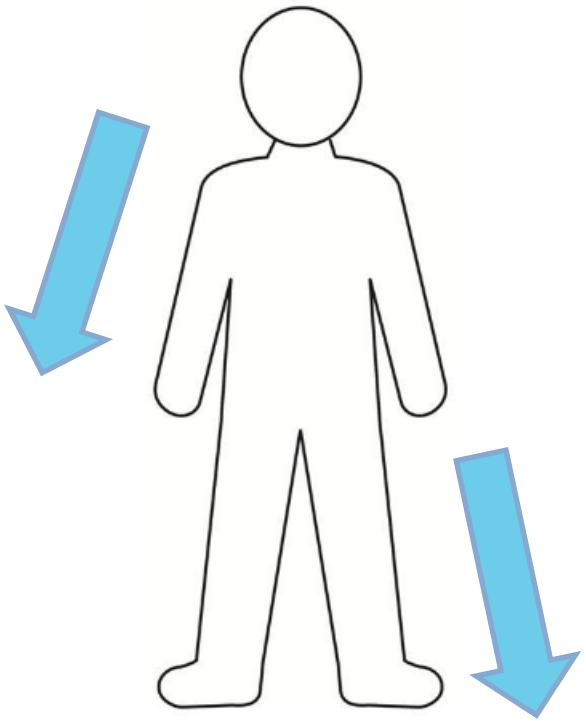
- Provide stability or constraint
- Reduce degrees of freedom controlled by learner

(Thomson, 2005)

PHYSICAL SUPPORT

Trunk
Shoulder
Upper arm
Elbow
Forearm
Hand

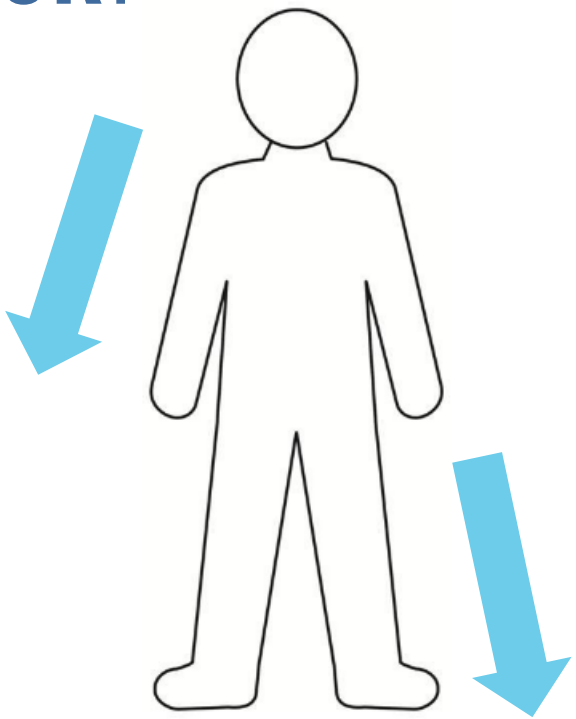
Hip
Thigh
Knee
Lower leg
Foot



(Bidabe, 2016)

FADING PHYSICAL SUPPORT

SOLID	mechanical
BALANCE	person's hand
GUIDANCE	flexible strap



(Bidabe, 2016)

Product Demonstration:

Rifton Pacer

Progressive Gait Training:

Prompt Reduction Concepts

Thank you

We appreciate your time and attention.

We'd love your suggestions for future webinar topics.