

# Motor skills: Classification systems

## **KINESIOL 1E03 - Motor control and learning**

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Fall 2022 Week 1  
Lecture 2

# Review from last lecture

# Motor skills are...

- goal-directed and performed voluntarily
- require movements of joints and body segments via muscular contractions
- need to be learned (or relearned)

# Motor skills...

- vs reflexes
- vs abilities
- vs movements
- == actions

# Characteristics of skilled performance

1. Maximum certainty of goal attainment
2. Minimum energy expenditure
3. Minimum movement time
4. Maximum adaptability

# Four characteristics of motor skills

1. Motor equivalence
2. Motor variability
3. Motor consistency
4. Motor modifiability

Any questions?

# How would you describe this?



Source: [https://thumbs.gfycat.com/ScholarlyDelightfullItaliangreyhound-size\\_restricted.gif](https://thumbs.gfycat.com/ScholarlyDelightfullItaliangreyhound-size_restricted.gif)

# Learning objectives

1. Identify and describe **a key challenge** for any theory of motor control.
2. Define and describe **different taxonomies** for classifying motor skills.
3. Apply **Gentile's 2-dimensional** taxonomy in relevant settings.

## Take-home message:

**There are many ways of classifying motor skills into categories that identify common characteristics of various skills. Skill classifications help us alter performance by providing a framework to understand what aspects are important.**

# The Degrees of Freedom problem

**DEGREES OF FREEDOM:** refers to the number of **individual components** in a system and the **number of ways** each component can **vary**



- **Shoulder:** 3 degrees of freedom at joint level (+10 muscles)
- **Elbow:** 2 degrees of freedom at joint level (+10 muscles)
- **Wrist:** 2 degrees of freedom at joint level (+6 muscles)

$$3 \times 10 \times 2 \times 10 \times 2 \times 6 = 7200 \text{ possible combinations}$$



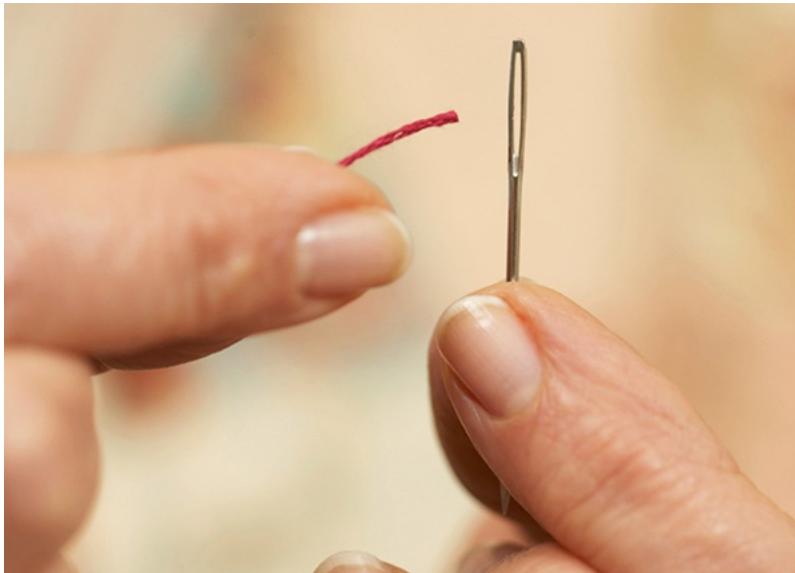
# We can classify motor skills using 1 dimension and 2 dimensions systems

## 1D classifications

- **Size** of the musculature (or movement precision)
- **Temporal** predictability (or where task begins and ends)
- **Stability** of the environment

# 1D classification: Size of musculature

Fine ← → Gross



Left: [https://cnib.ca/sites/default/files/inline-images/threading\\_needle\\_x2\\_0.jpg](https://cnib.ca/sites/default/files/inline-images/threading_needle_x2_0.jpg); Right: <https://crossfithavoc.files.wordpress.com/2014/11/extension.jpg>

# 1D classification: Temporal predictability

Discrete  $\longleftrightarrow$  Continuous



Left: <https://dsgmedia.blob.core.windows.net/pub/2016/01/How-to-swing-a-baseball-bat.jpg>; Right: <https://blog.mapmyrun.com/wp-content/uploads/2017/07/6-Things-to-Know-Before-Swimming-in-Open-Water.jpg>

# 1D classification: Temporal predictability

Discrete ← **Serial** → Continuous



Left: <https://scopeblog.stanford.edu/wp-content/uploads/2016/05/student-playing-piano.jpg>; Right: [https://www.mastermechanic.ca/blog/wp-content/uploads/2017/04/1280px-Opel\\_KARL\\_6\\_Interior.jpg](https://www.mastermechanic.ca/blog/wp-content/uploads/2017/04/1280px-Opel_KARL_6_Interior.jpg)

# 1D classification: Stability of the environment

Closed  $\longleftrightarrow$  Open



Left: <https://bloximages.chicago2.vip.townnews.com/qctimes.com/content/tncms/assets/v3/editorial/4/3e/43ef0202-0a6f-58d0-8e8c-9efc6e35b288/570d6f722b328.image.jpg?resize=1200%2C800>; Right: <https://www.thehockeypaper.co.uk/wp-content/uploads/2020/08/Hockey.jpg>

# Gentile's two-dimensions taxonomy

- 1D systems **does not always** capture the complexity of many skills that a practitioner must take into account when making decisions **instruction, practice routines, or therapy regimens**
- Gentile<sup>1</sup> proposed a 2D classification system based on **two general characteristics** of all motor skills:
  1. **The environmental context** an individual performs the skill
  2. **The function of the action** characterizing the skill
- There are multiple levels within each of these levels, resulting in **16 skill categories**

<sup>1</sup>Gentile 2000; Gordon et al. 2016 *In Memoriam: Antoinette M. Gentile (1936–2016)* (<https://doi.org/10.1080/00222895.2016.1198193>)

# Gentile's two-dimensions taxonomy

## Environmental context

1. **REGULATORY CONDITIONS:** features of the environmental context to which movements must conform if they are to achieve the action goal
  - i.e., *the relevant environmental context features*
  - they regulate **spatial** and **temporal** aspects of the movement
  - **do not** refer to the characteristics of a person's movements **BUT** only to characteristics in the environment in which a skill is executed

# Gentile's two-dimensions taxonomy

## Environmental context

2. **INTERTRIAL VARIABILITY:** whether the regulatory conditions during performance are the same or different from one attempt to perform the skill to another
  - is either **absent** or **present**
  - is **almost always** present when the environment is in motion
  - only time motion variability is absent from one trial to the next is when the motion is caused by a machine (e.g., treadmill)

# We can extend the 1D environmental context classification by including intertrial variability

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	No Intertrial Variability	Intertrial Variability
<b>Stationary Regulatory Conditions</b>	<p>Closed skills with no intertrial variability</p> <ul style="list-style-type: none"><li>• <i>Free throws in basketball</i></li><li>• <i>Walking in an uncluttered hallway</i></li></ul>	<p>Closed skills with intertrial variability</p> <ul style="list-style-type: none"><li>• <i>Golf shots during a round of golf</i></li><li>• <i>Taking several drinks of water from the same glass</i></li></ul>
<b>In-Motion Regulatory Conditions</b>	<p>Open skills with no intertrial variability</p> <ul style="list-style-type: none"><li>• <i>Hitting tennis balls projected at the same speed from a ball machine</i></li><li>• <i>Walking on a treadmill at a constant speed</i></li></ul>	<p>Open skills with intertrial variability</p> <ul style="list-style-type: none"><li>• <i>Hitting tennis balls during a rally in a game</i></li><li>• <i>Walking in a hallway crowded with moving people</i></li></ul>

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# Gentile's two-dimensions taxonomy

## Function of the action

1. **BODY ORIENTATION:** refers to whether or not the performance of the skill involves moving the body from one location to another
  - is either **body stability** or **body transport**
  - change in body location can be achieved either **actively** or **passively**
  - e.g., walking from point A to B would be active transport
  - e.g., moving from point C to D on a moving escalator would be passive transport

# Gentile's two-dimensions taxonomy

## Function of the action

2. **OBJECT MANIPULATION:** refers to maintaining or changing the position of an object

- skills that **involve** object manipulation are **more challenging** to perform
- must manipulate or control the object successfully **AND** make the appropriate postural adjustments to offset any imbalances created by the object
- this will **interact** with the individual performing the action

# Gentile's two-dimensions taxonomy

		Action Function			
Environmental ↓ Context	Body Stability		Body Transport		Object Manipulation
	No Object Manipulation	Object Manipulation	No Object Manipulation	Object Manipulation	
Stationary Regulatory Conditions and No Intertrial Variability	<b>1A</b> Body stability No object Stationary regulatory conditions No intertrial variability <ul style="list-style-type: none"> <li><i>Standing alone in a room</i></li> <li><i>Holding a yoga pose</i></li> </ul>	<b>1B</b> Body stability Object Stationary regulatory conditions No intertrial variability <ul style="list-style-type: none"> <li><i>Brushing teeth standing alone at a sink each day of the week</i></li> <li><i>Shooting basketball free throws</i></li> </ul>	<b>1C</b> Body transport No object Stationary regulatory conditions No intertrial variability <ul style="list-style-type: none"> <li><i>Climbing stairs</i></li> <li><i>Running around an empty track</i></li> </ul>	<b>1D</b> Body transport Object Stationary regulatory conditions No intertrial variability <ul style="list-style-type: none"> <li><i>Climbing stairs while holding a book</i></li> <li><i>Practicing a penalty shot in soccer without a goal keeper</i></li> </ul>	
Stationary Regulatory Conditions and Intertrial Variability	<b>2A</b> Body stability No object Stationary regulatory conditions Intertrial variability <ul style="list-style-type: none"> <li><i>Standing on different surfaces</i></li> <li><i>Performing handstands on different gymnastics apparatuses</i></li> </ul>	<b>2B</b> Body stability Object Stationary regulatory conditions Intertrial variability <ul style="list-style-type: none"> <li><i>Washing dishes while standing at a sink</i></li> <li><i>Putting golf balls from various locations on a putting green</i></li> </ul>	<b>2C</b> Body transport No object Stationary regulatory conditions Intertrial variability <ul style="list-style-type: none"> <li><i>Walking on different surfaces</i></li> <li><i>Agility drills through different obstacle courses</i></li> </ul>	<b>2D</b> Body transport Object Stationary regulatory conditions Intertrial variability <ul style="list-style-type: none"> <li><i>Walking on different surfaces while carrying a bag of groceries</i></li> <li><i>Pole vaulting over bars set at different heights</i></li> </ul>	

# Gentile's two-dimensions taxonomy

		Action Function			
		Body Stability		Body Transport	
Environmental ↓ Context	No Object Manipulation	Object Manipulation	No Object Manipulation	Object Manipulation	
In-Motion Regulatory Conditions and No Intertrial Variability	<b>3A</b> Body stability No object Regulatory conditions in motion No intertrial variability <ul style="list-style-type: none"> <li>• Walking on a treadmill at a constant speed</li> <li>• Riding a mechanical bull with consistent motion</li> </ul>	<b>3B</b> Body stability Object Regulatory conditions in motion No intertrial variability <ul style="list-style-type: none"> <li>• Walking on a treadmill at a constant speed while using a smartphone</li> <li>• Catching a series of softballs thrown at the same speed by a pitching machine</li> </ul>	<b>3C</b> Body transport No object Regulatory conditions in motion No intertrial variability <ul style="list-style-type: none"> <li>• Standing on a moving escalator at a constant speed</li> <li>• Sprinting to the top of an escalator moving in the opposite direction</li> </ul>	<b>3D</b> Body transport Object Regulatory conditions in motion No intertrial variability <ul style="list-style-type: none"> <li>• Standing on a moving escalator while holding a cup of water</li> <li>• Running to hit a tennis ball projected by a ball machine</li> </ul>	
In-Motion Regulatory Conditions and Intertrial Variability	<b>4A</b> Body stability No object Regulatory conditions in motion Intertrial variability <ul style="list-style-type: none"> <li>• Walking on a treadmill at different speeds</li> <li>• Cheerleader standing on a swaying teammate's shoulders</li> </ul>	<b>4B</b> Body stability Object Regulatory conditions in motion Intertrial variability <ul style="list-style-type: none"> <li>• Walking on a treadmill at different speeds while reading a book</li> <li>• Catching softballs thrown at various speeds by a teammate</li> </ul>	<b>4C</b> Body transport No object Regulatory conditions in motion Intertrial variability <ul style="list-style-type: none"> <li>• Walking in a crowded mall</li> <li>• Avoiding being caught in a game of tag</li> </ul>	<b>4D</b> Body transport Object Regulatory conditions in motion Intertrial variability <ul style="list-style-type: none"> <li>• Walking in a crowded mall carrying a baby</li> <li>• Practicing several soccer plays with a ball and defenders</li> </ul>	

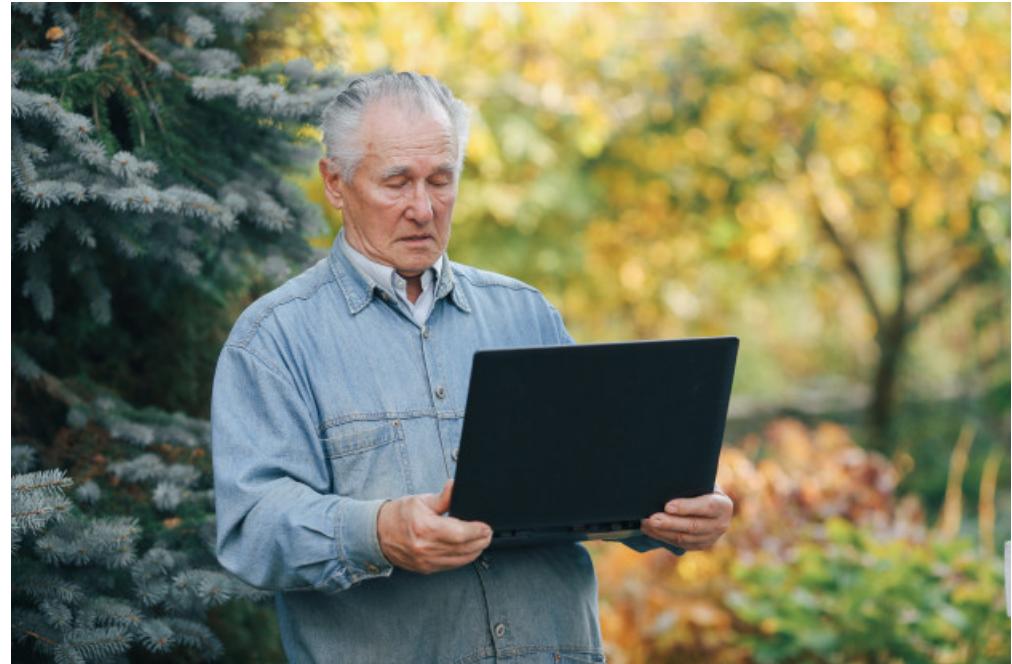
# We can use Gentile's taxonomy for at least 3 key reasons in real-world settings

1. **Evaluate** the learner's movement capabilities and limitations
2. **Select** a progression of functionally appropriate activities for a learner
3. **Record** the learner's progress

# Putting it into practice...

**A physiotherapist working with a client that suffered a stroke**

- Stands without assistance (*Category 1A*)
- Stands without assistance while holding a laptop (*Category 1B*)
- Walks without assistance a specified distance in an uncluttered walkway (*Category 1C*)
- Walks without assistance a specified distance in an uncluttered walkway while holding a laptop (*Category 1D*)



Source: <https://cdn.nohat.cc/thumb/f/720/43b3f862448a4e808cab.jpg>

# Putting it into practice...

**A physical education teacher working on catching skills with a student**

- Catches a ball thrown from the same distance at the same speed (*Category 3B*)
- Catches a ball thrown from various distances at various speeds (*Category 4B*)
- Catches a ball while running along a specified path with ball thrown the same distance and speed (*Category 3D*)
- Catches a ball while running along a specified path with ball thrown from different distance and speeds (*Category 4D*)



Source: <https://kiddipedia.com.au/wp-content/uploads/2019/08/iStock-907598788-e1567131167213.jpg>

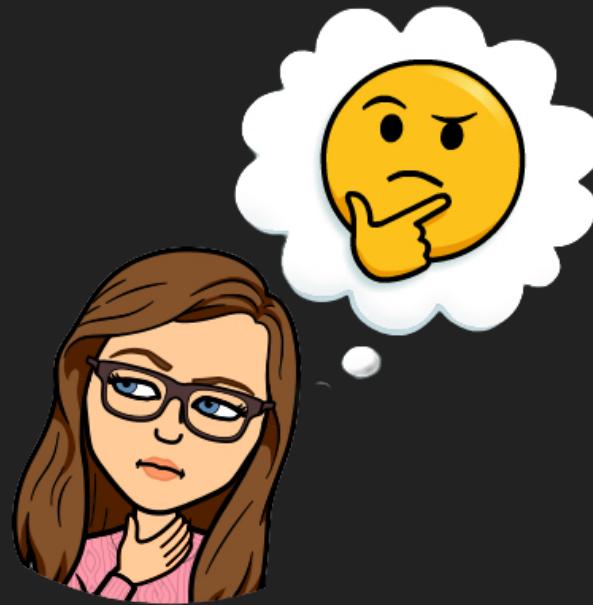
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## Take-home message:

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# What questions do you have?



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