Weeks 8 (Ch08)

Action Preparation

Ovande Furtado Jr., PhD.
Associate Professor, California State University, Northridge

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Objectives

1. Video Overview | Discuss why reaction time (RT) can be an index of preparation required to perform a motor skill.
2. Video Overview | Explain how Hick's law describes the relationship between the number of alternatives in a choice-RT situation and RT.
3. Video Overview | Describe various task and situation characteristics that influence action preparation.
4. Video Overview | Describe various performer characteristics that influence action preparation.
5. Video Overview | Discuss several motor control activities that occur during action preparation.

Objective 1: Why Reaction Time Reflects Motor Preparation

Breaking the Ice

Video Overview

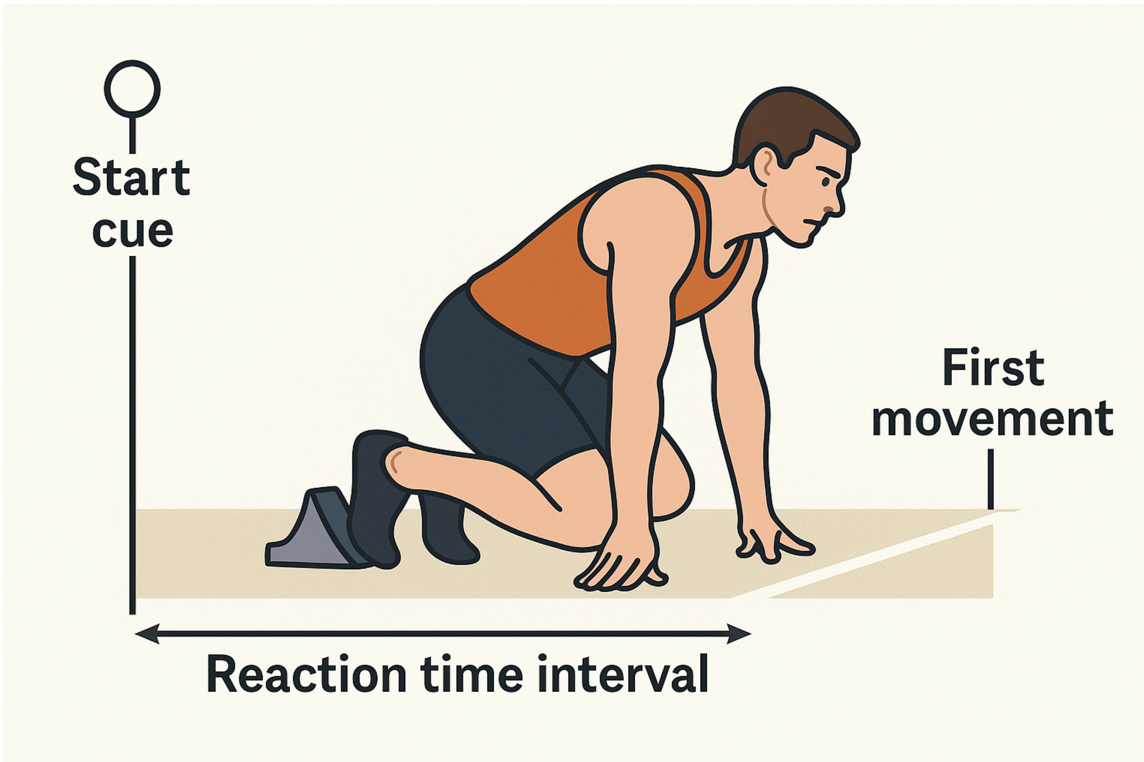
Audio Overview

Study these questions before coming to class:

1. **Have you ever tried clicking a really small button on your phone when you're in a hurry?** What happens to your accuracy?
2. **When you're about to catch a ball that's thrown to you, do you notice a brief moment where you're "getting ready" before you actually start moving your hands?**
3. **Have you ever been startled by a sudden loud noise and noticed how quickly you can react versus when you're trying to carefully thread a needle?**
4. **Why do you think race car drivers and sprinters spend so much time practicing their starts, even though the actual starting movement is very brief?**
5. **When you're typing and suddenly realize you're about to make a mistake, do you notice that brief pause before you correct yourself?**

Objective 1: Why Reaction Time Reflects Motor Preparation

- Objective: Discuss why **reaction time (RT)** can serve as an index of the preparation required to perform a motor skill.
- Focus Areas:
  - The concept of **action preparation**
  - How RT represents the **time needed for the brain to prepare** a movement
  - How this concept appears in everyday life and performance contexts



Let's begin by framing today's discussion. The central idea here is that before any voluntary action, the motor control system must first prepare itself to execute that action. This period of getting ready happens between the intention to move and the initiation of movement.

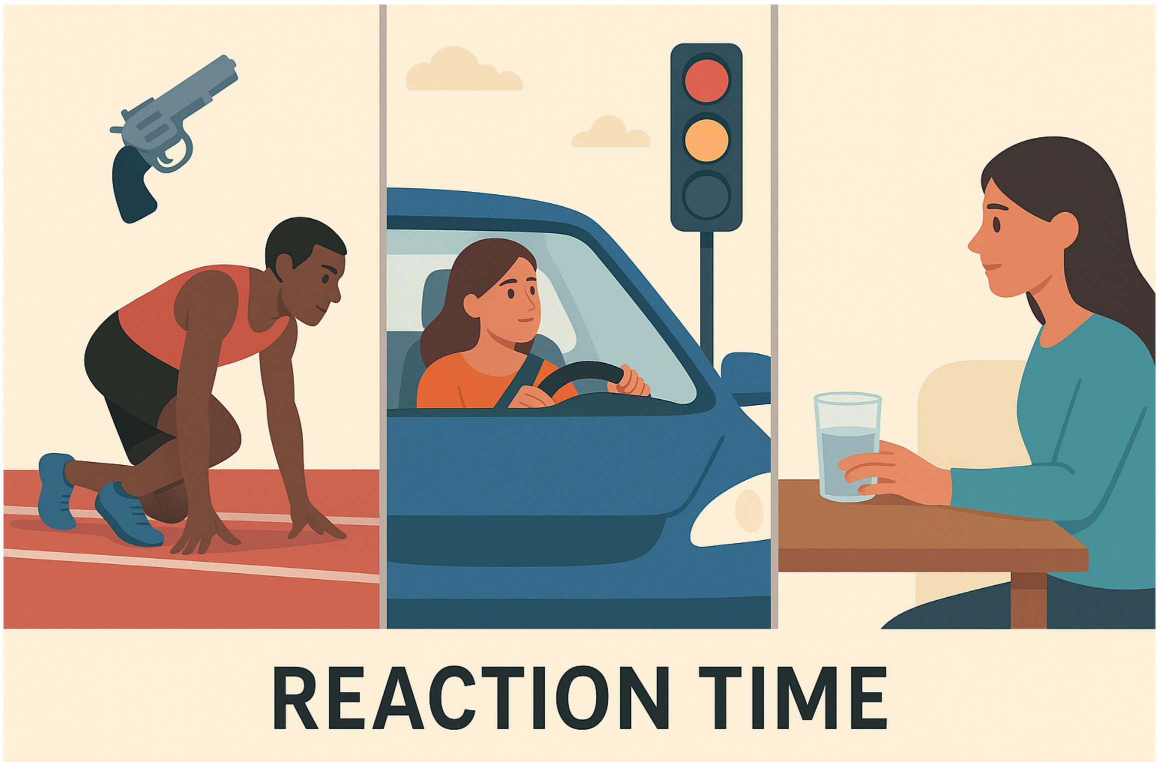
We call this action preparation, and it's a fundamental part of all movement control. Whether you are sprinting, picking up a cup, or reacting to a car pulling out in traffic, there's always a short, measurable delay before movement begins. That delay represents the time your brain and nervous system need to identify the situation, select the right muscles, and program the movement sequence.

In this objective, we'll use reaction time, or RT, as our main tool to study this preparation phase. RT is not just a stopwatch measure — it's a scientific window into how much work your nervous system must do before your body starts moving. By analyzing RT, we can understand the amount and type of preparation needed to perform a motor skill efficiently.

So, as we move through this lesson, keep in mind: RT reflects what happens inside the motor system before you see the first sign of movement.

Action Preparation: Getting Ready for Movement

- Performing voluntary movement requires preparation of the motor control system.
- Even simple daily actions show a delay between deciding to act and starting the movement.
- This delay is the time required for the nervous system to organize and activate the correct motor plan.



One of the clearest ways to see preparation in action is through everyday examples.

Think about reaching for a glass of water. The moment you decide to grab the glass, movement doesn't happen instantly. There's a brief pause as your brain processes the decision, determines where the glass is, and programs the arm muscles to move with the right direction and force.

Or imagine you're driving, and another car suddenly cuts in front of you. There's a measurable delay between when you see the car and when your foot starts moving from the accelerator to the brake. That delay isn't just slow reflexes — it's your motor control system preparing the proper action in response to the situation.

This same principle applies in sports. The rules of many competitions — like track or swimming — include a "ready" signal before the start. That signal isn't only for fairness; it gives competitors a brief but vital window to prepare their motor system. They adjust posture, focus attention, and prime their muscles for the exact movement sequence needed.

So, what this tells us is that action preparation is an essential stage in movement control. It's the difference between acting impulsively and acting efficiently and accurately.

Reaction Time: A Window into Motor Preparation

- **Reaction Time (RT)** is the interval between the presentation of a signal and the start of movement.
- RT serves as an **index of the amount of preparation required** before movement begins.
- Longer RTs indicate greater complexity or more demanding preparation.

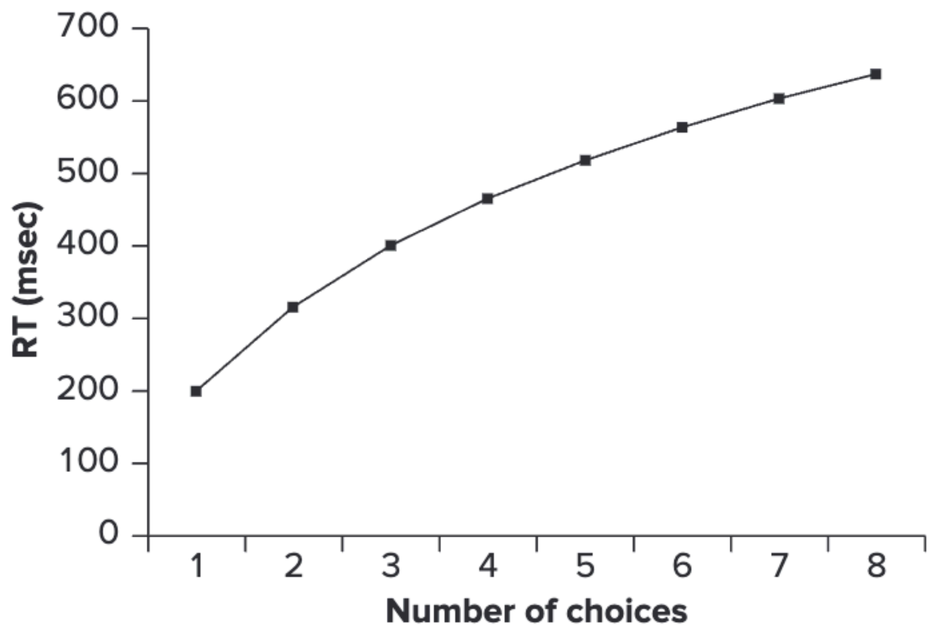


FIGURE 8.1 Predicted reaction times (RTs), according to Hick's law, for one through eight choice-RT situations, based on a simple (i.e., one choice) RT of 200 msec.

Figure 1: Predicted reaction times (RTs), according to Hick's law

Donders' Classic Reaction Time Experiments

- **F. C. Donders (1868)** first used RT to study the stages of mental preparation.
- Compared three tasks:
  - **Simple RT:** one signal, one response.
  - **Choice RT:** multiple signals and corresponding responses.
  - **Discrimination RT:** respond to a specific signal only.
- Developed the **subtraction method** to estimate time for each mental stage.

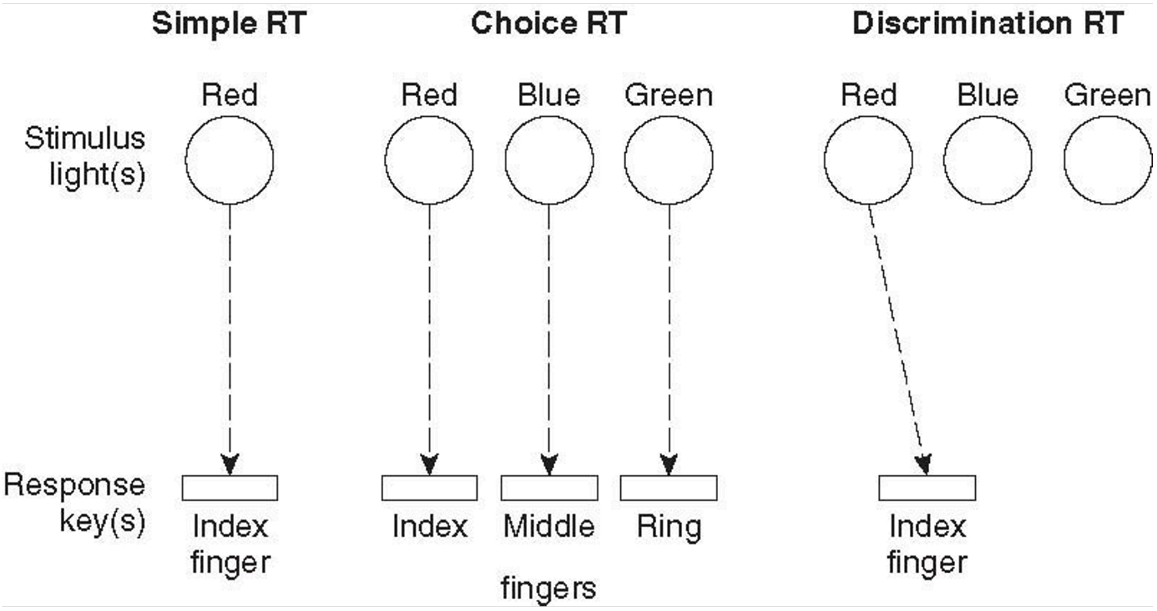


Figure 2: Donders' Use of Reaction Time to Study Action Preparation

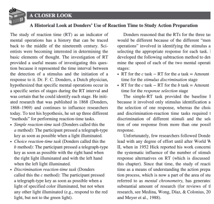


Figure 3: Click image to enlarge

Donders' 19th-century work was groundbreaking because it demonstrated that reaction time isn't a single, uniform event — it's composed of multiple stages of mental and neural processing.

He created three types of reaction-time tasks. In the simple RT task, participants reacted as quickly as possible to one light by pressing a key. This setup measured the baseline time needed to perceive a stimulus and initiate one response.

In the choice RT task, participants saw two lights and pressed a key with the right or left hand depending on which light appeared. This added a decision-making stage — selecting which response was appropriate.

In the discrimination RT task, participants had to respond only to a particular color or type of light, ignoring others. That required stimulus identification, since they had to decide whether the stimulus met the required condition before responding.

By subtracting the RTs of these tasks from one another, Donders could estimate how long each mental process — like identifying the stimulus or choosing the correct response — took. This method showed that each stage of processing adds measurable time before movement begins.

This was one of the first pieces of evidence that the brain's preparation time directly affects reaction time, confirming that RT reflects the complexity of underlying cognitive and motor operations.

Action Preparation Requires Time

- Preparation takes measurable time, even in simple actions.
- RT represents the total duration of processes like stimulus recognition, decision-making, and motor programming.
- More complex actions require more extensive preparation.

The textbook emphasizes that preparation doesn't happen instantly — it requires time. This is a crucial concept: the motor system must perform a sequence of operations before any movement occurs.

When you see a signal to act, several things happen in order. First, you must recognize the stimulus. Next, you decide how to respond. Finally, you program the motor commands that will activate the muscles.

Each of these steps adds milliseconds to your reaction time. The more complex the movement or the more uncertain the situation, the longer this preparation stage becomes.

This is why reaction time can tell us so much. For example, studies show that RT increases when there are more response options, when the required movement is complex, or when accuracy demands are higher. Conversely, RT decreases when people are practiced, alert, or familiar with the situation.

So, preparation is not wasted time — it's essential time that allows the brain to coordinate multiple systems for a smooth, accurate, and timely response.

Everyday Evidence of Action Preparation

- Everyday activities and sports illustrate preparation vividly.
- The phrase "I wasn't ready" reflects incomplete preparation.
- The "get ready" phase in competition rules exists to allow proper preparation.

You can observe action preparation in almost every physical activity.

In sports, the “ready” phase is built into the rules for a reason. Sprinters hear “on your marks, get set” before the gun fires. That moment allows their motor system to reach an optimal state of readiness — muscles are pre-tensioned, attention is focused, and the nervous system is fully alert. Without that, their start would be slower or uncoordinated.

In rehabilitation, we hear patients say, “Don’t rush me.” That statement perfectly captures the principle of motor preparation. Their nervous system needs that short interval to organize the required movement — for example, the sequence of muscle activations needed to stand safely.

Even in ordinary life, when we move before we’re “ready,” mistakes happen — we spill the drink, stumble, or misjudge timing. So, being “ready” is not just psychological; it’s neuromuscular readiness — the body and brain tuned to act efficiently.

This shows why understanding preparation is valuable not only for athletes but also for anyone learning or relearning movement skills.

Practical Application: Using RT and Preparation in Real Settings

Coaches

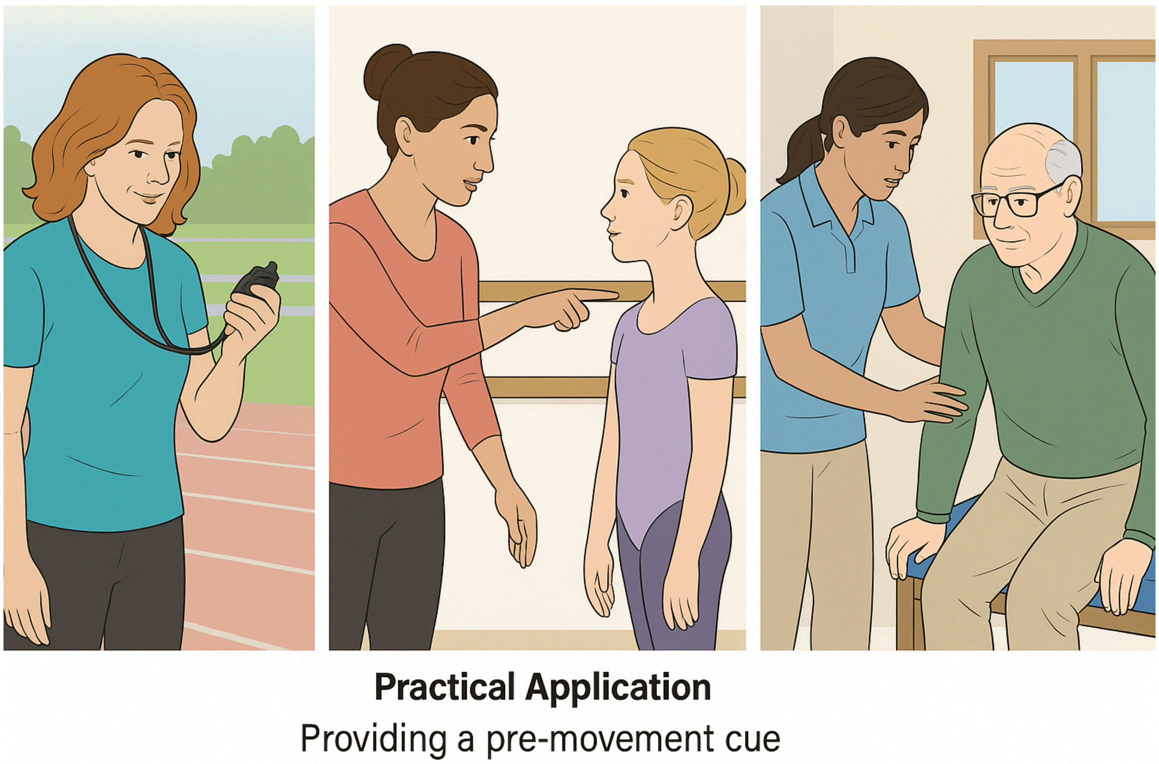
- Use reaction-time drills to train athletes’ readiness and decision speed.
- Example: Variable start cues in sprinting or unpredictable signals in passing drills.

Instructors (PE, Dance, etc.)

- Emphasize the importance of anticipation and focus before moving.
- Example: Cue students to visualize the movement or rhythm before execution.

Physical Therapists

- Allow sufficient preparation time to enhance movement safety and control.
- Example: Before gait or transfer training, encourage patients to pause, focus, and "get ready" before moving.



The principles of reaction time and preparation have very practical implications.

For coaches, understanding RT helps in designing training that mimics real competitive demands. If athletes only practice with predictable cues, they're not preparing the decision-making part of RT. Using variable or delayed start signals trains their motor systems to prepare more efficiently under uncertainty — just as they must in actual performance.

For instructors, especially in PE or dance, preparation translates into focus and anticipation. Before movement starts, the student's attention should shift from external distractions to internal readiness. Teaching students to take a breath, visualize the movement, or anticipate the rhythm enhances coordination and timing because it activates the same preparatory processes discussed in the text.

For physical therapists, preparation is essential for safety. Patients recovering from injury or neurological impairment need more time to prepare because their systems process slower.

Encouraging them to “pause and prepare” before standing or walking helps them recruit the right muscles, maintain balance, and prevent falls.

In all these contexts, the goal is the same: to ensure that the nervous system is properly prepared before movement starts — optimizing performance, accuracy, and safety.

Conclusion: Reaction Time as an Index of Preparation

- RT reveals the **time and processes** involved in preparing movement.
- The motor system must identify, select, and program before any action begins.
- Understanding RT helps improve performance, teaching, and rehabilitation.

To conclude, reaction time gives us a powerful way to study what happens before we move. The short interval between a signal and a response may seem trivial, but it contains multiple layers of processing — perceiving the signal, choosing an action, and programming the muscles to perform it.

When we measure RT, we’re not just timing reflexes — we’re measuring how efficiently the motor control system prepares for action. A longer RT doesn’t mean someone is lazy or unskilled; it often reflects greater complexity or uncertainty in the situation.

For practitioners — whether in sport, education, or rehabilitation — understanding these principles allows us to design activities that match or enhance a person’s preparation needs. In essence, RT serves as a mirror of the preparation process, helping us understand how the brain readies the body for coordinated, effective movement.

Every action, from a sprinter’s start to a patient’s first step, begins with preparation — and reaction time is how we measure that invisible yet critical phase.

Objective 2: Understanding Hick’s Law and Motor Preparation

Breaking the Ice

Video Overview

Audio Overview

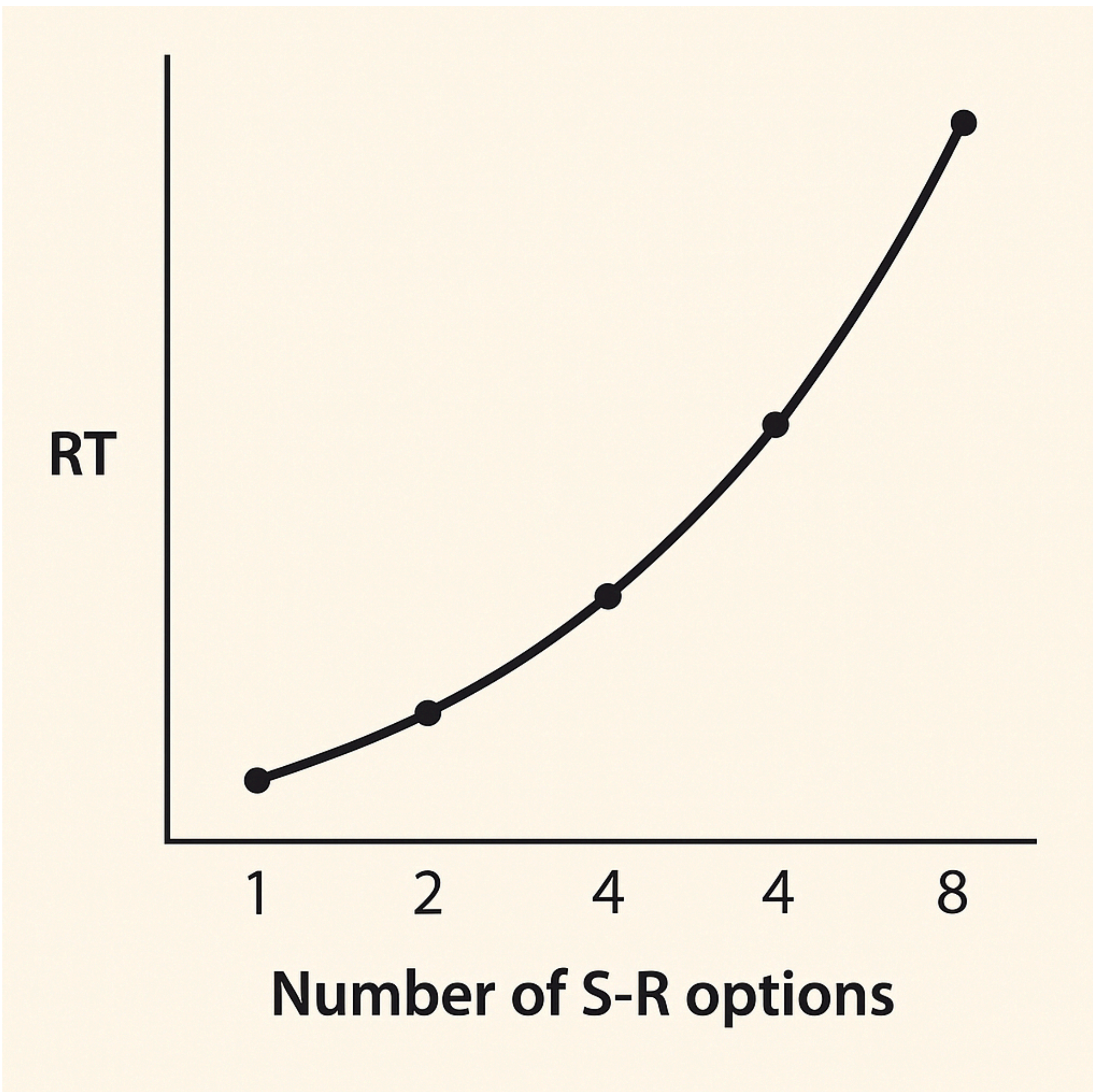
Study these questions before coming to class:

1. **When you’re driving and see multiple lane options ahead, do you notice your decision time getting slower?** What’s happening in your brain?
2. **Why does choosing what to watch on Netflix with 15,000+ options feel overwhelming compared to picking from 3 TV channels?**
3. **When you’re at a restaurant with a huge menu versus a simple 3-item menu, which feels easier to decide on?**
4. **Have you noticed that skilled video game players seem to react instantly even in complex games with many possible moves?**

5. **When you're trying to parallel park with someone giving you multiple simultaneous directions, does your response time slow down?**

Objective 2: Understanding Hick's Law and Motor Preparation

- Objective: Explain how **Hick's Law** describes the relationship between the number of alternatives in a choice-RT situation and reaction time (RT).
- Focus:
  - Task and situational factors influencing preparation
  - How the number of possible responses affects RT
  - Practical implications for skill performance and training



In this objective, we're focusing on a specific task factor that influences how long it takes to prepare and initiate movement — the number of possible response choices.

Researchers have consistently shown that when we have to choose between several possible actions, our reaction time gets longer. This relationship is summarized by Hick's Law, which predicts that RT increases in a systematic and predictable way as the number of stimulus-response alternatives increases.

Understanding this law helps us explain why some movements can be executed almost instantly — like pressing a single button when a light appears — while others, like responding to a complex sports play, require more time to prepare.

So, as we go through this section, keep in mind: Hick's Law links information processing with motor preparation, giving us a mathematical way to predict how choice complexity influences RT.

Task and Situation Characteristics: Number of Response Choices

- One of the most powerful predictors of RT is the **number of response alternatives** available.
- As the number of alternatives increases, the time required to prepare and initiate movement also increases.
- This is especially evident in **choice-RT tasks**, where a person must select one response from several possibilities.

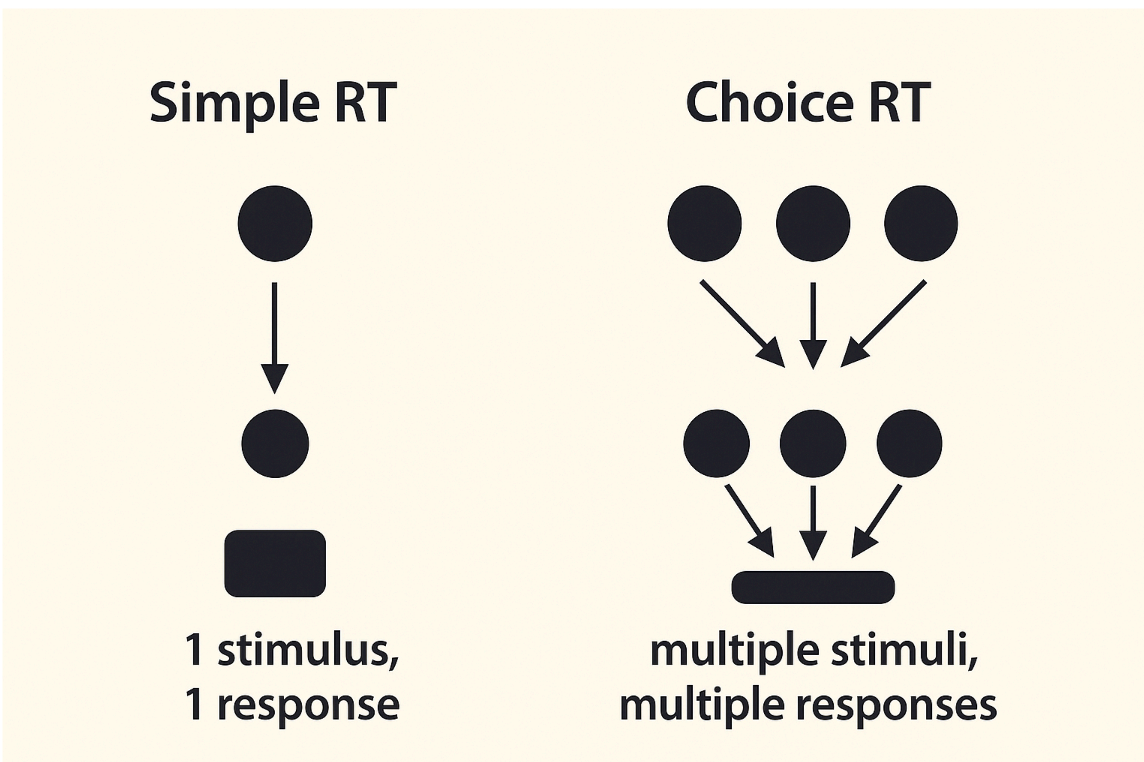


Figure 4: Simple diagram contrasting **simple RT** (1 stimulus, 1 response) with **choice RT** (multiple stimuli and responses

The textbook makes it clear that one of the strongest and most consistent factors affecting preparation time is the number of available responses.

Let's think about what's happening inside the nervous system. In a simple reaction-time task, there's only one possible signal and one corresponding response — for instance, pressing a button when a light comes on. Since there's no uncertainty, the motor system can almost fully prepare in advance, and reaction time is short.

Now compare that to a choice reaction-time task, where there might be two or more possible signals, each requiring a different response. For example, pressing one button for a red light and another for a green light. In this case, you can't pre-program a single movement — your brain must first identify the correct signal and then select the appropriate response.

That extra decision-making step adds measurable time to the preparation process. The key point here is that every additional alternative adds more information that must be processed before movement begins, which in turn increases reaction time.

Hick's Law: The Mathematical Relationship

- **Hick's Law (Hick, 1952)** predicts that RT increases **logarithmically** as the number of stimulus-response choices increases.
- Expressed as: **Choice RT = k [$\log_2$ (N + 1)]** where *k* = constant and *N* = number of possible choices.
- This means RT doesn't increase linearly but **levels off** as the number of choices grows.

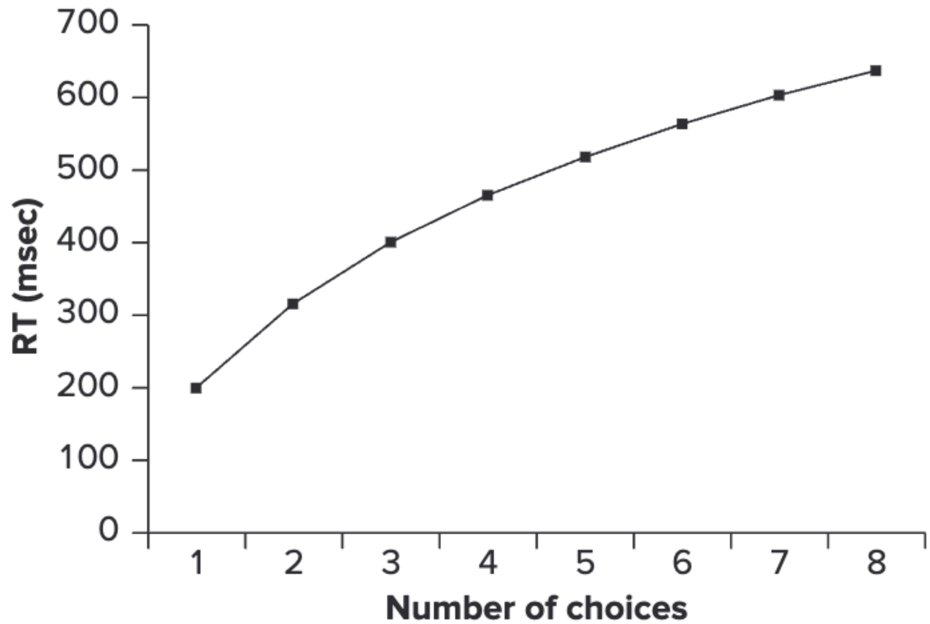


FIGURE 8.1 Predicted reaction times (RTs), according to Hick's law, for one through eight choice-RT situations, based on a simple (i.e., one choice) RT of 200 msec.

Figure 5: Predicted reaction times (RTs), according to Hick's law

Why the Relationship Matters: Information and Preparation

- Hick's Law shows that **decision complexity** — not just movement difficulty — determines how long preparation takes.
- RT increases with the **amount of information** that must be processed.
- The $\log_2$ function reflects the number of **yes/no decisions** required to select the correct response.

Hick's Law teaches us that what slows people down in choice situations isn't physical limitation — it's information load.

Every time we add another possible response, the brain must make an additional decision to identify which one fits the situation. The key insight here is that RT increases with information, not with the number of muscles or the size of the movement.

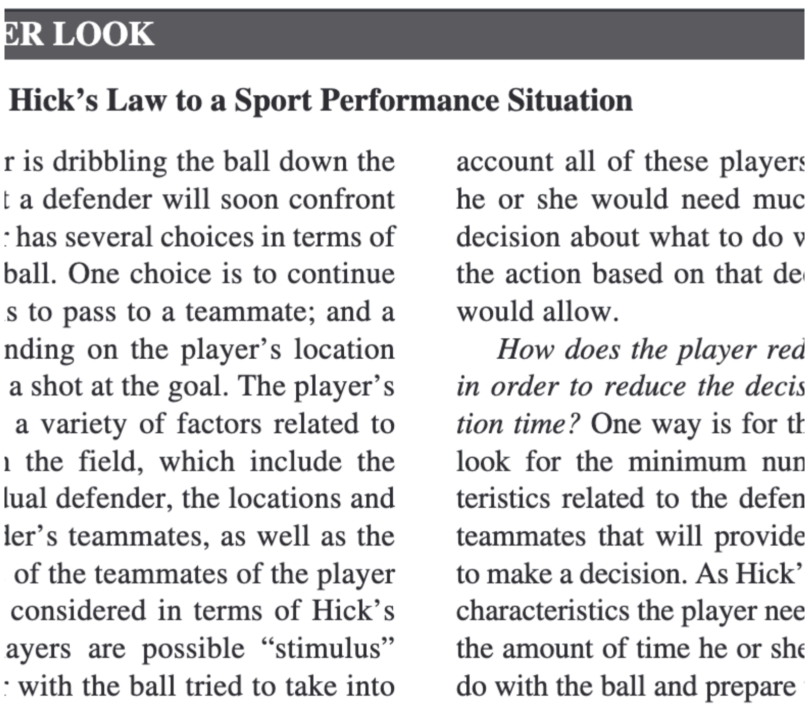
In information theory terms, each choice can be represented as a yes/no decision — a binary bit. For example, if you have two possible responses, you need one decision to pick the correct one. If you have four options, you need two binary decisions. For eight options, three binary decisions. Each decision step adds to the total preparation time.

That's why in sports or driving situations, even experienced performers slow down slightly when faced with more unpredictable or complex sets of choices. The more information to process, the more time the brain needs to prepare.

So, this relationship reinforces the idea that motor preparation is a cognitive process — the brain evaluates alternatives, eliminates incorrect ones, and programs the chosen response before any movement begins.

A Closer Look: Hick's Law in Sport Performance

- In dynamic sports, athletes face many possible stimuli and responses.
- According to Hick's Law, more choices lead to longer decision times — unless experience allows selective attention to key cues.
- Skilled athletes minimize RT by narrowing down relevant stimuli.



ER LOOK

Hick's Law to a Sport Performance Situation

r is dribbling the ball down the t a defender will soon confront has several choices in terms of ball. One choice is to continue s to pass to a teammate; and a nding on the player's location a shot at the goal. The player's a variety of factors related to the field, which include the lual defender, the locations and ler's teammates, as well as the of the teammates of the player considered in terms of Hick's ayers are possible "stimulus" with the ball tried to take into

account all of these players he or she would need muc decision about what to do v the action based on that de would allow.

How does the player red in order to reduce the decis tion time? One way is for th look for the minimum num teristics related to the defen teammates that will provide to make a decision. As Hick' characteristics the player nee the amount of time he or she do with the ball and prepare

Figure 6: Click image to enlarge

Hick's Law applies perfectly to real-world performance. In the A Closer Look example from the text, the authors describe a soccer player dribbling the ball toward an approaching defender. The player has several possible actions: continue dribbling, pass to a teammate, or take a shot.

If the player considered all possible movements and all player positions on the field, the number of "stimulus-response choices" would be huge. According to Hick's Law, this would drastically increase reaction time — far more than the situation allows.

However, skilled players don't consciously evaluate every option. Through practice, they learn to focus on the minimal cues that matter most — such as the defender's movement angle or a teammate's open space. By doing so, they effectively reduce the number of meaningful alternatives, which reduces the amount of information they must process.

This is how experts appear to "react instantly." It's not that they break Hick's Law; rather, they simplify the decision environment through selective attention and anticipation. Their preparation phase becomes faster because they've learned to ignore irrelevant possibilities and focus only on the most probable options.

Practical Application: Reducing Choice Complexity

Coaches

- Train athletes to recognize key cues early, reducing unnecessary options.
- Example: Defensive drills where players learn to anticipate likely movements from opponents.

Instructors (PE, Dance, etc.)

- Simplify initial learning environments by limiting possible responses.
- Gradually increase choices as students gain confidence and automaticity.

Physical Therapists

- In rehabilitation, avoid overwhelming patients with too many simultaneous movement decisions.
- Progress from simple, one-choice tasks to multi-choice activities as cognitive-motor coordination improves.

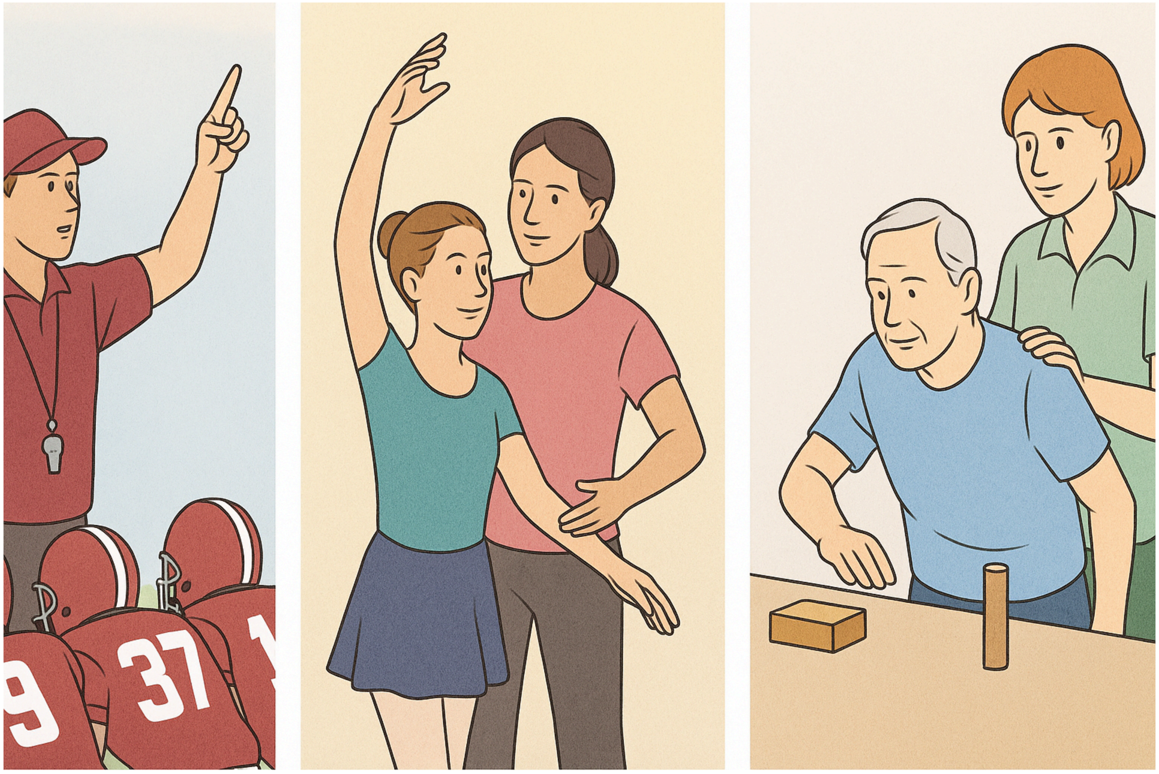


Figure 7: Practical application examples

Understanding Hick's Law gives us valuable strategies for practice and instruction.

For coaches, it means teaching athletes to manage choice complexity. In game situations, athletes who learn to pick up early cues — like an opponent's body orientation — can eliminate less likely options and make faster, more accurate responses. Drills that recreate real decision-making situations help reduce RT through experience and anticipation.

For instructors, especially in PE or dance, Hick's Law reminds us to start simple. When beginners are faced with too many cues or movement choices, their preparation time slows dramatically. By reducing the number of possible responses and gradually increasing complexity, we help them develop efficient information processing and movement readiness.

For physical therapists, the same principle applies in a clinical context. Patients recovering from injury or neurological impairment often have slower processing speed. Presenting too many simultaneous instructions can overload their motor preparation system. Starting with simple, single-response tasks and slowly adding choices helps retrain both cognitive and motor readiness safely.

In short, by managing the number of alternatives, we can improve both the speed and quality of action preparation.

Conclusion: Hick's Law and Motor Preparation

- **Hick's Law** demonstrates that reaction time increases logarithmically with the number of stimulus-response alternatives.
- This reflects the **information processing demands** of movement preparation.
- Skilled performers shorten RT by narrowing relevant options through experience and anticipation.

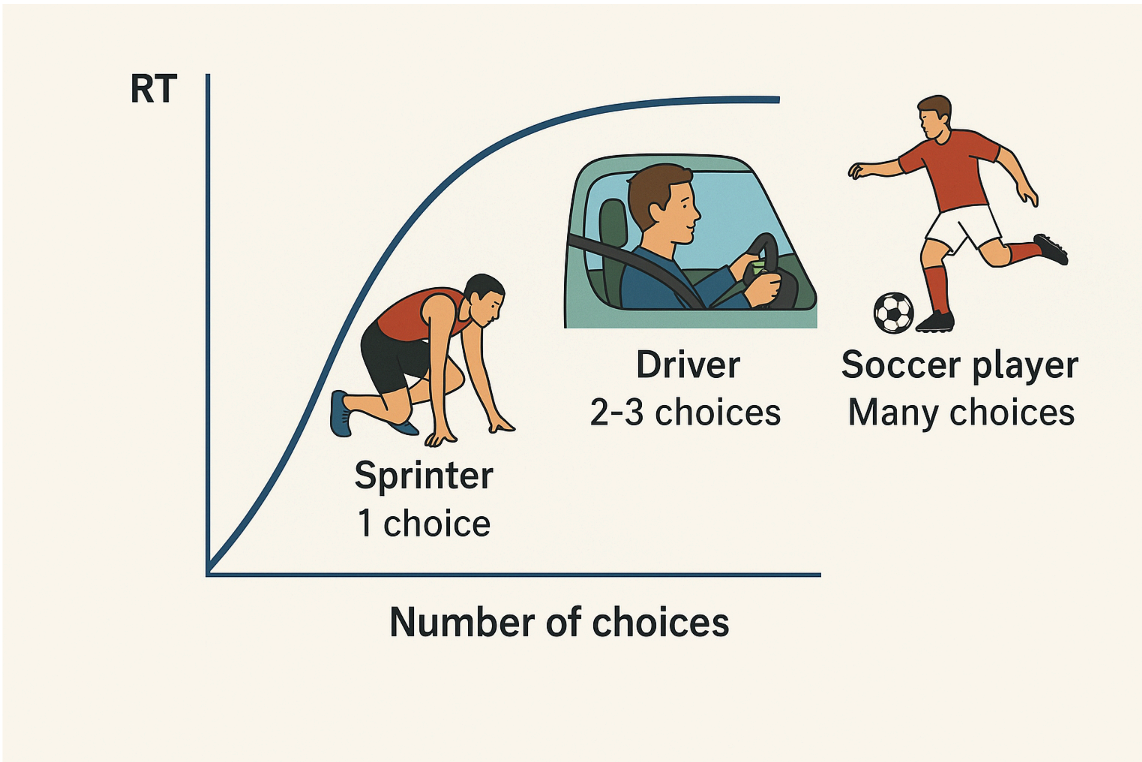


Figure 8: Different scenarios illustrating Hick's Law

To wrap up, Hick's Law provides one of the clearest connections between cognition and motor control. It shows that preparation time is determined not just by how fast muscles can move, but by how efficiently the brain processes information to select the correct action.

As the number of choices increases, RT increases in a predictable, logarithmic fashion — meaning the first few additional choices add a lot of time, but beyond a point, the increases become smaller.

In real life, skilled performers overcome this limitation not by defying the law, but by reducing effective choices through practice and experience. They recognize patterns, anticipate outcomes, and focus only on the most relevant cues, which dramatically shortens their preparation phase.

So, Hick's Law reminds us that speed of movement begins with speed of decision-making. The brain's ability to organize, filter, and program the right response underlies every fast and accurate action we perform.

Objective 3: Task and Situation Characteristics Influencing Action Preparation

Breaking the Ice

Video Overview

Audio Overview

Study these questions before coming to class:

1. **Have you ever noticed how a soccer goalie seems to "know" which way to dive before the ball is even kicked?** What allows this anticipation?
2. **Why does it feel easier to turn on a stove burner when the control knob is directly below the burner versus when they're arranged randomly?**
3. **When you're waiting for a traffic light that changes on a predictable timer versus one that changes randomly, which feels more stressful?**
4. **Have you ever tried to catch a ball while simultaneously answering a phone call?** What happens to your reaction time and accuracy?
5. **Why does typing feel slower when you switch from a familiar keyboard to a completely different layout (like from QWERTY to Dvorak)?**

Objective 3: Task and Situation Characteristics Influencing Action Preparation

- Objective: Describe various **task and situation factors** that affect how long the motor system takes to prepare an action.
- Focus:
  - How different task demands (e.g., complexity, accuracy) and situational features (e.g., predictability, timing) modify reaction time (RT).
  - How understanding these influences helps optimize performance and learning.

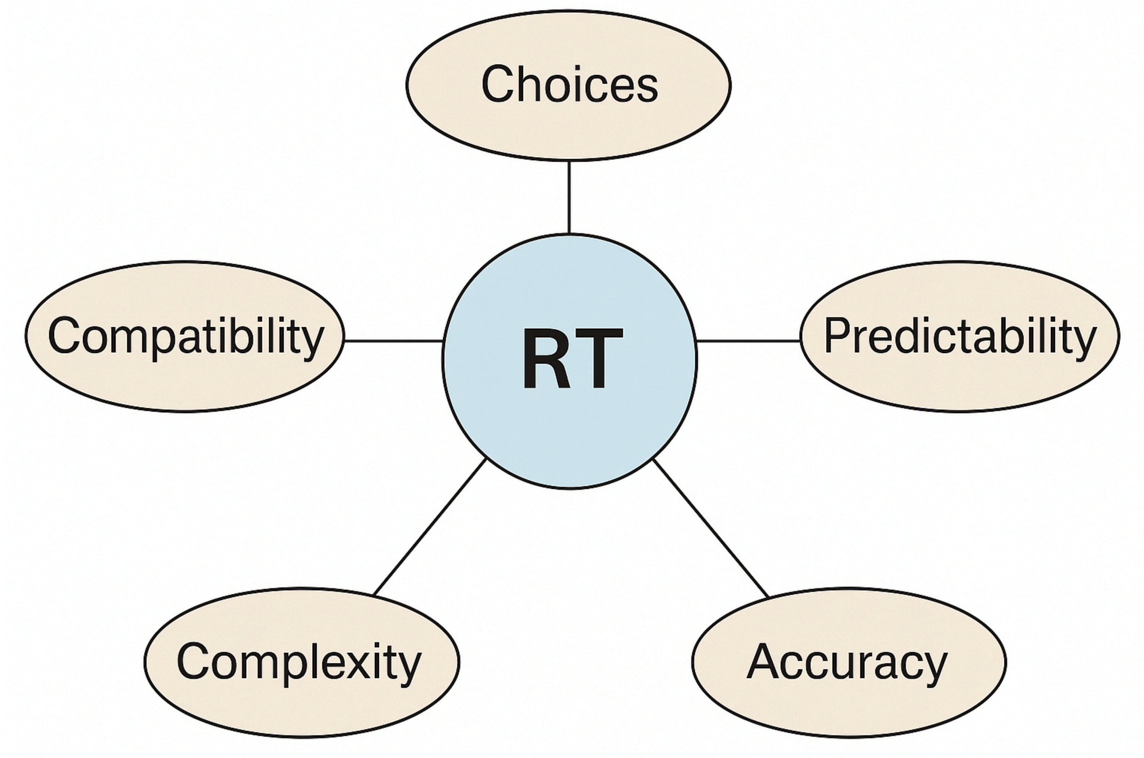


Figure 9: Conceptual overview diagram

Now that we understand that action preparation requires time — and that RT reflects this preparation — the next question is what influences how long that preparation takes?

The authors of our textbook, identify several task and situational characteristics that consistently affect reaction time and, therefore, the amount of preparation needed.

These factors include the number of choices available (as we discussed in Hick's Law), the predictability of the correct response, the accuracy or complexity of the movement, and even the timing between signals or repetitions.

Each of these variables changes how much the motor system must plan before it acts. For example, having to decide between many options, performing a precise movement, or responding to unpredictable signals all increase preparation time.

As we go through each, I'll highlight what the research shows and how these findings apply to real-world motor performance — from sports to therapy.

Predictability of the Correct Response Choice

- When one response is **more predictable** than others, RT decreases.
- The brain can **pre-select** the likely response, reducing preparation time.
- Studied using the **precue technique**, where advance information helps narrow the response options.

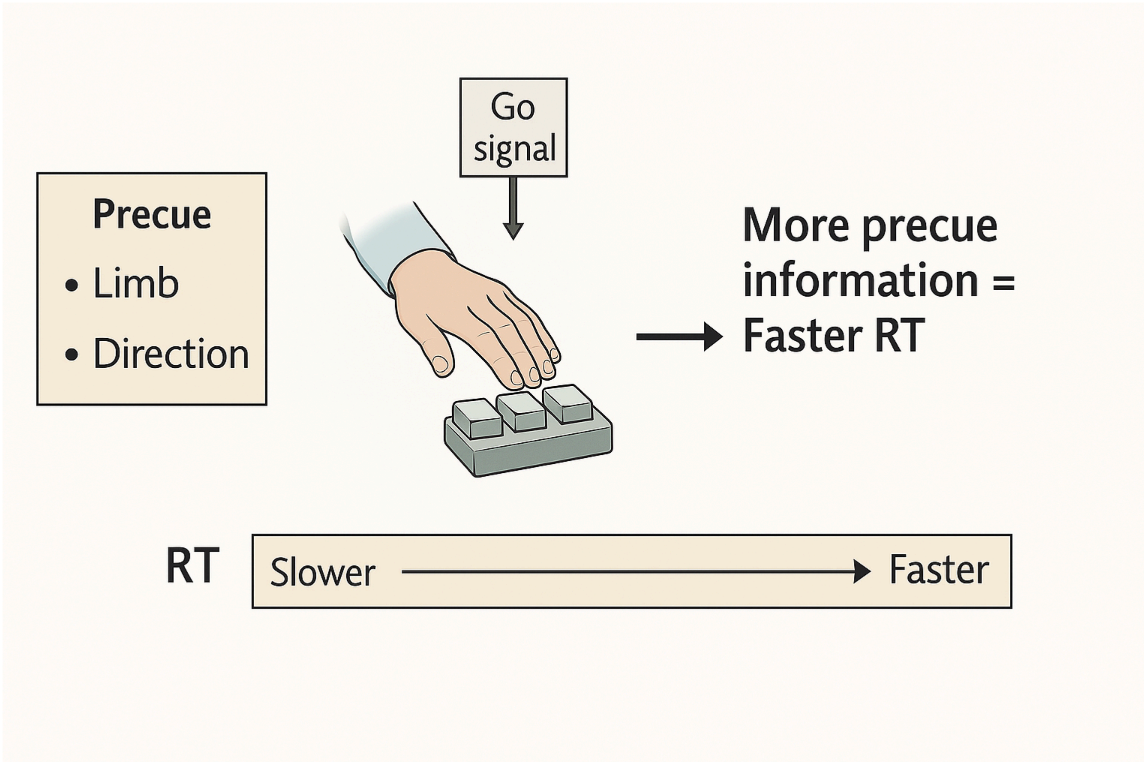


Figure 10: Diagram showing advance "precue" information (e.g., direction or limb) leading to faster RT

Probability of Precue Correctness: The Cost-Benefit Trade-Off

- If the precue is **usually correct**, the performer benefits from biasing preparation toward that response.
- If it's **incorrect**, RT becomes slower — a "cost" for being wrong.
- This balance between benefits and costs is called the **cost-benefit trade-off**.

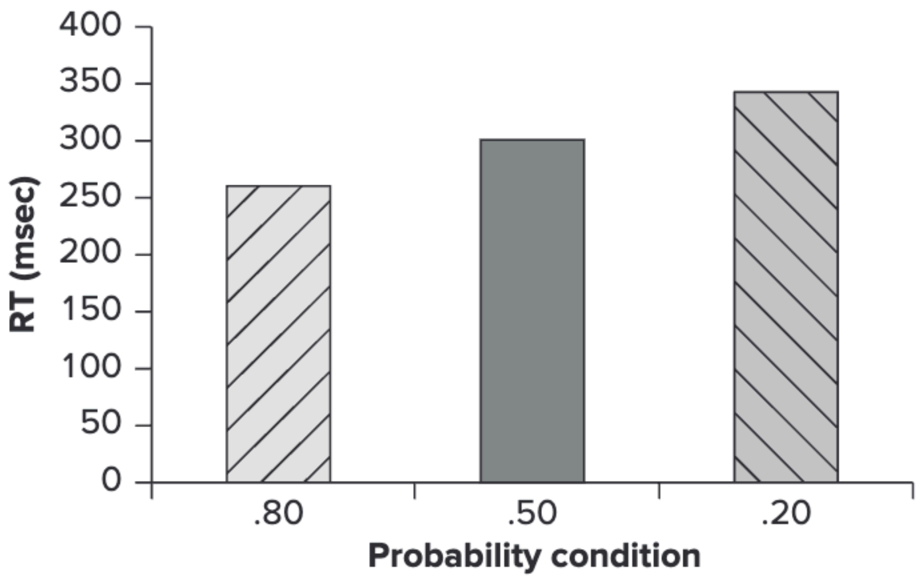


Figure 11: Effects on RT of different probabilities of precue correctness

Building on predictability, the authors of our textbook describe how the accuracy of advance information affects preparation. This is called the probability of precue correctness.

Larish and Stelmach's 1982 study showed that when participants received a precue that was correct 80% of the time, they responded faster when it was indeed correct — they had prepped that movement in advance. However, when the precue was wrong, their RT became longer than normal because they had to "reprogram" the movement after realizing their mistake.

This is the cost-benefit trade-off: biasing your preparation toward one likely action gives you a benefit when you're right but a cost when you're wrong.

Think about a basketball defender. If they know that a certain player passes the ball 80% of the time, they'll start preparing to block the pass. If the player shoots instead, the defender's preparation bias works against them, and their RT to react to the shot will be slower.

So, probability and bias shape preparation: when the precue is reliable, we gain speed; when it's misleading, we pay for it in slower reactions.

Stimulus-Response Compatibility (S–R Compatibility)

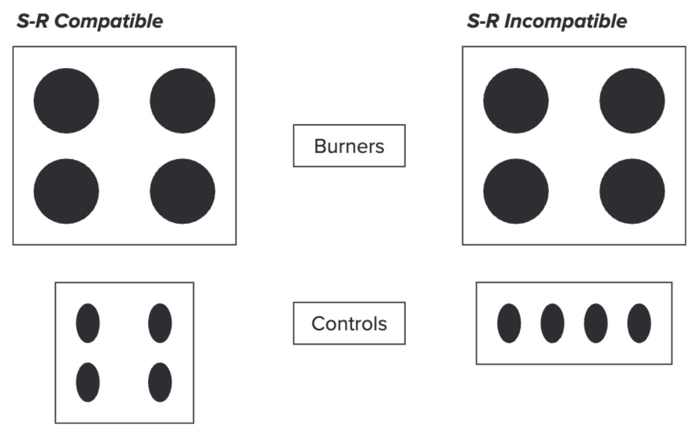
- **S–R compatibility**: the natural correspondence between stimulus and response locations or features.
- High compatibility → faster RT; low compatibility → slower RT.
- Includes **spatial relationships** and **meaning-based effects** like the Stroop effect.

Referenced images:

A CLOSER LOOK

A Stimulus-Response Compatibility Example in the Kitchen with Potential Serious Consequences

The article by Proctor, Vu, and Pick (2005) described the following example of how S-R compatibility is an important concern for the design of a kitchen appliance. The typical stovetop has four burners, usually arranged in a 2×2 layout of two in the front and two in the rear. However, the controls for these burners are organized in ways that vary in the degree of compatibility with the layout of the burners. The following examples illustrate two of these situations:



The selection of the correct controls is easy and fast for the high-S-R-compatible arrangement, but more difficult and slower for the S-R-incompatible arrangement. The potential for making a control selection error, with possible serious consequences, is much higher for the incompatible arrangement, especially in an emergency situation when a fast and accurate response is required.

Another strong influence on reaction time is stimulus-response compatibility — how naturally the stimulus and the required response "match."

When the stimulus and response are spatially aligned, reaction times are shorter because the mapping between perception and action is intuitive. For example, if lights and buttons are arranged in the same order, pressing the correct button is almost automatic. But when the arrangement is mismatched — say, lights are vertical and buttons are horizontal — RT increases because the brain must translate the stimulus into a less natural response.

This principle is critical in human factors design. The classic stove-top example in the text shows that controls arranged in the same layout as burners are much safer and faster to use than incompatible ones.

The Stroop effect illustrates another form of incompatibility. When a person must name the ink color of a word that spells a different color (e.g., the word "BLUE" printed in red ink), their RT is slower. The conflict between the word's meaning and its color causes interference in response selection.

So, S–R compatibility tells us that the brain prefers natural, consistent mappings. The less compatible the situation, the longer the time needed to select and prepare the correct response.

Foreperiod Length Regularity

- The **foreperiod** is the interval between a warning signal and the actual "go" signal.
- RT is faster when this interval is **consistent** across trials.
- Irregular foreperiods create uncertainty and increase RT.

Suggested image: Timeline showing "warning signal ⟶ foreperiod ⟶ go signal," with variable vs. constant intervals.

Movement Complexity

- As **movement complexity** increases, so does RT.
- More complex actions require more planning steps before initiation.
- Classic evidence: **Henry & Rogers (1960)** ballistic arm movement experiment.

Referenced box: "The Classic Experiment of Henry and Rogers (1960)" (p. 181).

Movement complexity refers to how many parts or elements an action includes. The more complex the movement, the longer the motor system takes to prepare it.

Henry and Rogers (1960) tested this using three rapid arm movements that varied in complexity. Participants either released a key, reached forward to grab a ball, or performed a sequence of reaching, striking, reversing, and grasping movements.

The simple movement had the shortest RT, while the complex movement — involving multiple components — had the longest. Importantly, the extra time wasn't due to muscle sluggishness but to the increased planning load before the movement started.

They concluded that the brain prepares an entire movement sequence in advance — like loading a full program before pressing "run." The more steps in that program, the longer the preparation.

This finding was crucial for supporting the idea of motor programming — that movement plans are organized before they are executed.

Movement Accuracy

- RT increases as **accuracy demands** increase.
- Smaller targets or narrower constraints require more precise motor programming.
- Related concept: **Fitts' Law**, linking accuracy demands with movement time.

Referenced study: Sidaway, Sekiya, & Fairweather (1995) manual aiming experiment (p. 181).

Accuracy is another factor that increases preparation time. When a task demands precise control, the brain needs extra time to program the necessary constraints on limb motion.

In manual aiming tasks, for instance, when the target is small or narrow, reaction time increases. Sidaway and colleagues found that participants took longer to initiate movements toward smaller targets and that the variability in their first movements depended on the difficulty of the next target.

This shows that accuracy demands influence preparation before movement even begins. It's not just that we move slower during the action (as Fitts' Law explains) — we also take longer to plan precise actions in advance.

The reason is that fine accuracy requires the motor system to program the correct force, direction, and coordination patterns ahead of time, reducing error potential during execution.

Repetition of a Movement Pattern

- RT decreases when the same movement is repeated on consecutive trials.
- With repetition, the motor system can **reuse previous programming**, reducing preparation time.
- The effect diminishes after several repetitions.

Referenced discussion: p. 182 (Campbell & Proctor, 1993).

Repetition has a powerful but short-lived effect on preparation. When a person performs the same movement several times in a row, RT for subsequent attempts becomes shorter.

Why? Because the response selection process becomes more efficient — the brain can reuse the previous movement program rather than constructing a new one from scratch.

This explains why practice drills that involve repetitive actions, such as repeated serves in tennis or kicks in soccer, often feel smoother and faster after the first few attempts.

However, this benefit plateaus. After several repetitions, RT stops decreasing, likely because the system has already reached its optimal level of preparation for that specific response.

Time between Different Responses: The Psychological Refractory Period (PRP)

- When two signals occur close together, the **second response** is delayed.
- This delay is the **Psychological Refractory Period (PRP)**.
- The brain must finish processing the first response before it can begin preparing the second.

Image: *Figure 8.3* (p. 182) — illustrates PRP in a basketball fake-and-drive scenario.

The psychological refractory period, or PRP, describes a fascinating limitation in action preparation.

Imagine a basketball player fakes left and then quickly moves right. The defender reacts to the first movement — the fake — and then must adjust to the second. The defender's second reaction is slower because their motor system is still completing the first response.

In Figure 8.3 of our textbook, this delay is shown as the "PRP interval" — the time between the defender's first and second reaction. The player performing the fake gains extra time to move because the opponent's second movement is effectively "on hold" while the first is being processed.

This phenomenon occurs because the brain's response selection system can only handle one decision at a time. The second response must wait until the first has cleared the processing channel.

Understanding PRP helps athletes design effective fakes and teaches coaches how to structure practice drills that exploit or overcome this delay in rapid decision-making.

Practical Application: Managing Task and Situation Factors in Preparation

Coaches

- Design drills that simulate real game unpredictability while developing cue recognition.
- Example: vary opponents' movements or timing cues so athletes learn to adjust preparation to changing response demands.
- Teach athletes to recognize reliable precues (e.g., body position, gaze direction) to reduce decision time and avoid false starts.

Instructors (PE, Dance, etc.)

- Begin with simplified environments — few choices, high compatibility — then progressively add complexity and accuracy demands.
- Example: in dance or gymnastics, start with predictable rhythm cues before introducing timing variations or directional changes.
- Highlight "attention to signal" versus "attention to movement" so learners know when to focus on the cue that initiates action.

Physical Therapists

- Structure rehabilitation tasks from simple to complex, allowing patients adequate preparation time.
- Example: start with single, consistent cues (constant foreperiods), then gradually add variable or dual-task elements.
- Teach patients to anticipate and prepare for movement safely, reducing risk of falls and optimizing coordination.

Suggested image: Three panels showing: 1. A coach leading players through decision drills. 2. A dance instructor introducing rhythmic cue changes. 3. A therapist guiding a patient to stand after a preparatory "ready" cue.

Conclusion: Task and Situation Factors in Action Preparation

- Many **task and situational characteristics** influence how long preparation takes.
- RT increases with:
  - More choices
  - Lower predictability
  - Incompatible stimuli and responses
  - Greater complexity or accuracy demands
  - Short intervals between different signals

- Recognizing these effects helps improve performance and learning.

To summarize, action preparation is influenced by a network of task and situational variables. Each of these changes how much time the motor system needs to identify, select, and organize an appropriate response.

Preparation time increases with more alternatives (Hick's Law), lower predictability, spatial or cognitive incompatibility between stimuli and responses, complex or precise movements, and quick successions of signals (PRP). It decreases with familiarity, repetition, and consistent timing cues.

By understanding these relationships, coaches, educators, and therapists can better manage practice conditions — for instance, simplifying tasks for beginners, introducing variability gradually, and allowing sufficient preparation time for safety and accuracy.

Ultimately, every factor we discussed shapes how efficiently the brain prepares the body to act. Recognizing these influences gives us tools to optimize both performance speed and movement quality.

Objective 4: Performer Characteristics Influencing Action Preparation

Breaking the Ice

Video Overview

Audio Overview

Study these questions before coming to class:

1. **Have you ever been "in the zone" during a sport or activity where your reactions felt incredibly fast?** What mental state creates this peak performance?
2. **When you're really tired or sleepy, do you notice your reaction time getting slower, even for simple tasks like hitting the snooze button?**
3. **Why do sprinters perform better when they focus on the starting gun rather than thinking about their leg movements?**
4. **Have you noticed that when you expect to perform well, you often do better, but when you're worried about messing up, your reaction time seems sluggish?**
5. **When you're watching a suspenseful movie or waiting for an important phone call, do you find yourself jumping at unexpected sounds?**

Objective 4: Performer Characteristics Influencing Action Preparation

- Objective: Describe **performer-related factors** that influence how long and how effectively the motor system prepares for movement.
- Focus:
  - **Alertness and vigilance** — readiness to detect and respond to signals.
  - **Attention focus** — whether attention is on the signal or the movement.

- ‣ **Expectations and psychological states** that modify preparation efficiency.

Suggested image: Diagram of a performer's preparation loop, showing sensory input, attention focus, and alertness level feeding into movement initiation.

Up to now, we've looked at how task and situation factors affect preparation time. But the performer also plays a crucial role.

Two people performing the same task under identical conditions can show very different reaction times — often because of differences in alertness, attention, or mental set.

This objective explores these internal performer factors. We'll look at how alertness (short-term and long-term), focus of attention, and even expectations about performance influence the efficiency of action preparation.

In practical terms, these are the qualities that separate a sluggish start from a sharp one, or a distracted performer from a focused, ready mover. Understanding them helps us train, teach, and rehabilitate people more effectively.

Alertness of the Performer

- The performer's **alertness level** strongly affects both RT and performance quality.
- **Optimal alertness** shortens preparation time and enhances accuracy.
- A **warning signal** before the "go" cue helps raise and time this alertness.

Referenced discussion: p. 183–184 — *"Alertness of the Performer"* section, including foreperiod and readiness effects. **Suggested image:** Graph showing RT shortest at optimal alertness, with performance drop-offs when too soon or too late.

Alertness refers to how ready a person is to detect and respond to a signal. The textbook emphasizes that alertness influences both the time to prepare and the quality of the resulting movement.

In reaction-time tasks, RT is shorter when the performer receives a warning signal — like "get ready" — a second or two before the "go" signal. This warning helps raise the nervous system's readiness to an optimal level.

But timing matters. If the "go" signal appears too soon after the warning, the performer may not yet be fully alert; if it comes too late, alertness fades, and RT lengthens again. Studies suggest that the best foreperiod for maintaining optimal alertness ranges between 1 and 4 seconds.

This principle explains why starters in sprint races vary their timing — to prevent athletes from perfectly anticipating the signal. It also helps instructors or therapists structure practice so participants are attentive but not anxious.

Alertness, then, is about tuning the performer's state — not too early, not too late — for the fastest, most accurate response.

Long-Term Maintenance of Alertness: Vigilance

- **Vigilance** = maintaining attention over long periods when signals appear infrequently.
- Performance deteriorates with time — RT slows, detection errors increase.

- Influenced by **fatigue**, **sleep deprivation**, and **task monotony**.

Referenced discussion: pp. 184–185. **Suggested image:** Example of a lifeguard, radar operator, or driver maintaining prolonged vigilance.

Vigilance is the long-term version of alertness — the ability to stay ready when signals appear only occasionally.

In many real-world tasks, from lifeguarding to air-traffic monitoring, performers must stay alert for long periods even though meaningful events happen rarely. The problem is that sustained attention fades over time. Studies since World War II have shown that after about 30 minutes, people start missing signals or responding more slowly.

Our textbook describes how sleep deprivation and mental fatigue worsen this decline. RT grows longer, and accuracy suffers. The nervous system essentially drifts into a lower state of readiness, even if the person thinks they're still paying attention.

This concept has major implications: pilots, surgeons, and drivers all rely on vigilance. Coaches and therapists must also recognize that fatigue undermines preparation — whether it's an athlete waiting for a play or a patient focusing on balance training.

Maintaining vigilance requires strategies like short breaks, task variation, and adequate rest — because even the most skilled performer can't sustain high alertness indefinitely.

A Closer Look: Vigilance Problems Resulting from Closed-Head Injury

- **Closed-head injury** can severely impair vigilance and sustained attention.
- Patients show slower RTs and declining detection accuracy across time.
- Indicates difficulties maintaining preparation over extended tasks.

Referenced box: *A Closer Look: Vigilance Problems Resulting from Closed-Head Injury* (p. 185). **Suggested image:** Graph comparing RT increase over time in brain-injured vs. non-injured participants.

Research on individuals with closed-head injuries provides striking evidence of how vigilance depends on intact cognitive preparation systems.

Loken and colleagues (1995) compared patients with severe brain injuries to healthy individuals on a simple visual detection task. Participants watched for a solid blue circle to appear among other blue outlines across 200 trials lasting 20 minutes.

While healthy participants maintained stable detection times, those with closed-head injuries showed two clear problems:

First: Their overall RTs were slower, especially when the visual display became more complex.

Second: Their detection speed declined steadily as the session continued.

These results confirm that damage to attention and arousal systems impairs the ability to maintain readiness. Over time, the patients' nervous systems struggled to sustain a preparatory state.

Clinically, this means therapists must account for reduced vigilance capacity — keeping sessions shorter, incorporating breaks, and providing more salient cues to re-engage attention. Preparation isn't only about muscles; it's also about the brain's ability to stay alert and responsive.

Attention Focus: Signal vs. Movement (Sensory Set vs. Motor Set)

- Reaction time depends on **where the performer's attention is directed** during preparation.
- **Sensory set:** attention focused on detecting the signal ⟶ faster RT.
- **Motor set:** attention focused on performing the movement ⟶ slower RT.

Referenced studies: Henry (1960); Christina (1973); Jongsma et al. (1987). **Suggested image:** Illustration comparing attention focus on "signal light" vs. "hand movement."

Where a performer focuses attention before movement dramatically affects preparation speed.

A sensory set means focusing on the stimulus — for example, the sound of a starting gun. A motor set means focusing on the movement itself — such as thinking, "I need to push off fast."

Franklin Henry and later Christina found that people with a sensory set had significantly shorter reaction times — about 20 milliseconds faster — than those focused on the movement. Interestingly, movement time (the duration of the action) didn't differ.

Why does this happen? Focusing on the signal allows the brain to detect and process the cue more efficiently. Focusing on the movement divides attention and delays the initiation process.

Jongsma and colleagues extended this to sport: sprinters who concentrated on the starting sound (sensory set) reacted faster than those thinking about their leg drive (motor set).

So, the best preparation strategy for fast responses is to focus on the signal, not the movement. Instructors and coaches can use this to teach athletes or students how to "listen for the cue" rather than overthinking their actions.

A Closer Look: Performance Expectations and Preparation

- **Expectations about performance success** influence movement efficiency.
- Positive expectancy ⟶ improved coordination and reduced energy use.
- Demonstrates that motivation and belief become part of the preparation process.

Referenced box: *A Closer Look: Performance Expectations as Part of Action Preparation* (p. 191). **Suggested image:** Runner or athlete receiving encouraging feedback while performing.

The textbook ends this section by connecting psychology and motor control through the idea of performance expectancy — how belief in success influences preparation.

In a study by Stoate, Wulf, and Lewthwaite (2012), experienced runners were told during a treadmill test that their oxygen consumption was among the top 10% for their group. This false but positive feedback increased their confidence and led to lower oxygen consumption over time — meaning they ran more efficiently.

Why? Because positive expectations likely enhanced the brain's action preparation efficiency. When performers expect to succeed, they prepare movements more fluidly, without excess muscular tension or hesitancy.

This research reminds us that psychological readiness is intertwined with physiological preparation. Encouraging cues and feedback can literally alter the motor system's state of readiness, improving performance efficiency even without physical changes.

Whether in sport or therapy, fostering positive expectations is a powerful way to enhance movement preparation.

Practical Application: Enhancing Performer Readiness

Coaches

- Use **pre-performance routines** and clear warning cues to optimize alertness.
- Train athletes to maintain focus on the **signal**, not the mechanics, during starts or reactions.
- Foster confidence and expectancy through positive, specific feedback.

Instructors (PE, Dance, etc.)

- Encourage students to maintain attention on cues and rhythm rather than overthinking execution.
- Use consistent preparatory signals and build routines that help sustain alertness in repetitive tasks.
- Manage fatigue by scheduling short focus intervals and brief rest breaks.

Physical Therapists

- Incorporate clear, predictable "ready–go" signals in therapy sessions to cue attention and readiness.
- Recognize that patients with cognitive or head injuries may have limited vigilance — provide rest and minimize distractions.
- Use encouraging feedback to enhance confidence and improve the efficiency of movement preparation.

Suggested image: 1. Coach giving "get ready" cue to sprinter. 2. Dance instructor leading students with rhythmic signals. 3. Therapist using countdown before gait training.

These performer characteristics — alertness, attention, and expectancy — can be actively shaped through practice and environment.

For coaches, using consistent warning signals helps athletes time their readiness. Teaching them to attend to the signal rather than their own movement improves RT and reliability. Confidence-building feedback enhances expectation and leads to smoother, more efficient performance.

For instructors, classroom or studio settings can mirror these same principles. Students perform better when tasks have clear cues and rhythm. Managing fatigue and attention cycles ensures that long lessons don't erode focus — much like vigilance declines in prolonged monitoring tasks.

For physical therapists, these concepts guide clinical pacing. Clear, consistent "ready–go" signals help patients with neurological or cognitive deficits engage their attention at the right time. Allowing rest between trials prevents vigilance lapses. Positive encouragement not only boosts motivation but also helps reestablish neural readiness for movement.

In all these cases, the key is shaping the performer's internal state of preparation — aligning alertness, attention, and expectancy to optimize both reaction time and movement quality.

Conclusion: The Performer's Role in Preparation

- Reaction time reflects not only task conditions but also **performer state**.
- Optimal preparation depends on:
  - Adequate alertness and vigilance
  - Focused attention on the signal
  - Positive expectations about performance
- Managing these factors enhances both speed and efficiency of action.

Suggested image: Flowchart linking "Alertness → Attention Focus → Expectation → Optimized RT."

To conclude, the performer's internal state is just as important as external task factors in determining reaction time and preparation quality.

A person who is alert, attentive to the right cues, and confident in their ability to succeed will prepare and act faster than someone who is tired, distracted, or uncertain.

These findings remind us that motor control is both cognitive and emotional. The nervous system's readiness depends not only on sensory input but also on motivation and mental focus.

For teachers, coaches, and therapists, the message is clear: we must train not just the movement, but the mindset that precedes it. By shaping alertness, focus, and expectation, we can improve performance, learning, and recovery alike.

Objective 5: Action Preparation Activities During Action Preparation

Breaking the Ice

Video Overview

Audio Overview

Study these questions before coming to class:

1. **Have you ever noticed that when you're about to catch a ball, your body automatically tenses up and adjusts your posture before your hands even move?**

2. **When you reach for your coffee cup, do you grip it differently depending on whether it's full or empty, even before you touch it?**

3. **Why do pianists' hands seem to "know" where the next keys are before they've finished playing the current notes?**

4. **Have you noticed that successful free-throw shooters in basketball often have very consistent pre-shot routines, even down to the timing?**
5. **When you're about to type a familiar word, do you feel like your fingers are already "programmed" to move in the right sequence before you start?**

Objective 5: Motor Control Activities During Action Preparation

- Objective: Discuss the **neural and muscular activities** that occur during the preparation stage before movement begins.
- Focus:
  - What the brain and body do between **intention** and **initiation**.
  - Evidence from reaction-time studies and movement physiology.

Suggested image: Diagram showing the action timeline — *Intention → Preparation → Movement initiation → Execution.*

By now, we know that reaction time (RT) measures the duration of movement preparation. But what exactly happens during that time?

This objective focuses on the internal activities that occur between deciding to move and actually moving — the unseen neural and muscular events that make up the preparation process.

Our textbook emphasizes that preparation involves perceptual, cognitive, and motor components. The brain identifies the signal, selects and programs the response, and begins activating the motor system even before we see movement.

We'll examine several specific processes that occur during this phase — including evidence from fractionating RT, postural adjustments, limb and object control, sequencing, and rhythmic preparation. These show just how much "hidden work" the nervous system does to make smooth, coordinated movement possible.

Evidence from Fractionating Reaction Time (RT)

- RT can be divided into two measurable components using **EMG recordings**:
  - **Premotor time** — from stimulus onset to muscle activation (cognitive/perceptual processing).
  - **Motor time** — from first muscle activity to movement initiation (neuromuscular activation).
- Separating these components helps identify which preparation processes are affected by task demands.

Referenced section: "Evidence from Fractionating RT" (p. 186–187). **Suggested image:** EMG graph showing premotor and motor components labeled.

To uncover what happens during the reaction time interval, researchers use electromyography (EMG) to record muscle activity.

This technique allows RT to be split into two parts. The premotor component is the time between the signal and the first sign of muscle activation — reflecting the brain's perceptual and decision-making processes. The motor component covers the period from initial muscle activation to visible movement — reflecting the final stages of motor output.

Christina and Rose (1985) found that when movement complexity increased, almost all the added RT occurred in the premotor phase — meaning that the brain needed more time to plan, not the muscles to move. Similarly, Siegel (1986) showed that longer movement durations increased the premotor time linearly, again confirming that preparation time reflects cognitive rather than muscular factors.

In short, fractionating RT provides direct physiological evidence that action preparation involves both brain-based planning and early muscular activation before the movement we see.

Postural Preparation: Anticipatory Postural Adjustments

- Before a voluntary movement, the body automatically activates **supporting muscles** to stabilize posture.
- These **anticipatory postural adjustments (APAs)** occur **before** the main movement begins.
- EMG studies show that trunk and leg muscles activate milliseconds prior to arm or hand motion.

Referenced section: “Postural Preparation” (pp. 187–189). **Suggested image:** *Figure 8.5* — muscle activation sequence during stepping (Mercer & Sahrmann, 1999).

Every time we move, our body quietly prepares the supporting muscles that keep us balanced — these are called anticipatory postural adjustments, or APAs.

Before you reach for a cup, your trunk muscles contract slightly to prevent you from losing balance. This happens automatically, usually 100–200 milliseconds before the arm muscles activate. EMG studies show these subtle activations even in simple tasks like finger tapping.

Weeks and Wallace (1992) found that as arm movement speed increased, the onset of leg muscle activity occurred earlier — showing that posture and action are tightly coordinated. Mercer and Sahrmann (1999) observed similar pre-activations in leg muscles during stepping, ensuring stability as weight shifts.

These findings tell us that the brain plans not just the movement itself but also the stability needed to support it. This coordination is vital for safety and efficiency. In rehabilitation, we often retrain these anticipatory adjustments in patients with balance or neurological issues, because without them, even simple movements can become unstable.

Preparation of Limb Movement Characteristics

- The brain prepares **which limb**, **direction**, and **trajectory** the movement will take.
- Movement characteristics are preprogrammed before execution begins.
- This ensures coordination and timing between limb segments.

Referenced section: “Preparation of Limb Movement Characteristics” (p. 190). **Suggested image:** Illustration showing direction and trajectory planning for a reaching movement.

Before movement begins, the motor system specifies several key features of limb motion — which limb will move, in what direction, how far, and along what path.

These movement characteristics are planned in advance to meet the task's constraints. For example, reaching to a target involves preparing both direction and trajectory so the arm moves efficiently and accurately.

Neural activity recorded before movement initiation shows that the motor cortex encodes these variables even before the muscles contract. In ballistic or spatially constrained tasks, such as hitting a target or catching a ball, the system must prepare the trajectory and timing beforehand.

This preprogramming is what allows us to move fluidly and avoid hesitation once the signal is given. In sports or rehabilitation, improving the clarity of these limb plans — through visualization, cueing, or repetition — can enhance both speed and coordination.

Preparation of Movements for Object Control

- When manipulating objects, preparation includes specifying:
  - **Force control** — how much force to apply.
  - **End-state comfort** — grasping based on the final, comfortable position.
- These anticipatory adjustments optimize efficiency and precision.

Referenced section: "Preparation of Movements for Object Control" (pp. 190–192). **Suggested image:** Person picking up a box or grasping a cup upside down, illustrating end-state comfort.

When we interact with objects, preparation becomes more complex — the brain must plan both how and how much.

First, there's force control. Before lifting a box or a pen, we anticipate its weight and prepare the appropriate grip and lifting force. If we expect an object to be heavy but it's actually light, our movement looks jerky because the prepared force exceeds what's needed. Butler and colleagues (1993) showed that people program lifting force before they feel the object — a clear sign that force control is part of preparation.

Second, there's end-state comfort control — planning the movement so that the final position is comfortable and efficient for the intended action. For example, if you pick up an upside-down cup to turn it upright, you'll start with an awkward grip that ends comfortably once the cup is rotated.

This shows that during preparation, the brain doesn't just plan how to start — it plans where the movement will end, prioritizing efficiency and precision over initial comfort.

Preparation of Sequences of Movements

- Sequential actions (typing, playing piano, etc.) are partially **preprogrammed** before the first movement starts.
- Evidence: increased RT with longer or more complex sequences.
- Kinematic studies show consistency in finger positioning across repeated trials.

Referenced section: "Preparation of Sequences of Movements" (pp. 192–193). **Suggested image:** Pianist or typist performing a movement sequence; visual cue showing finger paths.

Many motor skills involve sequences of movements — such as playing a piano passage or typing a word. Research shows that these sequences are at least partly prepared in advance.

Evidence comes from two areas. First, reaction time increases as the number of movements in a sequence increases. That's because the brain must organize more elements before the first one begins. Second, kinematic studies of pianists and typists show that their finger movements for upcoming notes are already positioned while the current movement is still occurring.

Engel and colleagues (1997) found that expert pianists adjusted their hand position before reaching certain notes, indicating that the brain had already planned the upcoming sequence.

This preparatory overlap explains why experienced performers can produce long sequences smoothly and without hesitation. In training or rehabilitation, breaking complex actions into smaller chunks helps learners gradually develop this anticipatory sequencing ability.

Rhythmicity Preparation and Preperformance Rituals

- Many performers use **preperformance rituals** to establish timing and rhythm before action.
- These routines create a consistent **rhythmic preparation pattern** that stabilizes performance.
- Research shows strong correlation between consistent rhythm and successful execution.

Referenced section: "Rhythmicity Preparation" (pp. 193–194). **Suggested image:** Basketball player performing a consistent free-throw routine.

A fascinating aspect of action preparation involves rhythmicity — the timing patterns people establish before executing a skill.

Athletes, musicians, and dancers often perform preperformance rituals — small, repeated behaviors like dribbling the ball a certain number of times before shooting or taking a deep breath before serving in tennis. These rituals are not superstition; they help the performer synchronize their motor system's rhythm with the upcoming task.

Southard and Amos (1996) analyzed these routines in golf, tennis, and basketball and found that consistent relative timing of pre-movement behaviors correlated strongly with successful performance. The rhythm of the routine helps "tune" the nervous system to the task's temporal demands.

When the rhythm is disrupted — for example, by time pressure or distractions — performance often declines. Thus, rhythmicity preparation helps stabilize the motor system, promoting smooth initiation and timing accuracy.

This is why coaches and therapists encourage routines: they anchor attention, regulate arousal, and help the performer enter an optimal preparatory state.

Practical Application: Understanding and Training Preparation Activities

Coaches

- Incorporate drills that train **anticipatory postural adjustments** (balance before motion).
- Teach athletes to plan **force and end-state comfort** for efficient object handling.
- Reinforce consistent **preperformance rituals** to stabilize readiness.

Instructors (PE, Dance, etc.)

- Use rhythmic warm-ups and cue timing to develop awareness of **pre-movement preparation**.
- Help students focus on sequence planning (e.g., choreography, instrument fingering).
- Encourage body awareness of stability and posture before movement.

Physical Therapists

- Address **anticipatory postural control** in balance and gait training.
- Teach patients to estimate and prepare force before lifting or grasping.
- Use repetitive task sequences to rebuild **motor planning and timing** in neurological rehab.

Suggested image: 1. Athlete rehearsing a start sequence. 2. Dancer synchronizing with rhythmic cues. 3. Therapist guiding patient through a reach-to-grasp task.

Understanding what happens during preparation allows us to design better training and rehabilitation interventions.

For coaches, emphasizing balance and postural readiness before action improves stability and reaction speed. Teaching athletes to anticipate required force and to use consistent preperformance routines enhances both precision and confidence.

For instructors, awareness of movement sequencing and rhythm is key. Encouraging rhythmic preparation helps students coordinate timing, while explicit cueing develops their sense of how movement is prepared internally before execution.

For physical therapists, these findings directly inform rehabilitation. Training anticipatory postural adjustments is critical for fall prevention. Helping patients plan and modulate lifting or grasping forces restores independence in daily activities. Repeated sequence practice — such as step or reach sequences — rebuilds the neural patterns required for efficient action preparation.

Across all disciplines, focusing on the preparation phase bridges cognitive planning and physical execution — leading to faster, smoother, and safer movement.

Conclusion: The Invisible Work of Preparation

- Action preparation involves multiple coordinated processes:
  - Cognitive planning (premotor phase)
  - Neuromuscular activation (motor phase)
  - Postural and limb readiness
  - Force, sequence, and rhythmic organization
- These occur **before movement starts** and ensure stability, precision, and timing.

Suggested image: Diagram showing overlapping layers of preparation: cognitive → postural → movement-specific → execution.

To conclude, movement preparation is far more complex than simply waiting for a “go” signal.

Within the reaction time interval, the nervous system performs an intricate series of motor control activities — identifying stimuli, selecting responses, organizing posture, programming limb trajectories, setting forces, and aligning rhythm.

This hidden preparation ensures that by the time movement begins, the system is already optimized for stability, accuracy, and coordination.

For practitioners, this means that improving performance isn't just about the movement itself — it's about improving what happens before movement starts. By training preparation — through cue recognition, balance work, mental rehearsal, and consistent pre-performance routines — we help performers and patients achieve smoother, faster, and more controlled actions.

Summary and Integration

Summary: Action Preparation in Motor Control

- Preparation = the **time and activity** between intention and movement initiation.
- **Reaction Time (RT)** measures how long preparation takes.
- Preparation involves **perceptual**, **cognitive**, and **motor** processes that ensure smooth, coordinated action.

Suggested image: Timeline from *Intention* ⟶ *Preparation* ⟶ *Movement*, showing "Reaction Time" highlighted.

Let's bring everything together. Action preparation is the critical phase between the decision to move and the start of movement. During this period, the brain interprets signals, selects responses, organizes posture, and activates the motor system — all before any visible motion occurs.

We use reaction time (RT) as a tool to measure how long this preparation takes. But RT is more than a stopwatch number — it represents the mental and neural work that the body must perform before any action begins.

Whether in sports, daily life, or therapy, understanding preparation helps us explain why some movements feel fluid and others feel delayed or awkward. Preparation is the foundation of all voluntary movement.

Objective 1: RT as an Index of Preparation

- RT reveals **how much preparation** is required for an action.
- Actions vary in preparation time depending on complexity and context.
- **Donders' RT studies** showed that each mental stage — identification, selection, programming — adds measurable time.

Suggested image: Diagram of Donders' three tasks (simple, choice, discrimination RT).

We began by exploring why RT can be used as an index of preparation. Donders' experiments in the 1800s showed that as a task becomes more complex — for example, requiring stimulus discrimination or response selection — reaction time increases.

This simple but powerful idea established that RT reflects the internal processing between perceiving a cue and beginning to move. So, every delay we measure tells us something about what's happening in the performer's brain before action even starts.

Objective 2: Hick's Law – Choices and RT

- **Hick's Law**: RT increases **logarithmically** as the number of choices increases.
- RT = $k\ [\log_2 (N + 1)]$.
- Each additional choice adds a predictable amount of preparation time.
- Skilled performers reduce effective choices through **anticipation** and **cue recognition**.

Suggested image: *Figure 8.1* – RT vs. number of response choices (logarithmic curve).

Hick's Law formalized the relationship between decision complexity and reaction time. Each extra choice adds cognitive load — more information to process, more time to prepare.

But the increase isn't linear; it's logarithmic. The first few options add substantial time, but beyond a certain point, additional choices add less delay.

In sports or fast decision environments, skilled performers counteract this by reducing the number of meaningful options — focusing only on key cues. That's why experience shortens RT — it's not about reflexes; it's about information management.

Objective 3: Task and Situation Factors Influence RT

Factors that **increase RT** (and preparation time):

- More response alternatives
- Lower predictability
- Incompatible stimulus–response mappings
- Irregular foreperiods
- Higher movement complexity or accuracy demands

Factors that **decrease RT**:

- Predictable cues
- Compatible layouts
- Consistent timing
- Repetition and familiarity

Suggested image: Flowchart linking each factor to "↑RT" or "↓RT."

Beyond the number of choices, task and situation characteristics also shape preparation time.

For example, RT increases when cues are unpredictable, movements are complex, or accuracy demands are high. It also lengthens when the stimulus and response are poorly matched — known as low stimulus–response compatibility.

In contrast, consistency, practice, and familiarity shorten RT. A predictable foreperiod or repeated movement allows the motor system to preload the response.

The key lesson is that designing the environment — whether in training, education, or therapy — directly influences how efficiently someone prepares to move.

Objective 4: Performer Characteristics Influence RT

- **Alertness** and **vigilance** determine readiness to detect signals.

- **Attention focus** (sensory set vs. motor set) affects RT — focusing on the **signal** leads to faster initiation.
- **Performance expectancy** and confidence influence preparation efficiency and energy use.

Suggested image: Performer's mental state continuum — drowsy → optimal → over-aroused.

Preparation doesn't depend only on external factors — it also depends on the performer's internal state.

High alertness and focused attention shorten RT, but fatigue or distraction increase it. Long-term vigilance tasks — like driving or monitoring — degrade performance as attention fades.

Where attention is directed also matters: focusing on the signal rather than the movement yields faster responses. And finally, expectations — believing one will perform well — enhance efficiency. Positive feedback improves preparation by reducing unnecessary tension and optimizing motor coordination.

In sum, the mind and body must be ready together for fast, effective action.

Objective 5: What Happens During Preparation

Key motor control activities:

- **Fractionated RT** → premotor (planning) and motor (activation) components.
- **Anticipatory postural adjustments** stabilize the body before motion.
- **Limb and object planning** — direction, force, and end-state comfort.
- **Sequence and rhythmicity preparation** — organizing movement order and timing.

Suggested image: Layered chart showing preparation components building up to movement onset.

Finally, during the reaction time interval itself, the body and brain are far from idle.

EMG studies show a clear premotor phase, when the brain is selecting and programming the response, followed by a motor phase, when muscles begin firing before movement starts.

Before every action, the system also engages in postural preparation, setting the base of support. When manipulating objects, it pre-programs force and final hand position for efficiency. For sequences, it organizes the order of movements in advance; and for rhythmic actions, it establishes timing through preperformance routines.

These processes illustrate the extraordinary sophistication of the motor control system — orchestrating multiple components seamlessly before we even move.

Integrative Summary: The Dynamics of Action Preparation

- **Preparation time (RT)** reflects the **complex interaction** of:
-
  - Task and situation demands
  - Performer state and focus
  - Neural and muscular pre-activation
- Optimizing performance means **training the preparation phase**, not just the execution.

Suggested image: Integrated concept map connecting: “Task,” “Performer,” and “Physiology” ⟶ “Reaction Time” ⟶ “Performance.”

Across all five objectives, the message is clear: action preparation is an integrated process. Task conditions, performer readiness, and underlying neural mechanisms all combine to determine how effectively and how quickly movement begins.

By understanding these interactions, we can design practice, teaching, and therapy that go beyond surface movement — focusing instead on the moment before the movement.

That’s where precision, speed, and control are truly built. When we train preparation — attention, anticipation, posture, timing — we train the foundation of skilled performance itself.

Final Application: From Theory to Practice

Coaches

- Simulate real-time decision-making and timing variability.
- Reinforce alert, cue-focused, confident preparation.

Instructors

- Emphasize readiness routines and attentional focus in learners.
- Use rhythm and consistency to teach efficient preparation.

Physical Therapists

- Train anticipatory postural control and task sequencing.
- Use clear cues and patient-paced intervals to rebuild readiness.

Suggested image: Collage — athlete on starting blocks, dancer preparing for a cue, patient standing with therapist support.

In practical terms, everything we’ve discussed about reaction time and preparation connects back to performance.

Coaches can train athletes to read cues and anticipate rather than react, shortening preparation time under pressure. Instructors can design learning environments that develop attentional focus and rhythmic readiness. Therapists can rebuild motor preparation and confidence after injury or neurological damage.

The unifying theme is that what happens before movement determines the success of the movement itself. When preparation is optimized — cognitively, physically, and emotionally — movement becomes faster, smoother, and more effective.

References

Bibliography