Motor learning

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Motor learning

It is a set of processes associated with practice, training, or experience that results in relatively permanent changes in motor behavior.

concepts of motor learning

➢ Learning is a process of acquiring skills.

➢ Learning results from experience or practice.

➢ Learning can`t be measured directly.

➢ Learning produces a relatively permanent change in behavior.

How to judge?

➢Performance.

➢ Retention .

➢ Transfer

Performance

➢Motor Performance is not Motor Learning.

➢Motor Performance is the temporary change in motor behavior seen during a practice session.

➢Example : A patient learns how to shift more body weight over the weaker leg at the end of the therapy session. However, the patient still bears more weight on the unaffected leg at the next visit to PT. Learning has not occurred.

➢Performance may be influenced by many other variables, e.g. fatigue, level of learning/skills, anxiety, motivation, medications, cues or manual guidance given to the learner

Retention

➢It refers to the ability of the learner to demonstrate the skill over time and after a period of no practice (retention interval).

➢Performance after a retention interval may decrease slightly, but should return to original performance levels within relatively few practice trials.

➢For example, riding a bike is a well-learned skill that is generally retained even though an individual may not have ridden for years.

Transfer

➢ The ability to adapt/tranfer and refine a learned skill to changing task and environmental demands.

➢ This is another important measure of motor learning.

➢ It required to perform a motor task in altered environmental situations.

➢ For example; transfer from WC to bed could be adapted to transfer from WC to car/toilet.

➢ For example: e.g., walking with a cane on indoor level surfaces) should be able to apply that learning to new and variable situations (e.g., walking outdoor).

Learning and Memory

- Memory storage of learning outcome.

➢**Short-term memory**: Refers to working memory, which has a limited capacity for information and lasts only a few minutes to hours. recall/ retrieval very rapid. Memory fade rapidly (Permanent forgetting).

➢**Long-term memory**: Long-term memory is intimately related to the process of learning

1) Initial stages of long-term memory reflect **functional changes** to the efficiency of synaptic connections.

2) Later stages of long-term memory reflect **structural changes** in synaptic connections.

Two forms of long-term memory

Explicit (declarative)
- Facts — Events
  - Medial temporal lobe areas
  - Sensory association cortex
  - Hippocampus

Implicit (nondeclarative)
- Nonassociative learning: habituation and sensitization
  - Reflex pathways
- Associative learning: classical and operant conditioning
  - Emotional responses
    - Amygdala
  - Skeletal musculature
    - Cerebellum
    - Deep cerebellar nuclei
    - Premotor cortex
- Procedural (skills and habits)
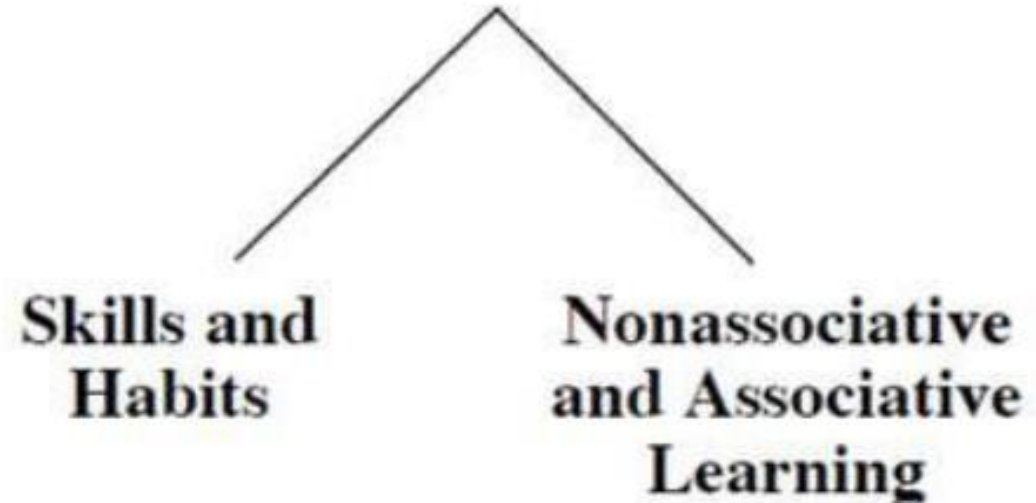 - Striatum and other motor areas (cerebellum, etc.)

Explicit (Declarative)	Implicit (Procedural)

Facts and Events	People, Objects and Places	Skills and Habits	Nonassociative and Associative Learning
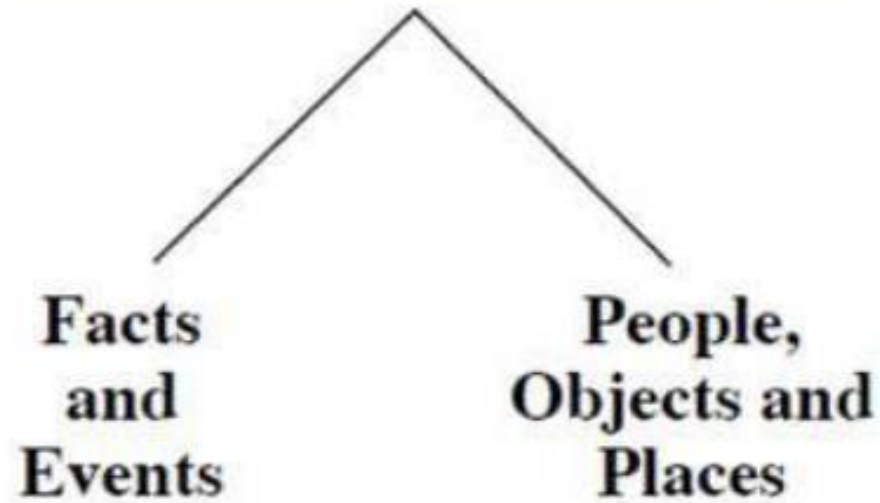
Medial Temporal Lobe Hippocampus

Amygdala, Striatum, Cerebellum, Reflex Pathways

Requires Conscious Attention

Does Not Require Conscious Attention

Implicit learning

Non associative	Associative
A simple form of learning that include habituation and sensitization	A more complex form of learning in which association between two events is formed

Non declarative (Implicit) Learning
Non-Associative Learning

➢ A single stimulus is given repeatedly and the nervous system learns about the characteristics of the stimulus.

➢ **Habituation** >>> ↓ response to the stimulus, e.g. exercises to treat dizziness in patients (vestibular habituation exercise).

➢ **Sensitization** >>> ↑ response to the stimulus, e.g. training to enhance awareness of loss of balance.

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Non declarative (Implicit) Learning Associative Learning

Classical Conditioning

➢ learn to predict relationships between two stimuli.

➢ Example :before learning: verbal cues + manual guidance + stand up; after learning: verbal cue then directly stand up.

➢ Patients are more likely to learn if the associations are relevant and meaningful.

➢ During classical conditioning, an initially weak stimulus (conditioned stimulus) becomes associated with another stronger stimulus (unconditioned stimulus)

Operant Conditioning

➢ learn to associate a certain response, from among many that we have, with a consequence; trial and error learning.

➢ Example : relearn stability limits after ankle sprain; verbal praise from PT.

➢ behaviors that are beneficial and rewarded tend to be repeated.

Non declarative (Implicit) Learning
Procedural Learning

➢Does NOT require attention, awareness, or other higher cognitive processes.

➢One automatically learns the rules for moving, i.e. movement schema.

➢Learning requires repeating a movement continuously under a variety of situations.

Declarative (Explicit) Learning

➢Require attention, awareness, and reflection.

➢Results in knowledge or facts (e.g. objects, places, events) that can be consciously recalled and expressed in declarative sentences.

➢Example: "1st I move to the edge of chair. 2nd lean forward and stand up"; instruction from PT; mental rehearsal; motor imagery.

➢Constant practice can transform declarative into procedural or non declarative knowledge.

➢Example: a patient first learns to stand up may verbally repeat the instruction; after repeated practice, the patient may be able to stand up without instruction.

➢Processes of declarative learning: encoding (neural circuit) ➔ consolidation(structural change in neurons) ➔ storage(long term retention of memory) ➔ retrieval (recall).

Theories & models of motor learning

1) **Adams Closed-Loop Theory**
2) **Schmidt Schema Theory**
3) **Ecological Theory**
4) **Systems Three-Stage Model.**
5) **Gentile's Two Stage Model.**
6) **Fitts and Posner Three Stage Model: Cognitive stage , Associative Stage , Autonomous Stage**

Application of motor learning theories

➢**Practice**
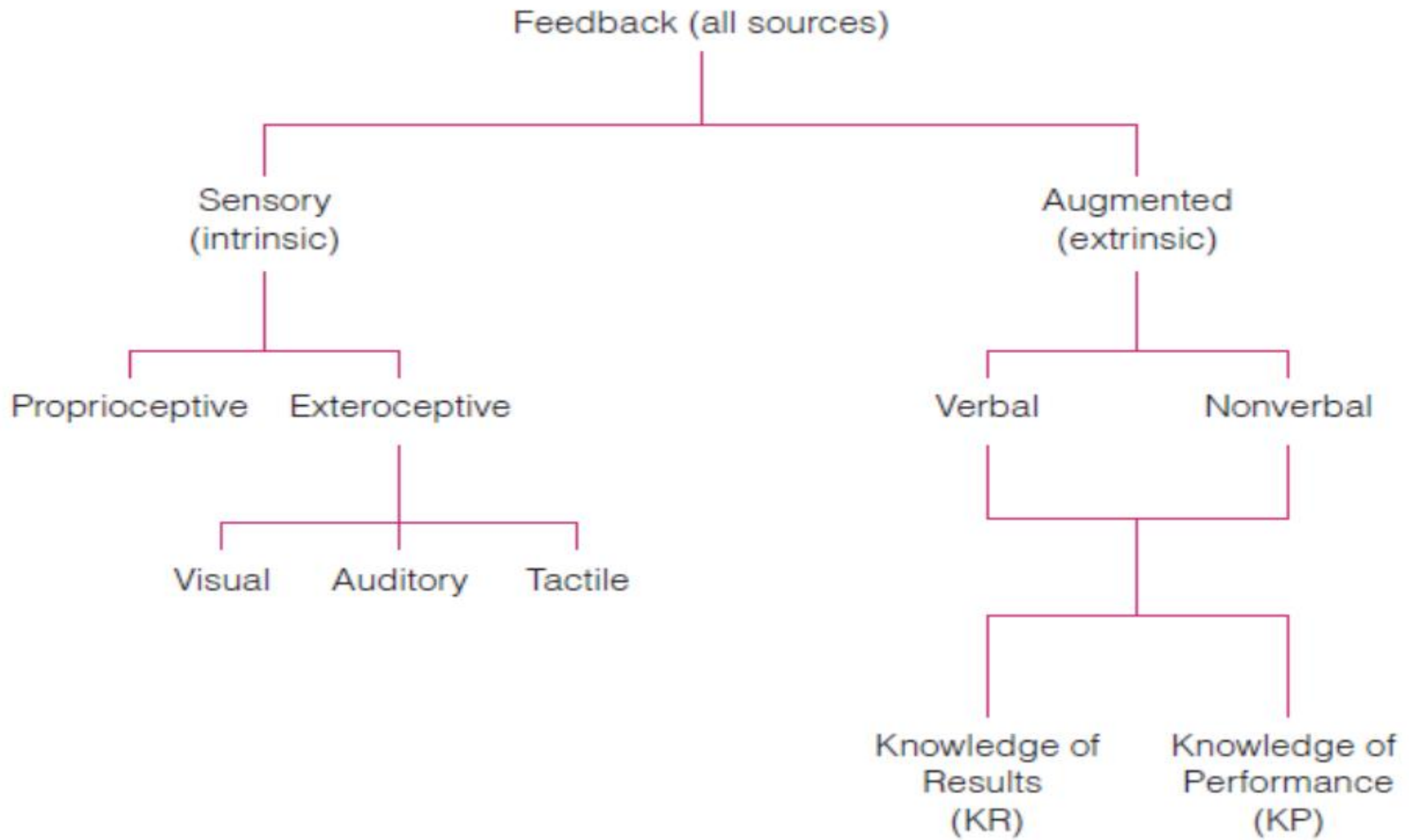
➢**Feedback.**

Practice Conditions

Massed vs. Distributed Practice Schedule	Massed (practice time > rest time) Distributed (rest time ≥≥practice time) / less or no fatigue.
Constant vs. Variable Practice	Usually variable practice (walk at different speeds) results in increase the ability to adapt & generalized . constant practice (walk at the same speed) .
Random vs. Blocked Practice	Random practice (practice multiple tasks in 15 min) (complete pattern) results in better learning >>> (ADL) than blocked practice (practice one task in 15 min) in healthy adults.
Whole- vs. Part-Task Practice	Whole(pat. Practice the whole task. Part(pat. Break task into stepes. Task specificity says the best practice is the task itself. If utilizing a part technique, the part (e.g. hip and knee flexion, extension) must be a naturally occurring component of the whole (e.g. walking).
Guided practice vs. Discovery Practice	Usually you start with guided practice to ensure proper application of exercises , then you can use discovery practice gradually to teach the patient to adapt new circumstances occurring within the motor performance .

Feedback (FB)

- It Is the information received during or following the movement, which inform the learner about the effectiveness of the response.

- Feedback is any response-related information received either during or after the production of a movement skill.

- During therapy, both intrinsic and extrinsic feedback can be manipulated to enhance motor learning.

Benefits of Feedback

- **Information** Informs learners about the outcomes of their actions as well as the correctness or incorrectness of their movement patterns.

- **Motivation** Energizes learners and encourages them to continue exerting efforts to accomplish learning goals.

- **Reinforcement** Promotes correct behaviors and discourages continuance of incorrect behaviors.

- **Guidance** Acts to guide learners toward correct actions (which can create dependency on feedback as a source of information

Feedback (all sources)

Sensory (intrinsic)

- Proprioceptive
- Exteroceptive
  - Visual
  - Auditory
  - Tactile

Augmented (extrinsic)

- Verbal
- Nonverbal
  - Knowledge of Results (KR)
  - Knowledge of Performance (KP)

Feedback (FB)

➢Type of feedbacks

1) according to the mode of delivery: Intrinsic (e.g. proprioceptive& extroceptive) and Extrinsic (e.g. instruction from PT/video/ EMG biofeedback).

2) according to information provided : Knowledge of results (KR) and Knowledge of performance (KP)

Knowledge of Performance (KP)

➢Information about the movement patterns.
➢ Usually intrinsic but can also be extrinsic.
➢ Proprioception, Biofeedback, video recording, verbal instruction (e.g. "Your elbow was too low.")

Knowledge of Results (KR)

➢Information about the result or outcome of the movement in terms of the goal.
➢ Verbal instruction (e.g. "You were off the target.")

Learning Phases-Fitts & Posner

There are three stages to learning a new skill:

* **Cognitive phase** - Identification and development of the component parts of the skill - involves formation of a mental picture of the skill.

* **Associative phase** - Linking the component parts into a smooth action - involves practicing the skill and using feedback to perfect the skill.

* **Autonomous phase** - Developing the learned skill so that it becomes automatic - involves little or no conscious thought or attention whilst performing the skill - not all performers reach this stage

Cognitive phase	▪ Target is to understand task = what to do/ Create cognitive map/ Frequents errors/Rely on vision/Environmental should give NO distraction = optimize learning/Gradual improving in performance
Training example	▪ Identify purpose of task/ Verbalize task components/ More attention to critical task elements/ Use vision greatly/ Establish reference of correctness/ Make rewards ▪ Knowledge of performance (KP) = more consistent errors **not** all errors. ▪ **Knowledge of Results** (KR) = focus on success.
Feed back (FB)	▪ After each trial = improve performance during EARLY learning.
Initial practice	▪ Control stress/ Use manual guide/ Break tasks into components/Block practice repetition of the same task/ Avoid fatigue. ▪ Disturbed practice (Rest) specially with poor attention / short concentration
Environment	▪ Reduce distractions.

Associative phase	■ Continued practice = refined pattern/ Theme = HOW TO DO? ■ Spatial & temporal organized = coordinated movement. ■ ++ consistency / -- errors. ■ proprioceptive > vision .
Training examples	■ Select proper feedback. ■ KP = interfere if errors consistent. ■ KP = Emphasize proprioception = feel of movement. ■ KP = ++ internal reference of correctness
Feedback	■ KR = focus on outcomes. ■ KR = help for self evaluation / decision making. ■ Guided movement NOT ideal.
Organized feedback	■ Keep it for motivation. ■ NOT excessive augmented. ■ Use variable (summed).
Organize practice	■ Consistency practice. ■ VARIABLE Practice order (serial – random).
Environment	■ Progress to OPEN environment

Autonomous phase	▪ Minimal attention/ Pt focus on HOW TO SUCCEED? ▪ Spatial & temporal +++ organized = coordinated movement. ▪ Do great whatever environment .
Training example	▪ Select proper feedback. ▪ Pt do self evaluation / decision making. ▪ KP/KR only occasional.
Organize practice	▪ Consistency practice in variable environment. ▪ High level of practice = MASSED
Environment	▪ Vary environment. ▪ READY for home/ community/ work

Cognitive stage

➢ Highlight purpose of the task in functional term

➢ Demonstrate ideal performance = reference of correction.

➢ Ask patient to verbalize task components.

➢ Point out similarities to other learned tasks.

➢ Direct attention to critical task element.

➢ Pair between extrinsic Feedback and intrinsic one.

➢ KR = focus on success of movement.

➢ KP= consistent errors.

- ➢ Use motivation – rewards.
- ➢ Feedback after each trial = early sessions.
- ➢ Variable FB later.
- ➢ Organize practice = -- stress / disturbed practice / block practice / break task into components / mental practice.
- ➢ Reduce external environmental.
- ➢ Use closed skills

Associative phase

➢ Focus on KP (Knowledge of performance).

➢ Emphasize proprioception FB = feel the movement = internal reference of correction.

➢ Help patient for self evaluation – decision making.

➢ Guided / facilitated movement is not valuable.

➢ Avoid excessive FB

➢ Encourage consistency of performance.

➢ Variable practice order.

➢ Open environment.

➢ Be ready for community

Autonomous phase

➢ Patient shows self evaluation / decision making skills.

➢ Occasionally FB.

➢ Consistency of stress in variable environment.

➢ Mass practice / random practice.

➢ Ready for community.

Factors affecting learning
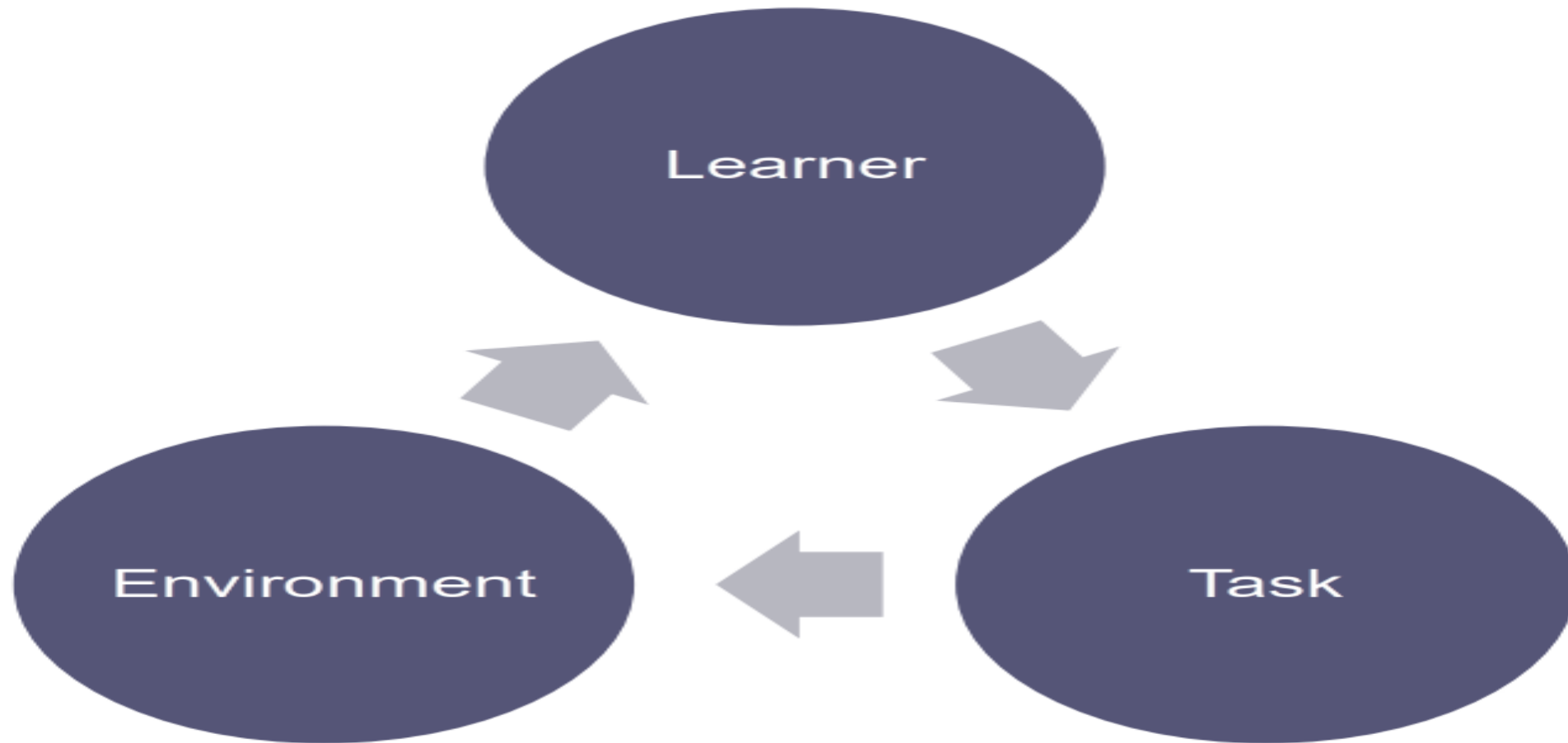
Learner (patient)

➢ Readiness.

➢ Level of Motivation.

➢ Physical status/ fitness level.

➢ IQ/ educational level.

➢ Abilities.

➢ Psychological characteristics.

➢ Practice.

➢ Individual difference

Environment (home/clinic)

➢Presence of observer.

➢Background .

➢Light/ surface/ voice.

➢Open/ closed.

Task (short/long-term goal)

➢ Type (Simple/ complex) .

➢ Alone or with others .

➢ Have clear start and end point/ continuous.

➢ Speed.

➢ Needs (equipment).

➢ Stability/ mobility.