© Global International Research Thoughts (GIRT)
ISSN: 2347-8861 | Volume: 10 Issue: 02 | December 2022
Paper is available at https://girtjournal.com
Email : info@girtjournal.com
Refereed and Peer Reviewed

Applying principles of motor learning and control to upper extremity rehabilitation

Dr Jagbir Singh
Assistant professor
DIET, Karkardooma, Delhi

Abstract
This article's goal is to provide a concise summary of the fundamental ideas behind motor control and learning. Several models of motor control, ranging from ancient to modern, are discussed in this article, with a particular focus on the systems model. The concepts of motor learning, such as the acquisition of skills, the assessment of learning, and the strategies that encourage skill acquisition by studying the numerous parts of practise scheduling and the use of feedback, are presented here. To assist the reader in comprehending these ideas and how they may be used in clinical settings, a fictitious patient case is presented at the beginning of the article and is carried forward throughout its whole.

Keywords Motor Learning; Motor Control; Hand; Upper extremity; Rehabilitation

Introduction

If a patient has a neurological condition or injury, it may be possible to overcome the difficulty of regaining hand and arm skills by including essential ideas of motor learning and control into their therapy regimens. However, in order to successfully include these ideas into hand rehabilitation programmes, motor learning and motor control mechanisms need to be better understood first. This will allow for a more seamless integration of these ideas. This review will provide an overview of fundamental concepts of motor learning and motor control that are applicable to the process of fostering skill development in upper extremity (UE) rehabilitation. The objective of this review is to explain these essential principles. We will use the example of "Joan," a woman of 38 years old who had a catastrophic brain injury that resulted in left UE hemiplegia, to demonstrate how these ideas may be used to those who have neurological problems.

Motor learning and control

The acquisition of motor abilities is accomplished by a process known as motor learning1, the principles of which include knowledge gleaned from fields such as psychology, neurology, physical education, and rehabilitation research. Our knowledge of how people develop from inexperienced to expert motor performance over the course of a lifetime is shaped by the collective contributions of these disciplines. Infants who are beginning to reach and grab make use of the perceptions they have of their own body and talents in order to secure things that range in both form and size. In order to adapt how they do manipulation activities; older persons often have to make accommodations for the progressive loss of strength and changes in sensory perception that occur naturally with age. Individuals who suffer from neurological diseases that have an adverse effect on the function of the UE may be required to relearn previously learned motor skills despite having a different quantity and quality of resources at their disposal.

Systems Model The many theories of motor control give a framework that may be used to guide the understanding of how learning or relearning movement happens. Perspectives on motor control are derived from ever-evolving models of the nervous system. These models, in turn, are representative of the paradigm changes that have occurred over the course of history. Throughout the course of history, new paradigms have been formed whenever the notions of an old paradigm began to constrain the manner in which movement and behaviour were understood. As an example, in the early 1900s, many believed that reflex connections were responsible for voluntary movement. This paradigm paved the way for several theories of motor control; but, as our understanding of the nervous system has grown, these ideas have been superseded. Even though the assumptions that are linked with the various theories of motor control are different from one another, the vast majority of contemporary theories have included a systems perspective of the dispersed regulation of the nervous system. According to the Systems model, movement is the consequence of the interplay of different systems cooperating with one another to find a solution to a motor issue. The flexibility and adaptability of motor behaviour may be accounted for using the Systems model, which is one of the benefits of using this model. Various environmental variables can be taken into consideration. Movement is mostly determined by functional objectives in addition to limits imposed by the environment and the activities being performed. This frame of reference offers a framework for establishing intervention methods based on task objectives that are targeted at enhancing motor abilities. The purpose of these strategies is to improve the individual's motor skills. Consider the instance of Joan, who is attempting to put on a blouse while seated on the edge of the bed. This scenario is intended to illustrate how mobility problems might be resolved. She has to figure out how to handle this motor challenge while taking into account the limitations that her brain damage imposes in order for her to be successful. When Joan makes this functional action, the Systems model of control argues that she needs to take into account a number of different elements, both internal and external to herself. At a bare minimum, internal elements might include a person's strength, flexibility, coordination, degree of discomfort, motivation, intellect, and autonomic function, as well as sitting balance. External influences might include the style of shirt worn, the level of hardness in the bed, the nature of the floor surface, the availability of assistive gadgets, and distractions from the outside environment. In order to successfully perform the process of dressing the upper body, it is necessary for all of the relevant systems to collaborate in order to develop a unified plan.

Degrees of Freedom Problem

The nervous system is faced with a considerable challenge whenever it is tasked with developing a single best strategy for movement. Nikolai Bernstein, a Russian neurophysiologist who lived in the nineteenth century and disputed the prevailing reflex theories of movement that dominated his profession, is credited with being the first person to propose the idea that different systems collaborate in order to produce movement. He maintained that the degrees of freedom issue had to be solved before one could accomplish smooth and effective voluntary movement. Bernstein realised that when several systems interact, a large number of movement options—also known as degrees of freedom—are available to achieve the same action. For instance, Joan may reach for a cup on a table in front of her by flexing her shoulder and extending her elbow, or she could maintain her arm close to her body and flex at the trunk to bring her hand near the cup. Both of these movements would bring Joan's hand closer to the cup. This redundancy occurs at several levels across the central nervous system. For instance, muscles may contract in a variety of different ways to regulate a variety of distinct movement patterns or joint movements. In addition, the same result or action may be achieved by the execution of a wide variety of distinct kinematic and movement patterns. A healthy person may put on a shirt by starting the activity with one arm, the other arm, or even both arms at the same time — all three methods achieve the same dressing objective. Bernstein, has proposed that one of the primary roles of the central nervous system is to manage redundancy. He proposes that this is accomplished by reducing the amount of

© Global International Research Thoughts (GIRT)
ISSN: 2347-8861 | Volume: 10 Issue: 02 | December 2022
Paper is available at https://girtjournal.com
Email : info@girtjournal.com
Refereed and Peer Reviewed

degrees of freedom or separate movement components that are used. The solution to the issue of degrees of freedom will be different for each student because of the differences in the components of the task and the environment, as well as the characteristics of the learner. When Joan tries to put on the shirt, her shoulder discomfort could make it more likely for her to engage in co-contraction in an effort to prevent unwanted movement in her body and stabilise herself. Because of her impulsivity and lack of understanding, it's possible that she'll be less successful at adequately restraining the degrees of freedom during her first few efforts at dressing. Therefore, when Joan is in the beginning stages of learning how to dress her upper body, she may produce very simple movements and limit the amount of joint motion by holding some joints rigidly via muscle co-contraction. This is because she is in the beginning stages of learning how to dress her upper body. By doing this step, the degrees of freedom are reduced, which results in increased chances of success. It's possible that Joan's muscular co-activation will diminish as she becomes better at the job. It is possible that as her competence increases, she will demonstrate a greater fluidity, which is a reflection of the CNS's capacity to utilise numerous motor resources in order to do certain tasks.

Dominant Theories

The subject of how certain movement patterns are chosen out of the huge number of accessible alternatives has a significant impact on the way in which therapists intervene. There are a lot of hypotheses that have been established that describe how various systems may possibly join together to make a functioning movement. Nevertheless, for over forty years, two separate categories of theory have been the ones that have dominated the conversation. The first theory is centred on the centralised control of movement instructions whereas the second theory is centred on the dynamic self-organization of various subsystems in relation to a significant objective (e.g., Dynamic Pattern or Dynamical Systems Theory [DST]). At first, the Motor Program Theory proposed that some kind of brain storage of motor plans took place and that these stored motor plans could be retrieved whenever they were required in order to accomplish certain motor objectives. The capacity of MPT to fully describe voluntary movement has been complicated by the emergence of three significant challenges: the difficulty of storage, the problem of novelty, and the problem of motor equivalence. The vast repertory of human motions is the root cause of the storage challenge. Where can I get the motor designs for the various movements? It would seem that the nervous system would need to have a limitless capacity for storage in order to hold all of the plans required for the many kinds of movement that are possible. The capacity to plan fresh behaviours is the subject of the second challenge, which is known as the novelty problem. How is it possible for there to be a programme for a movement that has never been carried out before? Last but not least, there is the problem of motor equivalence, which states that an identical action may be carried out utilising various combinations of patterns of coordination. If the behaviour is the consequence of a computer programme, how is this even possible? The generalised motor programme (GMP) hypothesis that was suggested by Schmidt provides an answer to a number of the problems that were discussed in the MPT earlier. his research, Schmidt makes the case that motor programming do not always need to be tailored to each individual activity. Instead, there are generic programmes that include instructions for a wide variety of behaviours that are quite similar to one another. This reduces the amount of space needed for storage, accounts for novelty (new actions are merely versions of other actions previously performed and, as a result, are a part of an existing class of movements), and explains motor equivalence by arguing that the rules of a GMP are not muscle specific. Instead, the programme specifies invariant features such as timing and force coordination. These invariants assist identify classes of movement and reduce the total amount of information that has to be saved, therefore they are quite helpful. On the other hand, the DST suggests that movement is not a sequence of motor steps that are "stored," but rather an emergent property that takes place as the neuromuscular system interacts with its surroundings; it is an online adaptation that is tailored to the activity that is currently being performed. During DST, a participant's ability to physically move is limited by factors including the person (such as size, intellect, and motivation), the environment (such as light and gravity), and the task (goals, rules, etc.). Even while the CNS is still required for beginning movement and keeping track of any errors that may occur during continuing movement, it is just one of the subsystems that is ultimately accountable for the output of the motor. One of the presumptions that is made by DST is that other movement patterns are able to arise whenever there is a change in one part of the system, despite the fact that some movement patterns are favoured, this does not mean that they are required. When dealing with patients, this is an appealing concept to consider since changes in their body structure (for example, hemiparesis of one arm) would signal a "shift in a sub-system," which would make it possible for a new adaptive motor pattern to arise. The use of the DST approach may be shown by the provision of possibilities inside clinic and home-based programmes for the formation of new patterns. It is not quite obvious whether of these two competing ideas will emerge victorious or if a middle ground explanation will emerge that better explains how movement takes place. Bernstein4 proposed that the result of a movement is reflected in a motor plan (for example, aiming a ball toward a goal), and that this representation is then disseminated at various levels of the central nervous system (CNS). This idea has been incorporated into a great number of different hypotheses. Flexible brain representations of the dynamic and dispersed mechanisms by which the nervous system may solve motor difficulties seem to exist, despite the fact that the particular structure of motor plans is not understood. A motor programme is now an abstract representation of a movement that centrally organises and regulates the degrees of freedom. This represents an evolution in the nature of the motor programme. The process of learning is dependent on the interaction and strengthening of various systems, and it is possible that there are robust brain connections across related systems that may be understood in a simplified manner as representations. It is necessary for this internal representation to be matched to the external world, and it is probable that functional movement will arise as a consequence of this interaction.

Conclusion

The acquisition of motor abilities is accomplished by a process known as motor learning. This article will provide an overview of the fundamental concepts of motor learning and motor control. We will use the example of "Joan," a woman of 38 years old who had a brain injury that resulted in left-hemiplegia. Many theories of motor control provide a framework that may be used to guide the understanding of how learning or relearning movement happens. According to the Systems model, movement is the consequence of the interplay of different systems cooperating with one another to find a solution to a motor issue.

The Systems model of control argues that Joan needs to take into account a number of different elements, both internal and external to herself. In order to successfully perform the process of dressing the upper body, it is necessary for all of the relevant systems to collaborate in order to develop a unified plan. When Joan tries to put on the shirt, her shoulder discomfort could make it more likely for her to engage in co-contraction in an effort to prevent unwanted movement in her body and stabilise herself. Because of her impulsivity and lack of understanding, it's possible she'll be less successful at adequately restraining the degrees of freedom during her first few attempts at dressing. The capacity of MPT to fully describe voluntary movement has been complicated by the emergence of three significant challenges: the difficulty of storage, the problem of novelty, and motor equivalence.

© Global International Research Thoughts (GIRT)
ISSN: 2347-8861 | Volume: 10 Issue: 02 | December 2022
Paper is available at https://girtjournal.com
Email : info@girtjournal.com
Refereed and Peer Reviewed

The generalised motor programme (GMP) hypothesis provides an answer to a number of the problems that were discussed earlier. During DST, a participant's ability to physically move is limited by factors including the person (such as size, intellect, and motivation) and environment. The use of the DST approach may be shown by the provision of possibilities inside clinic and home-based programmes for the formation of new patterns. Flexible brain representations of the mechanisms by which the nervous system may solve motor difficulties seem to exist, despite the fact that the particular structure of motor plans is not understood. The process of learning is dependent on the interaction and strengthening of various systems, and it is possible that there are robust brain connections across related systems.

References

1. Newell KM. Motor skill acquisition. Annual review of psychology. 1991; 42:213–237.
2. Kuhn, TS. The Structure of Scientific Revolutions. 2nd ed. University of Chicago Press; Chicago: 1970.
3. Sherrington C. Flexion-reflex of the limb, crossed extension-reflex, and reflex stepping and standing. J Physiol. 1910; 40(1–2):28–121. [PubMed: 16993027]
4. Bernstein, NA. The Coordination and regulation of Movements. Pergamon Press; Oxford: 1967.
5. Horak, F. Assumptions underlying motor control for neurologic rehabilitation. Alexandria, VA: 1991.
6. Gordon, J. Assumptions underlying physical therapy intervention. In: Carr, JA.; Shepard, RB., editors. Movement Science: Foundations for Physical Therapy in Rehabilitation. Aspen Publishers, Inc; Rockville, MD: 1987.
7. Keele SW. Movement control in skilled motor performance. Psychological Bulletin. 1968; 70(6): 387–403.
8. Schmidt RA. A schema theory of discrete motor skill learning. Psychological review. 1975; 82(4): 225–260.
9. Schmidt RA. Motor schema theory after 27 years: reflections and implications for a new theory. Research quarterly for exercise and sport. Dec; 2003 74(4):366–375. [PubMed: 14768837]
10. Thelen E, Ulrich BD. Hidden skills: a dynamic systems analysis of treadmill stepping during the first year. Monogr Soc Res Child Dev. 1991; 56(1):1–98. discussion 99–104. [PubMed: 1922136]
11. Scholz JP. Dynamic pattern theory--some implications for therapeutics. Physical therapy. Dec; 1990 70(12):827–843. [PubMed: 2236226]
12. Newell, KM. Constraints on the development of coordination. In: Wade, MG.; Whiting, HTA., editors. Motor development in children: Aspects of coordination and control. Nijhoff; Amsterdam: 1986.