CHAPTER I
INTRODUCTION

Human beings use movement to learn about their world, to function in the world as they grow and mature, and to maintain healthy bodies (Gale Encyclopedia of Education, 2012).

Technically, measurable motor movement of skeletal muscles of the body corresponds to the visceral changes, conduction of nerve impulses and circulation of the body fluids (Fricke and Schoenau, 2005). Motor movement is the visible aspect of performance on a task. It is connected with the action response linked information processing that takes place in the brain. It is further associated with task related variables e.g. task complexity contingencies and with person variables e.g. anxiety.

The well-known information processing approaches that have been providing different perspectives on the dynamics of efficient task execution include resource allocation (e.g. Kahneman, 1973; Norman and Bobrow, 1975), attenuation theory (e.g. Treisman, 1980), filter theory (e.g. Broadbent, 1982), working memory concept (e.g. Baddeley, 1980).

Motor control includes the information processing activities carried out by our central nervous system that helps us organize, move and coordinate our movements and muscles. It is an essential element of human life and allows us to do many of our daily activities (Wikipedia, 2012).

Within a large scheme, the problem of motor control is defined as the problem of how action goals are represented, how motor plans are formulated, and how movements are executed (c.f. Cisek, 2005).

Motor control was understood quite early in systems neuroscience as the output end of a long series of perceptual, cognitive, and planning processes (e.g. Newell and Simon, 1972).
The basic functional architecture of behavior is assumed to consist of separate serial stages as under:

<table>
<thead>
<tr>
<th>PERCEPTION</th>
<th>• To collect information from sensors and construct an internal representation</th>
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<tbody>
<tr>
<td>COGNITION</td>
<td>• To use the above representation alongwith stored past experiences and to make decisions about future courses of action</td>
</tr>
<tr>
<td>ACTION</td>
<td>• To prepare and execute motor plans to accomplish the organism’s goal, also known as feedforward</td>
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**Figure No. 1.1:- Schematic representation of motor control process**


Specifically, perceptual motor behavior has been referred to as the extracting of more and more refined information to produce greater control over overt motor behavior (Sage, 1977). Therefore, implementation and control of a wide range of physical, motor, cognitive, perceptual and emotional mechanisms is based on the appropriateness of action goals related representation in the brain.

Motor learning has been frequently labelled as psychomotor learning in order to understand the psychological aspects of such learning.

Motor learning is an internal process or state that reflects a person’s current capability for producing a particular movement (Zhang, 2011).

Psychomotor learning as described in the Encyclopedia Britannica (2012) edition refers to it as a “development of organized patterns of muscular activities guided by signals from the environment”. Behavioral examples include driving a car and eye-hand coordination tasks such as sewing, throwing a ball, typing or playing a trombone.)
Hilgard (1948) understood the concept of psychomotor learning from two angles:

1. Theoretical aspect - concerning the essential conditions or processes which are believed necessary to enable learning to occur, and
2. Factual aspect- relating to observations of behavior in the physical world.

Computerized psychomotor task performances have become an indispensable tool in cognitive neurosciences. Excellent controls over stimulus properties and precise monitoring of their effect on response choices and their timing have been shown to be extremely valuable in sorting out cognitive processes (Hans and Dongen, 2010).

For instance, driving is a complex psychomotor task, which requires cognitive and psychomotor abilities apart from efficient driving skills. Elander et al., (1993) made a distinction between driving behavior (i.e., style) and driving skills (i.e., perceptual-motor performance) and asserted that driver behavior is associated with personality characteristics, attitudes, beliefs, needs, and values.

There has been an effort on the part of researchers to study neurological dynamics of such behavior, given the fact that a action potential is a precursor to action behavior. A theory given, quite early in this context has been known as ‘The Memory Drum theory’ of neuromotor reaction (Franklin, 1960). This theory indicates that unconscious neural patterns acquired from experiences are stored in what may be known as “Memory-Storage Drum”. This store is used when a movement skill is learned. Herein, the initial attempts to perform a new skill are awkward and carried out under conscious control if there has been no similar “program” previously recorded in the drum. Although some response delay is attributable to the speed of nerve conduction, a minor “program” change is necessary for a simple movement. Once the “will to act” has been initiated, then “shorter reaction time” will occur, as per this theory. A long complicated program of movements is more difficult to change and results in delay of responses to the complex task. So this theory aids in explaining specificity of motor skill, as well as other phenomena related to motor learning.

Another conceptualization in this context is known as “Neuropsychological Model of Behavior” (Sage, 1977). From this perspective, information in the form of physical energy (light, sound, mechanical, chemical) impinges on the individual and
serves as a stimulus to the sense organs. This information is coded into electrical energy at the sensory receptors where it then takes the form of electrical impulses, which are sent over sensory nerve cells to the central nervous system. In the brain and spinal cord, present information is integrated with stored information (memories) and this process results in information (in the form of electrical impulses) being sent to the muscles and glands to produce a response of some kind. The response produces feedback information (in the form of nerve impulses) to control and direct the immediate response or may produce adaptive behavior for future responses to a similar stimulus situation (Sage, 1977).

Since the information from the environment is "picked up" by structures of the nervous system, transmitted over nerve fibers, integrated and interpreted by nerve cells, it is obvious that recognition of the critical role of this system must be an integral feature of any model of psychomotor behavior. Indeed, a successful model of motor learning and performance is unlikely to emerge without consideration of the functions of neural mechanisms, hence the name. Further elaboration is as under:

(A) Functional Component

Herein, the first sub model relates to the functional components of motor performance as under:

![Functional Components of Motor Behavior](image)

Figure No.1.2:- The basic functional components of motor behavior (Sage, 1977).

1. **Input** - Input is made up of all the stimuli, which are impinging on a person at any given time. The total amount of input is sometimes referred to as
“display”. There are relevant and irrelevant stimuli in a display. Relevant stimuli are those which are important for the present moment and irrelevant stimuli are those which are neither needed nor used for the immediate situation.

2. **Decision Making** – Decision making refers to the process of integrating and interpreting input and determining, or deciding upon, the appropriate response, which should be made to relate the stimuli to a response.

3. **Output** - Output is the response (or behavior) in the form of muscular action or glandular activity.

4. **Feedback** - Feedback refers to the information or re-stimulation, which is produced by the output. Feedback may be intrinsic to the task that is, the movement execution itself may also produce feedback information, or the feedback may be augmented as it is when an instructor gives information about the consequences of the movement.

(B) **Neurological Component**

The neurological mechanisms as described below are related to the components above. A simple sub model of this kind is shown as:

![Figure No.1.3: The basic neurological mechanisms of motor behavior](Sage, 1977).

Herein, input is received via the sense organs. The brain and spinal cord perform the decision making function, and output is mediated by the muscular and glandular system. Feedback is mediated by various sense organs. The information is transmitted from one part of the model to other parts via neural transmission.
Again, Gilbert and Thach (1977) found support for the theoretical formulation that motor learning takes place in the cerebellum through changes in the strength of transmission of parallel fibre synapse caused by climbing fibre input. On the other hand, Marisi (1977), Wise & Shadmehr, (2002) attributed individual differences in motor performance to genetic factors.

Further, ‘Central Monitoring Theory’ (Wolpert et al., 1995; Wolpert and Ghahramani, 2000) holds that the comparison between efferent signals at the origin of this action and those arising in the execution (the reafferent signals), provides cues about where the action originates. It also monitors the spatial and temporal congruence between the information it receives about the motor commands for a movement and the sensory information resulting from this movement.

Blakemore et al., (1999) suggested that the processing of auditory signals in the recipient temporal cortical area is different according to their origin of the tones. Self-produced signals activate the temporal cortex less than passively received external signals. The interpretation proposed for this difference is that predicted consequences of an action are attenuated. This mechanism would be adequate for understanding whether a sensory event is produced by one’s own action or by an external agent.

Further, the philosophical analysis of the concept of action representation (Searle, 1983, c.f Jeannerod, 2006, pg 2) emphasizes two major properties of action representation. First, an action representation is a state that represents future events, not present events. The notion of ‘mind to world direction of causation’ stresses the fact that action representations are anticipatory, not only with respect to the execution of the action itself, but also with respect to the state of the world that will be created by the action. As a matter of fact, insofar an action representations are the key feature of the motor cognition, it follows that motor cognition in general is more looking ahead in time than looking back. It is proactive rather than reactive.

The second notion is that an action representation precedes execution of the action suggests that it can actually be detached from execution and can exist on its own (Searle, 1983, c.f Jeannerod, 2006, pg 2).
Further, Jeannerod (2004b) has given the two modalities of action representations i.e. built from observing action of an external agent or generated from a self-produced intention can be understood as under:

a) In the proposed network there is a recipient part where the premotor mirror neurons and posterior parietal cortex (PAR) interact to establish an internal model of the represented action.

b) An executive part where premotor cortex (PM), primary motor cortex (MI) and possibly the cerebellum intervention specify the detailed kinematic parameters of the representations. Finally, execution is executed and the movement generates reafferent information for updating the various parts of the representation.

![Figure No. 1.4:- Schematic diagram for the motor simulation process (Jeannerod, 2004b).](image-url)

Johansson and Edin (1993) proposed a ‘Sensorimotor model’. Herein, manipulative actions were proposed as largely dependent on predictive mechanisms. It was held that by means of predictive feedforward sensory control, central nervous system monitors peripheral sensory events and uses them to develop suitable control signals. Feedforward processing allows task monitoring and triggering of immediate corrective actions if unexpected perturbations occur. This type of predictive control is
termed sensory 'discrete event-driven control'. When analysing a simple action task grasping, lifting, holding and replacing an object it can be noticed that each phase is characterized by a particular goal, a pattern of muscle activity and a mechanical event that leads to the next phase. The effect of a particular pattern of sensory inputs depends on both the phase of the motor task and the context in which it occurs. Moreover, the afferent discharge is not simply received and transferred to preset reflex arcs, but is constantly evaluated in a dynamic fashion (Johansson, 1996).

The information processing perspective has facilitated as well as defined the feedforward phenomenon in cognitive psychology in numerous ways. Such action control or the feedforward process has assumed different connotations in several contexts of cognitive psychology (Bassol and Belardinelli, 2006).

From the motor output perspective, the need for integration between feedforward and feedback based controllers has been recognized and accepted since a relatively long time (Davidson and Wolpret, 2005).

The term feedforward finds its origin in cybernetics and it is a process that could improve control over systems (Ashby, 1956). In applied psychology, the potential of the feedforward concept was first recognized in the social and organizational framework. Cognitive feedforward and feedback are considered as agents or learning operators. They have been found to be very helpful in motivating and enabling decision makers to realize new decision strategies (Annet, 1969 and Te'eni, 1991).

In the mid 1990s, motor coordination researchers formally adopted the concept of the feedforward control system. Feedforward systems predict the necessary correction factor in order to account for some perturbance in the optimal stage, before the actual perturbance occurs. A common example in physiology is the feedforward regulation in maintaining homeostatic heart rhythm. In feedforward systems, tasks can get complicated with greater speed. Further, feedforward systems rely on a predetermined response to a disturbance and therefore have the ability to deal with a wide variety of disturbances.

Feedforward has been understood as leading to a prespecified decisions (Björkman,1972). Through the years, the feedforward construct was flexibly adapted
to the scope of research in a social background and was developed along two interconnected perspectives, representing problem-solving and learning processes.

Although the standards and frameworks are rarely prescriptive, they can provide clues and ideas on how to move forward with feedforward, e.g., to provide new or different dimensions to view and evaluate your library, to provide examples of good and best practices that have proven successful for many top performing organisations (Crook et al., 2008).

Alongwith this perspective, feedforward has been frequently compared with feedback, since both can decrease process ambiguity in different ways. While feedforward gives the process a direction by delineating a goal to be achieved, feedback provides information on whether the process is being correctly realized (Cazier et al., 2001).

Technically, in computational modeling, feedforward normally refers to a perception in which the outputs from all neurons go to the following layers but not back to the preceding layers so there are no feedback loops (Wikipedia, 2009).

Thus, in its action control interpretation “Feedforward is a term describing an element or pathway within a control system which passes a controlling signal from a source to the control system's external environment. A control system which has only feedforward behavior responds to its control signal in a pre-defined way without responding to how the load reacts with it” (Wikipedia, 2009).

Feedforward controllers use knowledge of the system they are thought to control in order to act directly on it, anticipating the changes that will occur. A completely feedforward-driven system would be able to adjust its performance with respect to the changed environment. It has been demonstrated (Brosilow and Joseph, 2002) that even when modelling errors are presented in the system, a feedforward control can often reduce the effect of the disturbance better than the feedback control alone.

Feedforward controls are desirable because they allow management to prevent problems rather than having to cure them later. Unfortunately, these controls require timely and accurate information that is often difficult to develop. Feedforward control
is sometimes called preliminary control, precontrol, preventive control, or steering control.

Feedforward has been used in a wide variety of situations e.g. in organizations, feedforward design can influence our perceived control in emerging situations by offering alternative perspectives from which to adjust emotional biases and project outcomes.

Butz et al., (2007) outline three types of anticipation we use in preparation for emerging situations:

- Payoff anticipation maximizes the frequency of rewards by preemptively imagining pleasure.
- Sensory anticipation minimizes the effort required to understand a situation by guiding sensory attention toward significant emerging relationships.
- State anticipation primes emotional bias by framing the value of situations systemically.
Payoff behaviors necessitate experiential comparisons, sensory behaviors utilize specific situational cues, and state behaviors benefit from holistic scenario-driven simulations. Feedforward preemptively addresses our interpretations in payoff, sensory, and state anticipation substantiates, design decisions and behaviors by targeting the anticipation of stress.

Thus, feedforward as person interaction design strategy can influence the anticipation of stress due to impending change. Feedforward parallels the embodied process of anticipation, which enables us to adapt to changing conditions. Feedforward synchronizes the situated, dynamic, and personalized capacities of emerging technologies with the beneficial capabilities of anticipation. It could direct our attention towards relevant emerging relationships within situations to which we might ignore or not have access. It encourage us to maintain a sense of agency in demanding situations and help us to visualize possible trajectories of impact throughout multiple timeframes.

Goldsmith (2012) has enumerated the following benefits of feedforward:

1. It is positive because it focuses on solutions, not on the problems.
2. It is especially suited to successful people because they have a positive self-image which tends to resist negative judgments and so they always get new ideas, which further help them in achieving their goals.
3. It does not require personal experience. It just requires having good ideas for achieving the task. It can come from anyone who knows about the task.
4. People do not take feedforward as personally as feedback. It cannot involve a personal critique, since it is discussing something that has not yet happened! Positive suggestions tend to be seen as objective advice and personal critiques are often viewed as personal attacks.
5. It can reinforce the possibility of change and is based on the assumption that the receiver of suggestions can make positive changes in the future.
6. It tends to be much faster and more efficient than feedback. By eliminating judgment of the ideas, the process becomes much more positive for the sender, as well as for the receiver.
7. It can be a useful tool to apply with managers, peers and team members. It does not imply superiority of judgment. It is more focused on being a helpful
"fellow traveler" than an "expert". As such it can be easier to hear from a person who is not in a position of power or authority.

8. People tend to listen more attentively to feedforward than feedback.

Technology Acceptance Model (TAM) (Singh and Singh, 1997) theorized relationships from cognitive feedforward and feedback to perceived usefulness and ease-of-use. Cognitive feedforward (training) can create dissatisfaction with the current solution by showing that a better solution exists, reduce the time, cognitive effort and uncertainty required to perform a task by offering decisional guidance and reduce outcome ambiguity by demonstrating the benefits of the new solution.

![The Technology Acceptance Model (Singh and Singh, 1997).](image)

From the angle of resources, Belardinelli (1986) has found that when an event occurs, the information brought by this event is selected, and the attentional resource effort is focused on this incoming information and this will elicit a number of potential coping responses in the subject.

On the other hand, if one of these responses reaches a certain threshold, the system recognizes the event and starts the motivated behaviour associated with this particular event. The response is considered suitable to eliminate the disturbance, and the feedforward process fixes the end state determined by the elicited response.
If none of the responses reaches the threshold, the system interprets the incoming information as a completely new one. No predetermined response is associated to the event and the feedforward process determines the motivational investment into the behaviour together with the final point, based on the characteristics of the discrepancy information. This is like creating a new catalogue for a new title in the library and envisaging its use.

Olivetti Belardinelli and Basso (2001); Basso (2005) proposed a 'Planning model' based on a feedforward mechanism of action selection. Herein, feedforward process chooses the appropriate strategy at the beginning of the action and provides for an on-line control that guides action by representing the final state.

In the case of known stimuli, a goal-directed behaviour (chosen from a repertoire of actions) is started in order to retrieve the equilibrium that leads to the purpose. In case of unknown stimuli, the feedforward mechanism works by successive refinements, and the regulation is based on the comparison between the actual and the desired states taking into account the possible consonance between the behaviour outcomes and the goal (Pribram, 1971). In case the outcomes of the new response are consonant with the goal established by the feedforward, a certain type of "internal repetition" of the event takes place. This temporal widening of the process determines a reduction of the disequilibrium generated in rapidly changing situations and the registration of the experience by the amygdala (Olivetti Belardinelli, 1977).

This way, an on-line feedforward-based control is performed allowing the ongoing action to be rearranged and modified during the execution (Basso et al., 2001 and Phillips et al., 2001).

This model of functioning shares a lot of elements with other systems used in cognitive psychology such as the 'Supervisory Attentional System' (SAS) by Norman and Shallice (1980). They do not explicitly mention feedforward processing, but their regulating system, the SAS module, could be approximated to a feedforward-based unit. The SAS controls behaviour in non-routine situations when (a) none of the existing action schemas, contained in the contention scheduling (CS) mechanism, fit to the input data or (b) when the selected schema has not been considered as the
suitable one. The SAS operates mainly in a twofold manner inhibiting the schema selected by the CS mechanism or combining together existing schemas in order to create new ones.

This second function of the SAS has been explained by Shallice and Burgess (1991): the temporary new schema created in a working space can control and reorganize the relationship among the lower level schemas, in a way that is functional to the previewed result to be obtained with the newborn schema. Shallice’s model is probably a heuristic itself, rather than a faithful representation of action selection and preparation mechanisms.

However, predictions provided on the basis of this model are still conveniently used in neuropsychological evaluation (Fortin et al., 2003) and rehabilitation (Vallat et al., 2005).

Figure No. 1.7:- Norman and Shallice’s Supervisory Attentional System (1980) (Complete-arrows represent input information and the dotted-arrow represent output information from recently activation schemata).

Anxiety may emanate from a feedforward which indicates upcoming difficulty, so here anxiety represents troubling emotional states that are heterogeneous in their expression, pervasive in their incidence, and frequently devastating in their
effects on the lives of people. Although, anxiety has long occupied a central position, in the theoretical conceptualizations of psychodynamic and behavioral models, in the various fields of psychology (e.g. Ingram and Kendall, 1987; Rachman and Maser, 1988).

Yet it was Freud who singled out anxiety as the nodal problem in emotional and behavioural outputs. Since then, for quite some time, anxiety was the concern of only the clinician and a concept of importance only within the framework of psychoanalysis. Now anxiety is an important construct in learning theories of behavior. While studies of anxiety and variables similar to anxiety (e.g., stress) have been conducted in a wide variety of theoretical frameworks.

Specifically, a lower threshold to certain events marks anxiety. In classic definition, Ausubel et al., (1953) defined anxiety as an “acquired reaction- sensitivity in individuals”.

Anxiety, as compared to fear as a transient reaction, has been reported as sustained psychological state (e.g. Lang et al., 2000; Walker et al., 2003 and Hasler et al., 2007).

Arousal is operationally defined by sensory alertness, motor activity and emotional reactivity as well as the driving force behind the behavior of all organisms according to their responses to stimuli (e.g. Valdes et al., 2006 and Miron et al., 2007).

Luu et al., (1998) offer an account of anxiety based upon a consideration of the evolution of the organization of the brain and that anxiety characterized by focused attention to threat information and preparation for specific defensive actions, is supported by a particular set of structures that includes the amygdala and orbitofrontal and ventrolateral prefrontal cortex and emphasizing the generally adaptive volume of anxiety, rather than disrupting cognition, “anxiety appears to be a control process that is integral to the cognitive apparatus”.

Anxiety can play a role in creating a wide array of unfavorable outcomes in different domains.
The first cognitive model of anxiety was developed aside from experimental cognitive psychology and cognitive science. For instance, Beck et al., (1979) concluded from their clinical observations that cognitive processes were impaired in emotional disorders and he further elaborated a therapy based on the modification of cognitive impairments.

Beck and Clark (1997) proposed a three stage schema-based information model of anxiety. These different stages imply different levels of automaticity from rapid, involuntary, and unconscious processes to controlled, strategic, and elaborative processes.

Figure No. 1.8: Examples of impact of anxiety
1. Initial Registration Stage:

- It involves an automatic recognition of the valence or the personal relevance of stimuli, named orienting mode.
- If the stimulus is assessed as threatening, attentional resources are allocated to process it. In anxiety, the orienting mode is hypersensitive to detect negative stimuli. For example, when giving a speech, a socially anxious individual would appraise negatively the yawns of an audience’s member. This appraisal activates an orienting mode of...
danger. The attentional resources are oriented towards this threatening stimulus (Buckner, et al., 2010).

2. Immediate Preparation Stage:
   ❖ It involves the activation of a primal mode that triggers a series of physiological, behavioural, affective and cognitive responses.
   ❖ In anxiety, primal mode results in biased cognitive processing, such as hyper vigilance to threat cues rather than safety cues and automatic negative thoughts.

3. Secondary Elaboration Stage:
   ❖ It is characterized by a full semantic activation as well as the activation of other relevant schema.
   ❖ Individuals activate a metacognitive mode in which they evaluate the availability and the efficiency of their coping resources. This mode of processing is necessarily conscious and explicit.

Earlier, a number of investigations have suggested that cognitive and information processing biases may play an important role in the maintenance and possibly in the etiology of anxiety disorders (e.g., Mathews, 1990; Mathews and MacLeod, 1994; Vasey and MacLeod, 2001).

From the cognitive perspective, anxiety is seen as an enduring disposition (for example, your preference for certain kinds of tasks over others), momentary intentions and evaluation of the demands on one’s capacity. It plays a significant role in situations where the central executive needs to prioritize. It deals with the way resources are allocated to cognitive tasks (Kahneman, 1973). The more complex the stimulus, the harder the processing and therefore more resources are engaged. However, people have some control over where they direct their mental resources and they can often choose what to focus on and devote their mental effort to.
Further, it distracts attention and thus has important implications for performance and further presented a slightly different model for what attention is. Attention is a set of cognitive processes for categorizing and recognizing stimuli.

An analogy could be made to an investor depositing money in one or more of several different bank accounts herein, the individual “deposits” mental capacity to one or more of several different tasks. Many factors influence this allocation of capacity, which itself depends on the extent and type of mental resources available. The availability of mental resources, in turn, is affected by the overall level of arousal, or state of alertness. Kahneman (1973) argued that one effect of being aroused is that more cognitive resources are available to devote to various tasks.
In decision making linked with taking action situations, Kahneman (1973) pointed out the role of arousal. The arousal state or anxiety is usually considered to be a general and continuing state of the organism, a personality characteristic.

In the context of working memory, Baddeley (1986) proposed that visual sketch pad deals with visual and spatial information and worry is in the form of subvocalisation, and is processed into the short term store within the articulatory loop. Therefore, when an individual experiences high level of anxiety, cognitive resources are used, which further put impact on the amount of processing capacity available for the actual task, thus reduces the task performance.

![Model of Working Memory (Baddeley, 1986)](image)

Cognitive views on anxiety mention attentional biases towards threatening information in high trait anxiety individuals as playing an important role in the maintenance of anxiety (e.g. Beck et al., 1985; Eysenck, 1992; Williams et al., 1988, 1997; Fox and Geoggiou, 2005; Koster et al., 2006).

According to the Attentional control theory (Eysenck et al., 2007), anxiety decreases the influence of the goal-directed attentional system and increases the influence of the stimulus-driven attentional system. Therefore, anxious people are prone to get distracted by worrying thoughts that are supposed to occur in threatening situations. Anxiety predicts performance decrements in a cognitive task only if a potential distraction (in terms of threat) is given and the individual momentarily lacks the energy required for self-control. When people engage in executive acts like
controlling their attention or overriding behavioral tendencies (i.e., self-control), they expend energy.

Hence, after initial self-control, energy is exhausted and people experience problems continuing in executive control (Gailliot et al., 2007). In such a state of self-control depletion, more anxious people are expected to be less successful in directing their attention away from distracting, worrying thoughts and in directing their attention to the task at hand. Thus, if a threat occurs and energy for attention regulation is lacking, cognitive performance should suffer with elevated anxiety. People who are not in a state of ego depletion should be able to better regulate their attention.

The Information based model of anxiety (Ohman, 1993) and attention described as under:

1. Incoming information is first analyzed by feature detectors, before being passed on to a nonconscious “significance evaluating system.” Biologically prepared or high intensity stimuli may result in feature detectors activating autonomic arousal, without need of further processing.

2. Otherwise, after significance evaluation, information is then passed on to a “conscious perception system,” which allows a slower conscious appraisal of meaning via interaction with emotional memories stored in an “expectancy system.” Again, if such an appraisal results in the perception of danger, then autonomic arousal occurs via this slower conscious processing route. Autonomic arousal has the effect of setting the significance evaluator into a more sensitive mode, increasing its output.

3. Finally, feedback from the expectancy system to the significance evaluator primes early detection of other incoming stimuli related to the expected danger. These related stimuli (such as threatening words) may now receive greater priority for further processing, leading to attentional bias effects.
Cognitive anxiety consists of individuals’ cognitive reactions or internal dialogue regarding evaluative situations, in the times prior to, during, and after evaluative tasks. Thoughts commonly entertained by individuals dealing with high levels of cognitive anxiety center on (a) comparing self-performance to peers, (b) considering the consequences of failure, (c) low levels of confidence in performance, (d) excessive worry over evaluation, (e) causing sorrow for their parents, (f) feeling unprepared for tests, and (g) loss of self-worth (e.g. Deffenbacher, 1980; Morris et al., 1981; Depreeuw, 1984 and Hembree, 1988).
The cognitive interference model suggests that individuals with high levels of test anxiety perform poorly in large part due to an inability to suppress competing thoughts during the exam. This theory was derived from findings that individuals with high levels of test anxiety are more likely to worry about the outcome of the test, compare their abilities to others, or dwell on the notion that they are not fully prepared for the exam (e.g. Sarason, 1986; Schwarzer and Jerusalem, 1992).

This interference explanation is consistent with Easterbrook’s (1959) classic work on cue utilization which revealed that individuals with high levels of anxiety are either constraining their attention to inappropriate cues for the task or are incapable of restricting the range of cues, allowing competing thoughts to enter conscious awareness thus interfering with performance (Schwarzer and Jerusalem, 1992).

Drive theory is concentrated on the experience of learning new skills to complete a task, and the tendency to react instinctively when put under pressure (Weinberg and Gould, 2007).

The influence of skill level on arousal and performance suggests that in the early cognitive stage of learning whilst completing an unfamiliar task under circumstances of increased arousal, an individual will act instinctively to the situation resulting in a less than moderate performance. If the same task were to be completed
in the autonomous stage of learning with the same level of increased arousal, the level of performance is likely to be improved. This is because the instinctive response has been replaced with the correct learned response, and actions performed in heightened arousal are more likely to reflect previous experiences of the task. Learnt skills and behaviours, with practice, become habitual (e.g. Movahedi, et. al., 2007).

Worry can be seen as an ineffective cognitive attempt to solve problem and thus remove a perceived threat, while simultaneously avoiding the aversive somatic and emotional experiences that would naturally occur during the process of fear confrontation (e.g. Borkovec et al., 2004).

Worry is negatively reinforced by the removal of aversive and fearful images (e.g., Borkovec, 1994; Borkovec et al., 2004). In addition, worry is further reinforced by positive beliefs, such as a belief that worry is helpful for problem-solving, motivating performance, and avoiding future negative outcomes. Positive beliefs are reinforced when negative future events do not occur or are not effectively managed, thus further reinforcing the worry.

Figure No. 1.14:- Layout of worry (Borkovec, 2004).

From the angle of task difficulty, Kahneman’s (1973) proposal of a single capacity in which a single pool of cognitive assets (capacity or resources) is shared amongst competing tasks, seems to be relevant. The assets available at any time depend upon arousal and individual differences, and allocation of those resources is to some extent, under voluntary control. Competition in dual-task performance occurs,
Navon and Gopher (1979) proposed a framework that sheds some light on the task difficulty. Tasks can be difficult because they are either data-limited or resource limited. A data limited task is one which is made difficult by the nature of the information provided. Resource-limited tasks are ones that are made difficult because of the cognitive demands that they make. The difference is that the performance of the latter can be improved by investing more cognitive assets into a task, e.g. by concentrating upon it to the detriment of a concurrent task.

Since only resource limited tasks are able to benefit from juggling assets between multiple tasks, these must be the ones that can be combined with varying degrees of success with secondary tasks. Data limited tasks are largely unaffected by a secondary activity. Data limitations may impose some resource demands since reducing the quality of auditory stimulation on a concurrent, resource limited visual task (Payne et al., 1994).

In fact, tasks which involve building up an overview and using alternative strategies need more than simple repetition if they are to be learned with least effort. The status of errors is different in learning a complex task. Studies on cortical activation (e.g. Neubauer and Fink, 2002) have shown that a complex task situation bears the brunt of shortage of needed resources e.g. a driver's normal performance may get ridden with errors due to overload on available resources (Reimer, 2009).

Task difficulty also contributes to the ease or difficulty with two tasks combined. A difficult task is likely to be more demanding of attentional resources or capacity than a simple one and delimits the cognitive assets that can be devoted to a secondary task. However, some tasks will always be intrinsically more difficult than others owing to the requirement to process greater amounts of information in the former.

1. **Skehan’s Model of task difficulty (1998, 2001)**

For Skehan and Foster (2001)

"Task difficulty has to do with the amount of attention the task demands from the participants. Difficult tasks require more attention than easy tasks".

Having evidence of the effects of task demands on production can be used to direct learners' efforts toward different areas of performance separately or simultaneously. In addition to that, if links are established between production and
have a positive value as a source of information about the nature and limits of the tasks. However, a variety of working methods used in this connection need to be advance and cultivated, a wide knowledge of task alternatives also needs to be practiced, in order to avoid any anxiety effort.

Again, Jacko and Ward (1996) proposed and validated a link between an existing information-processing model for psychomotor tasks and a comprehensive characterization of task complexity. It was achieved by incorporating four constructs of task complexity either alone or in combination into a hierarchical computer based menu system. The results showed that as the number of constructs presented in the interface increased, subjects experienced an increased challenge to short-term memory, which impaired performance due to felt complexity of a psychomotor task.

The complexity-performance relationship could be negative, positive, contingent, or even inverted-U shape. So, to gain an explicit understanding of this relationship, the influence mechanism of task complexity should be considered. In most pertinent studies, a high-complexity level had a negative impact on performance. It could be explained by several theories. For example, according to the human information processing model, a complex task is likely to challenge short-term, working memory, long-term memory (Jacko and Ward, 1996). In complex tasks the amount of information for processing overruns the capability of human beings, which might lead to the deterioration of human performance.

Activation theory has been used to explain the existence of inverted-U relationship between task complexity and task performance (Gardner, 1990). This theory predicts an inverted-U relationship between activation level and performance, given initially in Yerkes-Dodson Law, 1908 (c.f. Sonstroem, 1984) because activation level is believed to have a monotonically positive relationship with task complexity (operated by the number of stimuli, variation, novelty, etc.), thus, the relationship between task complexity and performance appears to be an inverted-U shape. It is pitiful that a few evidences exist to support the inverted-U relationship between task complexity (except visual complexity) and performance (Tassi et al., 2003).

Johnston and Heinz (1978) made similar assumption in their account of selective attention. They proposed that assets are allocated flexibly. If the main tasks make comparatively few demands, non-selected stimuli need not be attenuated to as low a level as would be the case if the main task was highly demanding cognitively.
reduce task complexity: “task complexity is not the same at the beginning and at the end of learning”.

Grandom Gill’s Blog (2012) mentions that task complexity consists of three dimensions:

1. **Unfamiliarity**: This refers to the question regarding what is it about the task that you do not, or cannot, know? Where unfamiliarity is present, the tasks tend to be perceived as difficult.

2. **Complicatedness**: This refers to the amount of structure of knowledge required to move from current state to where one’s want to go. Another way of thinking about it is how much information is needed to proceed down the path that one selects. When complicatedness is present, the description of the path and the amount of information processing required tends to rise.

3. **Objective Complexity**: This refers to the degree of challenge required in choosing an appropriate goal or end state. Where complexity is high, there tends to be a lot of possible end states, many of which are peaks. This leads to a condition called ‘ruggedness’.

Further, task complexity has been defined in various ways. Tasks differ in terms of their complexity as determined by their characteristics (e.g. Prasad and Akhilesh, 2002). Different researchers and studies show a great variation about the ways of operationalizing task complexity (Wood, 1986). Several studies summarized various constructs of complexity (e.g. Campbell, 1988; Block, 1991; Jacko et al., 1995; Gill and Hicks, 2006).

Wood (1986) classified task complexity into three types:

- **Component complexity**: It is defined as a function of the number of distinct acts that need to be executed and the number of distinct information cues that need to be processed.

- **Coordinative complexity**: It is defined as relationships between task inputs (acts and information cues) and task products.

- **Dynamic complexity**: It is due to “changes in the states of the world which have an effect on the relationships between task inputs and products” (Wood, 1987).

In a simple task, the number of errors made is less and wrong responses do not get associated with inputs. By contrast when learning a complex task, an ‘error’ can
to the detriment of one or both tasks, when the pool of assets is too small, the
demands of the tasks exceed what is available, or both.

In this context, dual task paradigm also makes tasks difficult to handle. A simple way of accounting for many dual-task findings is to assume that there is some central capacity (e.g. central executive) which can be used flexibly across a wide range of activities.

This central processor has strictly limited resources, and it sometimes is known as attention or effort. The extent to which two tasks can be performed together depends on the demands that each task makes on those resources. If the combined demands of the two tasks do not exceed the total resources of the central capacity, the two tasks will not interfere with each other.

However, if the resources are insufficient, then performance disruption is inevitable. In this context, task complexity can range from a simple repeated task to an alternating task that involves central executive processes, including switching and inhibitory control (e.g. Tun and Lachman, 2008).

Today's systems are becoming increasingly complex and strive for efficiency and the need to handle more complicated problems strains human capabilities. Moreover, human roles are shifting towards supervisory and cognitively demanding tasks. Therefore, learning and using systems efficiently is getting increasingly crucial.

The fundamental problem with task complexity is that everyone has a vague notion of what it is, or should be, and everyone's notion is different from each other (Grandom Gill's Blog, 2012).

Task complexity has been investigated in the fields of goal-setting, decision-making, auditing, learning, human-computer interaction and information seeking, retrieval, and searching etc. (e.g. Gill and Hicks, 2006).

According to Deese (1958) “A difficult task is generally the one that takes us a relatively long time to learn and mentioned that since other conditions like the ability of the learner, his motivation, the amount of preceding practice etc. influence the length of time spent in learning, it is not possible to equate difficulty with the length of time or number of trials it takes the learner to reach a criterion”.

According to Leplat (1988) complexity is coupled to the operator. A task may be complex for one person, but simple for another. Increasing the operator's skill may
"Task complexity is the result of attention, memory, reasoning, and other information processing demands imposed by the structure of the task on the language learner. These differences in information processing demands, resulting from design characteristics, are relatively fixed and invariant".

Robinson proposes a three-dimensional model that distinguishes between three different types of factors:

<table>
<thead>
<tr>
<th>Cognitive factors</th>
<th>Interactive factors</th>
<th>Difficulty factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task complexity</strong></td>
<td><strong>Task conditions</strong></td>
<td><strong>Task difficulty</strong></td>
</tr>
<tr>
<td>a) resource directing</td>
<td>a) participation variables</td>
<td>a) affective variables</td>
</tr>
<tr>
<td>e.g. +/-few elements</td>
<td>e.g. one way/ two way</td>
<td>e.g. motivation anxiety</td>
</tr>
<tr>
<td>+/-Here – and –Now</td>
<td>convergent/divergent</td>
<td>confidence</td>
</tr>
<tr>
<td>+/-no reasoning demands</td>
<td>open/closed</td>
<td></td>
</tr>
<tr>
<td>b) Resource dispersing</td>
<td>b) Participant variables</td>
<td></td>
</tr>
<tr>
<td>e.g. +/-planning</td>
<td>e.g. gender familiarity</td>
<td></td>
</tr>
<tr>
<td>+/- single task</td>
<td>power/solidarity</td>
<td></td>
</tr>
<tr>
<td>+/- prior knowledge</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure No. 1.16:- Model of Task Complexity (Robinson, 2001).

Further, Robinson (2003a) held that task complexity "refers to the intrinsic cognitive demands of the task", and it can be manipulated during task design along resource-directing and resource-dispersing dimensions. Therefore by task complexity, accounts for within participant variation. By task difficulty, Robinson understands what learners bring to the task, and suggests that differentials in ability variables (e.g. working memory capacity) affect learners' perception of the task with consequences for performance and learning.

The contrast between simple and complex tasks underlines the importance and consequences of task complexity. Understanding, sense making and problem formulation require conformation processed through various kinds of channels as well as assessing of the levels of the complexity of a task, for their resolution and decision making efficiency (Bystrom and Jarvelin, 1995, Dunlop and Romer, 2010).
acquisition, research evidence can be used to manipulate tasks to maximize the effectiveness of language learning.

<table>
<thead>
<tr>
<th>Code complexity</th>
<th>Cognitive complexity</th>
<th>Communicative stress</th>
<th>Learner factors</th>
</tr>
</thead>
</table>
| Linguistic complexity and variety | • Cognitive familiarity  
• Familiarity of topic | • Time pressure  
Scale  
• Number of participants | • Learner’s intelligence  
• Breadth of imagination |
| Vocabulary load and variety | • Familiarity of discourse genre  
• Familiarity of task  
• Cognitive processing  
• Information organization  
• Amount of computation  
• Clarity of information  
• Sufficiency of information | • Number of participants  
• Length of text used  
• Modality  
• stakes  
• Opportunity for control | • Personal experience |

Figure No. 1.15:- Model of Task Difficulty (Skehan, 1998).

Skehan (1998) as well as Foster (2001) suggested a study of the effects of task manipulation such that improvement in one area will be considered by improvements in others. Their starting point is language instruction, which in their view should foster a balanced improvement in the three areas of production. Information about how fluency, complexity, and accuracy as affected by increasing task demands should be used to arrange individual tasks in a principled way in a long-term instructional sequence, which will promote such balanced development.

2 Robinsons' Model of Task Complexity (2001)

Task Complexity is the result of the preoccupation with grading and sequencing tasks in a principled way in a task-based syllabus. Acknowledging the rich research tradition in the interactive dimension of tasks, Robinson has shifted the focus to the cognitive processes involved in task production. Robinson (2001 a) says that: