INTRODUCTION
Chapter 1

Introduction

“the frontal lobes...with their associated sensory centers, form the substrata of those psychical processes which lie at the foundation of the higher intellectual operations”. (Ferrier, 1886, p. 467)

It is the ability of human beings, to behave and adapt smartly in various complex situations requiring different cognitive operations that make him different from other species on earth. It has become possible through the advance evolution of the human brain, mainly prefrontal cortex. It is generally thought that the prefrontal cortex plays a key role in the overall organization of the behavior.

In our today’s fast-paced and competitive life, it is generally assumed that everybody experiences problems of varied nature and/or difficulty during their lifespan. In general, a problem can be defined as any conflict or difference between one situation and other situation we wish to produce i.e. our goal. From a cognitive psychological perspective, a problem involves a state where no obvious, standard or usual means of attaining a goal are present. Some problems are easier and so can be solved quickly - without much effort. While others are tricky one and we are not able to solve them as quickly as easier ones. Problems may differ on the basis of their nature also. Few problems are emotionally toned such as a quarrel between husband-wife, while others are less emotional, but may involve emotions (e.g. Anxiety) in certain conditions (e.g. Arithmetic problems). Problem solving studies mainly focus on less emotional problems, but it is considered that the ways or strategies we use to solve both emotional and non-emotional problems are similar.

Problem Solving: Broadly, problem solving carries the meaning of a goal with some barriers/constraints. Sometimes the barriers are so strong that each avert, or at least seriously
interfere with success. From a cognitive psychological perspective, the process under which we employ mental strategies to crack problems is known as problem solving. Many ways of solving a problem are possible. Trial-and-Error method that was observed by Thorndike is among them. Solving the problem with this method is a 'hit-or-miss' approach in which one tries one solution after another until one finds the correct answer. Some people solve problems by trial and error method, while others come to solve at a sudden, i.e. some 'insight or pop-up' have directed them to crack the problems. Famous Gestalt psychologist, named, Kohler referred to this sudden/abrupt awareness of a solution to a problem as 'insight'. Cognitive psychologists support a different viewpoint and they propose that insightful solutions are consequences of reforming a problem in such a manner that the basic elements of the problem rejoin together abruptly to solve the problem. This reforming may occur when an individual perceives the problem in a different manner/way, sees novel information, or differentiates those associations of problems that were earlier not detected by him.

Cognitive Processes and Cognitive/Executive Control: From a cognitive psychological perspective, human beings are basically conceptualized as information - processing system whose mental processes can be elucidated in computational terms (Neisser, 1967). Within this frame, it is possible to make a general distinction between relatively permanent cognitive structures such as short-term and long-term memory, and the cognitive processes that operate alongside them. In simple terms, there are two means by which a computer stores and uses information, the random-access memory (RAM) and the hard disk. The hard disk is the means through which information is stored permanently in a steady and secure mode. In order for this information to be used, it has to be retrieved and loaded into the RAM - a temporary working space. Retrieval and loading of a program can either be commenced by external input (a command given by the user through the keyboard or mouse interface) or internally (initiation of an antivirus check when scheduled). All these processes are controlled by the central processing unit (CPU). The analogy to the cognitive components can be nicely described by the hard disk/long-term memory and similarly by the RAM/working memory analogy.

Many of our daily activities involve the execution and monitoring of habitual well-established routines, such as preparing meals and cleaning the bath, and these routines are considered to be
established in memory that require little attention. Many other tasks, including problem-solving activities such as finding out why the remote of the television is working, involve a series of operations such as searching, matching, deciding, evaluating and transforming. In such situations, established cognitive skills may have to be reorganized to allow new patterns of behavior to be executed. It is still controversial to decide exactly how such mental processes are controlled, but several theorists have hypothesized an ‘executive mechanism’, including Baddeley (1996) when proposing the central executive in his model of working memory.

In 1999, Smith and Jonides have made significant efforts to recognize the important role played by central executive. They proposed five functions of central executive:

1st - switching between tasks,

2nd - planning of sub-tasks to attain objectives that were previously determined,

3rd - paying attention to particular aspects/components united with inhibitory processes,

4th - updating and examining of the information which is included in working memory, and

5th - a function that is associated with coding representations within working memory based on information about time (when) and place (where) of the stimuli concerning to the representations were faced/met.

Cognitive/Executive Control: According to Yarkoni & Braver (2010) the process of ‘cognitive control’ also known as executive control, may be defined as a set of functions that influence and organize mental processes with reference to the internal requirements of the cognitive system without directly representing them. With assistance to these control processes humans are able to temporarily maintain any stimulus-response association, even at the times when no relation in the nature or nurture exists between them (Goschke, 2000). Norman & Shallice, (1986), have expanded the importance of cognitive control processes, particularly in novel or difficult situations - situations that require a lot of planning, involvement in poorly learned responses, when mistakes/errors must be corrected with a fast pace, and when we have to think or act to conquer the leading (but not pertinent) tendencies.
Rogers & Monsell (1995) have categorized control mechanisms into two broad categories - endogenous and exogenous. Endogenous control is applied from inside without any influence of external sources, whereas exogenous control is initiated by stimuli from surrounding. In most situations, executive control involves both types of processes.

A disagreement about the number of controlling functions within human cognition exists till date. Miyake, Friedman, Emerson, Witzki, and Howarter (2000) have divided these control processes into four main categories-

(i) Processes that are concerned with updating of present/ongoing information,
(ii) Inhibitory processes of predetermined reactions,
(iii) Processes related to shifting of responses from one task to another, and
(iv) Processes associated for harmonization between dual task demands.

Executive Functioning: We are living in a world where we have to do activities/tasks of varied nature and executive processes are fundamental requirements for successful completion of these activities. Executive functions (EF) involve higher-level cognitive abilities that are responsible for supervising and self-control of various cognitive processes (attention, thought & action), along with organization of behavior and inhibition of inappropriate actions. According to Shallice (1988), “these intended cognitive control processes are effortful and have been described as providing a system for overriding routine or reflexive behavior in favor of more situationally appropriate and adaptive behavior.” The importance of the EF is apparent in developmental states such as attention deficit hyperactivity disorder (ADHD), autism, and fetal alcoholism spectrum disorder (FASD) that are distinguished by deprived executive functioning in different types of behavioral areas. Developmental studies have reported that these processes did not obtain their mature level of development up to early years of life, but build up with the slow pace up to kindergarten level and mature development of these processes take place in adolescence years. For example, earlier research demonstrates that 2 to most 4 year olds consistently execute deprived performance on tasks that necessitate the ability to restrain a dominant but unsuitable response in a conflict situation, to represent an object in two diverse
means concurrently, or to execute a plan. In contrast, 5 and 6 year olds perform these tasks very well, though a number of the more complicated replications of these tasks will not be executed successfully until later childhood or adolescence (Goswami, 2007).

**Problem Solving and Mental Set:** Problem solving is a main cognitive operation that is necessary to attain goals when no earlier successful solution can be regained from memory. We reason to solve problems: for instance, we make assumptions to tackle Sudoku problems (Lee Goodwin, & Johnson-Laird, 2008). But, how does our reasoning, improve our ability to solve problems? One way to answer the question is to track the mental steps that individuals follow to solve a specific problem (e.g. Anzai & Simon, 1979). Another way, however, is to monitor how individuals develop strategies as they deal with a series of related problems, commonly known as ‘Series problem’. The well-known common series problems are those in which each problem requires a quantity of water to be measured using only three jugs of fixed capacities (e.g. Luchins & Luchins, 1950). When individuals undertake such problems, they are likely to use a single deterministic procedure learned in earlier problems, even when a simpler solution exists (the so-called set effect or mental set). Before proceeding further, we have to understand the term ‘set’. In psychological terms, a set may be defined as a collection of probabilities that shape experiences by making individuals particularly susceptible to precise information. The term has been used in various contexts:

**Perceptual Set:** It is the expectation of a person to see or perceive things in a certain way. It is also known as perceptual expectancy.

**Mental Set:** A way of thinking about a problem that can be framed by practice or desire. A mental set may be profitable, beneficial as well as detrimental. It is helpful in making a class of problems easier to solve, although fixation/rigidity to an unsuitable mental set can limit problem solving and creativity. A well known form of mental set is functional fixedness, in which an individual fails to identify the diversity of uses to which an object can be put.

For about two decades, researchers in the field of cognitive psychology have started to elucidate the phenomenon of mental set by experimental procedures. Such procedures include a set of rules that identify such conditions in which a task is performed; with a procedure becoming
stronger with the more practice. From a group of measures related to specific criteria/domain, the principal procedure available with them is always preferred. Inside this structure, “mental set is an artifact resulting from selection processes that can be interpreted as a temporary consequence of procedural learning (Anderson, 1982; Newell, 1990; Lovett and Anderson, 1996; Anderson and Lebiere, 1998; Ohlsson, 1992)".

Set-Switching

It is a fundamental characteristic of human beings to behave according to changing environmental demands. This adaptability and flexibility in behavior are achieved with the help of cognitive processes. Due to this control and flexibility, we are capable of responding quickly and accurately in achieving our goals. Let us consider an example from our daily routine activities. A student is sitting on his chair and typing a letter, the mobile phone rings, he picks it up, answers, chats and finally notes down the conversational information and continues his work. Each task in this example necessitates an appropriate pattern of mental resources, a procedural schema or task-set. External stimuli are partially responsible for the initiation of each task (the phone rings and the student pick it up) but certain executive functions are accountable for the intentional control exerted over the selection of the appropriate task in order to attain current goals (suppression of the ‘typing’ task-activation of the ‘answering the phone’ task). In this case, the fulfillment of the typing goal has been intentionally put aside (switched-away task set) in order for another more immediate goal to be completed that is, answering the call (switched-to task-set).

What gets switched?

Studies involving addition-subtraction problems reveal a switch in the actual task. While, the cumulative counts task involves switch between different mental representations in working memory instead of no real switch in the task. In other words, some tasks require switching between different mental representations in working memory and no switch in the task/condition. While several other conditions/tasks necessitate switching between diverse attended features of the same stimulus and no alteration in the condition/task. Meta analysis of studies related to what exactly is switched revealed various prefrontal cortex (PFC) areas that are associated with task
switching (Sakai, 2008). Activation of different regions of PFC suggests that the brain may put up several switching mechanisms. Behavioral researches related to this area have documented 3 main switch types: 'stimulus (or perceptual), response, and cognitive set switching' (Meiran and Marciano, 2002).

According to Delis, Kaplan, & Kramer (2001), Wisconsin Card Sorting Test (WCST) has been considered the ‘gold standard of executive function tests’ from a long time. The successful execution on the WCST requires - “efficient switching to the new sorting rule on the basis of feedback, i.e. set-switching”, and “retaining the current sorting rule in mind through varying stimulus conditions, while ignoring irrelevant aspects of the stimuli i.e. set-maintenance” (Barceló & Knight, 2002 and Heaton et al. 1993).

*Set-switching and Individual differences:* An important feature of executive control mechanisms is “the ability to quickly, flexibly, and efficiently switch mental sets between various kinds of information in a rapidly altering environment, commonly referred to as set-switching” (also known ‘set-shifting’, ‘task-switching’, ‘attention-switching’, ‘task-shifting’, or ‘attention-shifting’) (Jersild, 1927; Corbetta et al., 1993; Wager et al., 2004). It is generally considered that this process is governed by a group of executive mechanisms vital to execute the task, known as ‘task set’ (Rogers and Monsell, 1995; Logan and Gordon, 2001).

In our day to day life, we have to do activities of varied type and nature, and in which we have to change our attention or action from one movement to another, to make decisions accordingly so that we adapt or adjust to our surroundings adequately or properly. Individual differences exist in this ability to switch between various types of tasks. Some may switch very quickly from one task to another and hence results in a faster shifting while others may take longer time, hence, results in a slower shifting. This ability of individuals which is associated with an ability to switch response sets on the basis of feedback is known as Set-switching. In psychology, “set switching may be defined as a cognitive operation that entails an ability to switch response sets, whereby one must inhibit previously learned rules and apply new ones” (Barcelo & Knight, 2002).
Usually, experimental psychologists have emphasized more on examining the performance of individual(s) on perceptual - motor and various other cognitive measures. However, our daily routine activities frequently entails performing numerous tasks either concurrently or in quick variation, as when people drive the car while operating mobile phones. For describing how performance on such multiple tasks is managed, some researchers have reported that executive processes systematize the selection, starting, execution, and termination of each task (e.g., Baddeley, 1986; Duncan, 1986; Meyer & Kieras, 1997a, b; Norman & Shallice, 1986; Shiffrin & Schneider, 1977). Experimental paradigms of task switching have been developed for examination of such control processes that are considered responsible for flexible task performance. Some of them have gained prominence in present scenario (Allport, Styles, & Hsieh, 1994; Jersild, 1927; Rogers & Monsell, 1995).

**TASK SWITCHING PARADIGMS**

Recent research has emphasized more on examining the cognitive processes in experimental conditions in which subjects have to switch among diverse cognitive tasks. In the majority of these experiments, participants have to switch quickly between two or more speeded simple cognitive tasks. Task switches are identified with those trials which involve a task that is not identical with the task that is immediately executed on earlier trial, whereas task repetitions are associated with trials in which the same task as the one in the previous trial is carried out. In most of the conditions, prior to the final experiment, participants experience several training blocks of trials on the tasks to be performed during the experiment. The stimuli that are usually used can be either univalent or bivalent in nature. Univalent trials include stimuli that have a single aspect that clearly signals the task to be performed (e.g., a single letter character ‘A’, ‘J’, ‘M’ is present in a given trial and a ‘consonant’ or ‘vowel’ response is needed via pressing the suitable button).

On the other hand, bivalent trials include stimuli that contain more than one task relevant feature. Each feature signals a task to be performed according to the instructions or cue, so for each trial a difference of the relevant task from the irrelevant task can be made. For example, a stimulus that has both a letter and a digit (e.g., A4, J7, and M2) may be presented. According to
cue/instructions, one of the characters must be categorized on a given trial while the other must be overlooked. With bivalent stimuli and in the lack of additional instructions, which task (alphabetic or arithmetic) to execute remains vague? But in case of univalent stimuli - the presentation of a digit unambiguously signals the arithmetic task. On trials where an arithmetic task is required, the letter is considered as the irrelevant aspect and the digit is considered the relevant aspect of the stimulus. One significant distinction relative to univalent stimuli is that when bivalent stimuli are executed, the irrelevant character may be processed involuntarily and automatically trigger the irrelevant task causing some kind of interference with the relevant task. As a consequence, performance in bivalent trials is impaired on both non-switch and switch trials relative to performance on univalent trials (Mayr, Diedrichsen, Ivry, & Kelee, 2006).

There are different ways of presenting these stimuli in task switching experiments. In general, participants go through blocks of trials where they have to either repeat or switch tasks between trials. Performance is compared on switch relative to non-switch trials. Typical findings related to these involve switch costs, i.e. performance is poorer on task switch trials relative to task repetition trials. However, in some studies, participants run through blocks of same task. Their performance is comparable to blocks in which they are required to switch tasks on every other trial. Typical outcomes in these involve the mixing cost i.e. performance is poorer on blocks of trials where participants alternate tasks on every other trial relative to blocks where they have to repeat the same task throughout the block. The difference between the two costs is that mixing costs involve switch cost plus an additional memory load (keeping track of the task sequence). This confounding was first observed in the now classic task switching study of Jersild (1927). A number of different methodologies have been developed since and these along with their findings will be described in the following section.

**Mixed Task Blocks v/s Single Task Blocks**

In former studies of task switching, participants have to switch on every trial (Allport et al., 1994; Fagot, 1994; Jersild, 1927; Spector & Biedermann, 1976). Performance on such mixed-task blocks was contrasted with performance on single task blocks where participants were administered a single task. In Jersild's (1927) study, subjects were employed only one arithmetic
task in a block (adding or subtracting a fix digit, say 6, to every number) or to switch each time between two arithmetic tasks in a set of problems (adding 6 to the first number and subtracting 3 from the second and so on).

Newer studies within this paradigm frequently employed mixed-task blocks having both switch plus repetition trials (e.g., AABB run). Whatever the type of task combination, it was reported that mixed task blocks require more time in comparison to single task blocks, representing alternation or mixing costs (Los, 1996; R. Hußner, Futterer, & Steinhauser, 2001; Koch, Prinz, & Allport, 2005; Rubin & Meiran, 2005; Steinhauser & Hußner, 2005).

According to Mayr (2001), mixing costs characterize the “global” costs related to task switching contrasted with the single task performance. Rogers and Monsell (1995; also Fagot, 1994) have provided another explanation for mixing costs and define mixing costs with more working memory load in mixed task blocks. As in single task blocks, a single S-R mapping (task set) is required, but in mixed task blocks, two dissimilar task sets are required (Logan, 2007). Since such disapproval, this paradigm is not often employed now a days.

Alternating-runs Paradigm (Predictable Sequences)

This paradigm was pursued by Rogers and Monsell (1995). In this paradigm, participants have to switch in accordance to a planned (e.g. after executing a regular number of trials - run) way, involving the same task (AABBAABB successions). Following this paradigm, Rogers and Monsell (1995) assessed performance in the switch trials (i.e., Task A executed after Task B or conversely) by comparing performance in repetition trials within the same settings. The main outcome of this paradigm is poor performance in the form of switch costs (more RTs and errors) in the switch trials in comparison to repetition trials.

Alternatives of this paradigm can be formed by varying the run length of tasks, e.g., by increasing the run length to 4: “AAAAABBBB” (e.g., Monsell, Sumner, & Waters, 2003), or by prespecified short sequences of only two tasks (e.g., Goschke, 2000; Sohn & Anderson, 2001). An interesting outcome of this paradigm is that participants frequently take more time only in the switch trial of a run, i.e. first trial (Rogers & Monsell, 1995; Monsell et al., 2003). In spite of the
variability in these paradigms, one common thing between them is that they are useful in measuring 'local switch cost', which is considered to be a highly dynamic experimental finding.

Task-Cuing Paradigm (Unpredictable Sequences)

This paradigm was developed as a substitute to predictable sequences paradigm (e.g., Meiran, 1996; Sudevan & Taylor, 1987; Shaffer, 1965, 1966). Here, the order of arrangement of tasks, task switches and repetitions is random. To identify the current task’s demands, an explicit/overt cue (in any form such as a letter or a digit) is presented before the stimulus.

Performance in this paradigm is also evaluated by comparing the performance between switch and repetition trials. The same results as were observed in predictable task-switching paradigms also happened here, i.e. poor performance in the switch trials in comparison to repetition trials (e.g., Meiran, 1996; Meiran, Chorev, & Sapir, 2000; Koch, 2001; Dreisbach, Haider, & Kluwe, 2002; Altmann, 2004). In comparison to predictable runs paradigm, an interesting finding of this paradigm is that a decrement in response time is usually observed if the same task is presented on numerous trials (Meiran et al., 2000; Monsell et al., 2003). A significant feature of this paradigm is that it permits varying CSI - cue stimulus interval.

Intermittent Instructions Paradigm interrupt

In this paradigm participants are required to execute a succession of trials with the similar task. Sometimes a cue is provided which disrupt the sequence of trials and enlighten participants about the task to be performed until the subsequent disruption by a cue. The task cues are presented in random order in such a way that the tasks either replicate or switch in successive runs.

Performance (in the form of switch cost) in this paradigm is calculated by comparing performance between cued switch and cued repetition trials. An important feature revealed by this paradigm is ‘restart cost’ - repetition trials that were overtly cued reported a decline in response as compared to repetition trials that were not instantly lead by a task cue. Many researches (Altmann, 2002; Altmann & Gray, 2002; Poljac, de Haan, & van Galen, 2006; Poljac, Koch, & Bekkering, 2009) following this paradigm examined that with an increase in run length, RT and error rates also increased within a run, revealing ‘within run slowing’. In reference to
these findings, it is vague to decide whether a decrease in performance within a longer run depend on intermittent instructions or similarly take place as in predictable task-switching conditions with extended runs.

**Voluntary Task Selection**

In this paradigm, participants are required to choose themselves, which of the two tasks they have to perform. Similar to other task switching procedures and to assist free choice, this paradigm also involves bivalent stimuli. One unique feature of this paradigm that makes it distinct to others is that here responses for both tasks are provided on discrete, non-overlapping sets of keys; in such a manner that the experimenter can conclude which task was preferred by participants. Even free choice for a task switch is provided in this paradigm, vigorous switch costs were also reported.

**Can switch cost be reduced?**

Over the last few decades, cognitive psychology has made substantial growth through developing sophisticated premises and representations concerning specific cognitive realms or functions (such as word recognition, object identification etc.). In spite of this fruitful development, there are still many theoretical concerns or phenomena with very much little information. Similar to those concerns, Monsell (1996) has inquired to identify how the performance of complex tasks is controlled and coordinated by specific cognitive processes. In other words, the field (cognitive psychology) still necessitates a persuasive account of executive processes that modulate various cognitive sub-processes functions and regulate the cognitive dynamics of human beings.

Cognitive flexibility, also known as “shifting, attention switching, or task switching”, refers to the ability of individuals to flexibly shift between diverse tasks, goals, or mental sets. It requires discharging from currently irrelevant information (i.e., the previous task set) and attending currently pertinent information (i.e., the upcoming task; e.g., Meiran, 1996; Monsell, 2003). Cognitive flexibility permits to think divergently and creatively for making quick responses to
unexpected changes in the surroundings. It helps to alter the perspective and develop new solutions when we are caught with a problem (e.g., trying to handle a new electronic instrument or software tool). Attentional control is necessitated when we focus on a specific stimulus while minimizing interference from irrelevant stimuli. In our many daily life routine activities we use this ability, e.g. when we are talking on the phone and have to tune out conversations of other people around us. Another form of cognitive control involves the inhibition of automatic processes or impulsive response tendencies. For example, if a dog suddenly comes in front of our car, we have to repress the tendency to veer. Similarly, if we want to lose weight, we have to resist fatty foods and sweets.

Over the last decade, researchers have shown a growing interest in cognitive interventions designed to improve cognitive functions in childhood and adolescence. Many recent studies examining the benefits of cognitive training interventions demonstrated that cognitive plasticity is significant not only in children and adolescents, but also up to old age (Buitenweg et al., 2012; Diamond, 2012; Karbach and Schubert, 2013; Kray and Ferdinand, 2013; Strobach et al., 2014; Titz and Karbach, 2014; Verhaeghen, 2014). Most of these studies usually revealed significant performance improvements on the trained tasks and frequently also revealed the transfer of performance to similar tasks that were not trained, but assess similar aspects as the training task, and a few times exhibit transfer of performance to a different or new task that assess a different aspect.

Despite these encouraging findings, the literature clearly shows that different studies revealed diverse results i.e. there is a lack of consistency in outcomes related to transfer gains, a fact that has inspired intense recent debates regarding the transferability of training-induced performance gains (e.g., Shipstead et al., 2012; Melby-Lervåg and Hulme, 2013; Redick et al., 2013). A lack of consistent pattern of findings may be explained in terms of use of different types of training, amount of training, intensity and length of the training administration and the fact that different methodologies have been adopted across studies. Thus, the comparability of previous results is often very limited.

Different type of intervention strategies focusing on the cognitive/executive control can be divided into two broad categories. First, strategy based training, involves the training of task-
specific approaches designed to support the execution of certain tasks. It has often been used in memory training studies and typical examples of such training strategy comprise mnemonic techniques, such as the method of loci. Meta analysis by Verhaeghen et al. (1992) and Rebok et al. (2007) revealed that such training strategies frequently produced large as well as durable improvements on the training task, but produced only limited transfer.

Second, training strategies and process based training protocols emphasized more on common processing capacities following a range of cognitive operations, such as speed of processing or executive functions. A number of process-based interventions involving EFs have reported very promising extensive transfer across the lifespan (Karbach & Schubert, 2013; Kray & Ferdinand, 2013; Titz & Karbach, 2014), proposing that these trainings might be more efficient than strategy based interventions.

Above stated training strategies clearly revealed that EF may be enhanced by means of cognitive training. Such findings are particularly important for children and adolescents, because executive function (EF) is a significant predictor of various areas of life, such as academic success, socioeconomic status, and physical health (Eigsti et al., 2006; Blair and Razza, 2007). Moreover, behavioral and neural plasticity is mainly high in childhood and the brain areas serving EF (i.e., the prefrontal lobes) are particularly sensitive to environmental influences in children (Bull et al., 2011).

Therefore, it is not surprising that several training interventions have been formulated with an aim to enhance executive functioning across the lifetime, with more emphasis on children and adolescents. These studies have included not only normal population, but also individuals suffering from neuro-developmental or psychiatric disorders; some of them are characterized by significant cognitive deficits (e.g., ADHD or autism).

The most important characteristic of these paradigms is that participants are required to execute by alternating (in some way) between two diverse tasks - frequently a choice reaction-time (RT) tasks. The ‘switching’ is evaluated by comparing the performance on the switch trials with non-switch trials. The significant outcome from such paradigms is that shifts between essentially competing tasks cause significant performance costs. It is found that switch costs in the form of reaction time (RT) and switch errors are noticeably higher in conditions where a task demands
shifting as compared to the situation in which the same task is replicated on successive trials. It is generally supposed that shifting or switching task-set insists precise requirements from cognitive processes, such requirements are diminished or even absent on task repetition trials; and this postulate has motivated researchers to examine task switching processes in recent years. Focus on cognitive/executive control training results into decreasing or eliminating switch costs up to a greater extent, performance improvement on trained tasks and transfer of performance to similar tasks that were not overtly trained, but assesses the similar aspect/phenomenon as the training task. Such training occasionally exhibits far transfer of performance to tasks measuring a new process not only in children and adolescents but also in old.

**Anagram Solution**

A very ordinary type of arrangement problem used in various types of reasoning problems, the anagram, necessitates participants to rearrange the given letter strings (e.g. TMHA) to form meaningful words (MATH) by using all the letters of the string. Anagrams have been used in experimental psychology to investigate cognitive processes from a long period. Novick & Sherman (2003) seek to investigate individual differences in such rearrangement problems (anagram) that offered new directions in the field of human reasoning and problem solving. The solution to an anagram problem requires flexibility in directing/operating various aspects of a problem to produce solutions and determining if those aspects fulfill the limitations of the problem (Newell & Simon, 1972; Novick & Sherman, 2003).

Solution to anagram has been conceptualized as a two-stage process. First stage includes letter rearrangement and the second includes the matching of the rearranged word with a word accessed from memory (Safren, 1962; Warren & Thomson, 1969; Bourne & Dominowski, 1972; Jablonski & Miieller, 1972; LeMay, 1972; Schuberth, Spoehr, & Haertel, 1979). A number of studies (e.g. Dominowski, 1966; Kaplan & Carvellas, 1968; Mendelsohn & O'Brien, 1974; Mendelsohn, 1976; Gilhooly & Johnson, 1978; Richardson & Johnson, 1980; Seidenstadt, 1982) have revealed the effect of manipulation of structural features of the letter string in influencing the rearrangement process. Mayzner & Tresselt (1958) have revealed that high frequency solution words more likely take significantly less time to solve than do low frequency solution words in
certain types of anagram tasks. Dominowski & Ekstrand (1967) and Schuberth et al. (1979) have reported the effect of manipulation involving the solution word on lexical access and these manipulations included word frequency (e.g., Dominowski, 1967; Mayzner & Tresselt, 1958; Warren & Thomson, 1969) and imageability (e.g., Dewing & Hetherington, 1974; Jablonski & Mueller, 1972; Stratton, Jacobus, & Leonard, 1975). Baumeister, Bratslavsky, Muraven, & Tice (1998) found that solution to anagram problems necessitated self-control because participants had to maintain both breaking and altering of possible combinations of letters they had created and applying new solutions in spite of early failures.

Foley and Foley (2007), Kinoshita (1989) and Mulligan (2002) have conceptualized anagram solving as a letter transformation type task. McElroy & Slamecka (1982); and Nairne et al. (1985) have reported that when participants followed simple transposition rules to generate nonwords, they reorganize letter strings by switching two letters that were underlined (e.g. changing RGAONE to ORANGE). Rules related to letter-switching occasionally result in the creation of words (Kinoshita, 1989; Nairne & Widner, 1987). Mulligan (2002) reported that when participants were required to “correct spelling errors,” by switching two underlined letters (e.g., FDAE); they make words (e.g., FADE).

**Arithmetic/Numerical Abilities**

Mathematical achievement is among one of the fundamentals that flourish a society. The significance of executive functions in mathematical attainment is well established, and researches of last decade have witnessed a shift from a focus on simply measuring working memory to an insertion of additional executive function skills, namely inhibition and shifting. A single digit arithmetic problem requires only one or possibly two strategies for a solution, but it is necessary to learn multiple strategies to solve more advanced mathematical problems. For example, in comparison to a single digit problem, a double-digit addition problem requires an additional strategic step for a correct solution. Yet more advanced problems require combining basic knowledge of strategies, with other higher-level strategies. For mathematical success, it is necessary to learn how to execute strategies, deciding when to use them, and identifying the correct strategies.
A number of studies (Gilmore, McCarthy & Spelke, 2010; Jordan, Glutting, & Ramineni, 2010) make it obvious that domain-specific numerical skills and knowledge are important for mathematical success, but cognitive factors are also important. In particular, the domain-general skill of working memory (holding and manipulating information in mind) has been found to be significant (Raghubar, Barnes & Hecht, 2010). Inhibition (ability to inhibit distracting information and unnecessary responses (Bull & Scerif, 2001; Gilmore et al. 2013; St Clair-Thompson & Gathercole, 2006), and shifting - ability to flexibly switching between different tasks (Yeniad et al., 2013), have also been associated in mathematical achievement. The function of ‘updating’ might be significant for grasping pertinent information and in the storage and retrieval of incomplete outcomes during the problem solving process. ‘Inhibition’ process may be required to suppress inappropriate strategies (e.g., subtraction when addition is required). Shifting ability may be useful in switching between various processes, strategy based solutions and quantity ranges (e.g. between verbal numerals, written Arabic signs, and, non-pictorial quantity symbols), and between the procedures of a multi-procedural problem. In a study by Dowker (2009), it was reported that children’s failure in mathematical problems is a constant and serious problem (21% of 11year olds departed primary school without attaining the mathematics level that was anticipated from them), and 5% did not succeed even after attaining the numeracy skills expected of a 7-year-old (Gross, 2007). According to Williams et al. (2003), these problems are not limited only to children, but persist into adulthood, as it was found that about 20% of adults accounted numeracy skills under the essential level required for daily circumstances. Differences in mathematical achievement are a resultant of many factors, such as, attitudes (Ma, 1999), motivation (Steinmayr & Spinath, 2009), language ability (Donlan et al. 2007) and IQ (Mayes et al., 2008), in addition to educational (Nunes et al., 2009; Opdenakker & Van Damme, 2007) and social factors (Byrnes & Wasik, 2009). Ancker & Kaufman (2007) have reported that mathematical aptitude is essential for success in Western countries. Parsons and Bynner (2005) have reported bigger impact of poor mathematical skills on life chances than poor literacy.
Cognitive Interference/Facilitation

It is the most significant attribute of human behavior to become accustomed and flexible in accordance to the altering situational requirements. This plasticity in behavioral performance involves higher cognitive control processes, which allows human beings to respond quickly and to act in a more positive manner to attain objectives and execute tasks in a well manner.

Since the inception of experimental psychology, the nature of attention has gained critical significance (Cattell, 1886; Pillsbury, 1908). Shiffrin and Schneider (1977) have emphasized on two main types of cognitive processes – one is control process and the other is an automatic process. Controlled processes, on one side, are intentional, involve attention and are comparatively time-consuming, whereas automatic processes, on the other hand, are fast and do not demand attention for their execution. Researches related to this assumption have reported that performance on novel tasks considerably depends on controlled processing; although, a few tasks with extensive practice, can become automatic (LaBerge & Samuels, 1974; Posner & Snyder, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977).

One of our cognitive processes, mainly memory, enables us to store task sets learned previously either through instructions or by trial and error. Practice effects and recency effects make easier to retrieve that task set. Those stimuli we experience/face evoke tendencies to execute tasks that are habitually linked with them without our intention. For example, we unintentionally read the numbers on vehicles or retrieve our best friend's name on meeting. More awkwardly, despite a contrary intention, stimuli evoke the tendency to execute tasks habitually related with them. The most common example of this is the Stroop effect (MacLeod, 1991). It was named after its developer John Ridley Stroop (1935). This color-word task is considered as a milestone for attentional and linguistic research field. Alan Allport and his colleagues were inspired by this interference task and it is exactly this task in their study that announced the rebirth of the task switching research in 1994. The novel, interesting effect of the Stroop task is seen with color words printed in different color ink, like, for instance, word RED printed in green ink. So, answering 'green' in response to the stimulus word RED is difficult and frequently amazing for those executing the task for the first time. The effect is made more interesting by the fact that
reading the color words in any ink as well as naming the ink of the multiple Xs seems to be an easy task to perform. Basically, the Stroop effect reveals the interference of the reading process when color naming is required in color words.

The Stroop task is a very popular means for studying interference, and since its emergence it aroused much argument over how and why its results are achieved. Many theorists attempted explanations as to how and why the Stroop effect occurred. Interference in the Stroop task can be simply explained in terms of ‘speed of processing’ for color naming and word reading. It is sure that every time subjects responded quickly to word reading task as compared to the color naming task. Based on this assumption, it is frequently supposed that information related to word reading appears before color information at processing stage. In congruent condition (i.e. When word matches with color) facilitation of color naming response takes place, while in the incongruent condition (word and color do not match) conflict between word reading and color naming leads to interference with color naming process which ultimately results to longer RT for generating correct response. This interference occurs because color naming information comes after the word information on the response stage, so no effect on word reading process. Posner & Snyder (1975) has explained interference on the Stroop task by arguing that color naming is a controlled process, so it will not take place in the condition which demands to overlook the color and read the word.

The incredible effects of Stroop task lead many other researchers to design different Stroop-like tasks in 1960s’ (MacLeod, 1991). It was examined that Stroop effect is not related only to the word-color interaction, but can also take place with other stimuli having at least two dimensions (i.e., bivalent stimuli) that can be allotted to different tasks. Such tasks which use numerals also considered to fall into this category. When participants were asked to respond to a group of identical digits, counting the number of digits was delayed by incongruent numeral value, but not the other way around (Windes, 1968).

To investigate the cognitive processes underlying a flexible switching between task sets the Stroop paradigm has become a very important research tool at present. Generally, experimental studies of task switching requires from participants to switch among two tasks. For instance,
participants are asked to switch between color naming and word reading in a color-word discrimination task by pressing right and left response keys. Word reading is the more dominant task in comparison to color naming task, as revealed by the Stroop task (MacLeod & MacDonald, 2000; Stroop, 1935); subjects have to depend on a dominant task set on color naming. In other words, when the task is to switch between color naming and word reading, switching between challenging task sets is required (Allport, Styles, & Hsieh, 1994; Gilbert & Shallice, 2002; Masson, Bub, Woodward, & Chan, 2003).

**Nervous System Properties (NSPs)**

One of the earliest Eastern pioneers in the area of nervous system activity level, and the one who first proposed the concept of endurable ranges for the simulations was Ivan Pavlov. Two ideas of Pavlov have become very popular. First is the theory of 3 essential properties of the nervous system, i.e. the strength of the nervous system, equilibrium of the excitatory and inhibitory functions and mobility of the nervous system. The second idea is about the theory which stated that there are four basic kinds of nervous system. The theory of four kinds of nervous processes mainly comes from Pavlov’s three fundamental properties of the nervous system. Originally, Pavlov built his type classification on the principle of equilibrium between the excitation and inhibition processes. But later on, he based his classification on the strength of the nervous processes; assigning equilibrium principle to second place and in his final variant of the classification Pavlov intentionally used ‘mobility of the nervous processes’.

Pavlov’s first two properties, namely, the strength of the nervous system with regard to excitation and inhibition are much well known, but his third property is the most obscured, which is, mobility of nervous processes. Teplov, a supporter of Pavlov’s ideas of the individual differences in higher neural system, declared the requirement of enlarging the research in this way by the application of new approach/manners and techniques. His information/account, “The Theory of Types of Higher Nervous system activity and Psychology” presented at the “International Congress of Psychology” (Teplov, 1955a, 1955b) accelerated researchers to move forward from physiology to psychology of individual differences. He made improvements in the
research methods/tools that were used for studying various higher nervous system processes and instigate researchers to offer new principles.

The term 'mobility' seems suitable for denoting the property characterized by the speed of transformation (physiologists used it in this way with experiments on animals). Data obtained in these experiments indicate that the mobility of excitation and that of inhibition may be different. But the indices of speed of initiation and termination of the excitatory processes show good correlation with each other, and no correlation with speed of transformation. The property of the nervous system characterized by them may be named 'lability' (Teplov, 1963). Thus, in conclusion, mainly four properties of the nervous system are proposed which are: (1) strength (endurance), (2) dynamism (the ease of generation of the nervous system), (3) mobility (speed of alteration from one process to another), and (4) lability (the speed of initiation and termination of the nervous processes). Each of these properties is different from each other in regard to the excitatory or inhibitory processes.

Bodily functions (both internal and external) are mainly controlled and regulated by nervous processes which are concerned with the co-ordination and control of responses to environmental stimuli and appropriate behavior through a bundle of independently conducting neural fibers. Soviet psychologists have defined temperaments as the properties of the nervous system which are revealed by an individual’s behavior and action (Smirnov, Leontev, Rubistein & Teplov, 1966). According to Strelau (1998), “Temperament is defined as personality traits which are present since early childhood that can be observed not only in human behavior, but also in animals, and refers rather to formal aspects of behavior.” According to present view, the characteristic features of the nervous system (such as Mobility, Lability, and Equilibrium/balance, etc.) are the fundamental attributes of the functional system which guarantee the integrative functioning of the brain and the whole nervous system.

- Mobility has been explained as the pace with which nervous processes altered i.e. time taken in alteration of the current process. The ability to respond rapidly as well as sufficiently to variations in the environment was measured by Pavlov’s alternation
method (changed conditioned stimuli (CS's)). The mobility of excitation is different from that of mobility of inhibition (Teplov, 1972).

- Lability may be defined as the pace with which nervous processes are stimulated and extinct, i.e. time taken in initiation and cessation of any activity. It is a neo-Pavlovian property proposed by Teplov (1963). The most common measures used are the length of the visual after image (Ravich-Shcherbo, 1956), which was initially believed to be a measure of mobility, and the efficiency of photic driving in the high frequency band (beta 2, 20-30 Hz) (Golubeva, 1973; Golubeva & Schwartz, 1965; and Nebylitsyn et al., 1965).

Equilibrium/balance is the relative readiness with which the nervous system generates excitatory or inhibitory functions in the form of conditioned reflexes, in the speed of replacing one process for the other, and so on. It can be represented by the end process of interference-facilitation among two or more excitatory or / and inhibitory processes at the same time - presently taken as cognitive interference- for e.g. Stroop color-word interference (Stroop, 1935).

Problem solving, which is often considered as a search process, entails a trade-off between exploiting old solutions and investigating new ones. A wide range of decisions is influenced by such trade-offs in our daily life. Problems like purchasing and vending stocks, maintaining or abandoning relations, and having your usual eating or seeking “the special” are all examples of a decision between persevering with precedent actions and attempting something novel. Central executive processing is the much common characteristic between them, whose goal directing and attention-maintenance characteristics are of very much importance in working memory literature (Baddeley, 1996; Hazy, Frank, & O'Reilly, 2006). Our daily routine activities require frequent shifts between simple or complex cognitive tasks. Laboratory based experiments on task switching has become a very popular means for studying mental processes in simple cognitive tasks and also allow us to examine the fundamental cognitive processes that lie beneath the switching. The popularity of these task switching paradigms/patterns reflects the budding interest in understanding the attentional and other executive processes. Profound knowledge of such processes will ultimately contribute to an improved understanding of cognition and the brain in general.
Hence, after describing the three basic aspects of neuro-cognitive processes: interference among processes; speed of initiation and termination of processes; and speed of transformation of processes; and three tasks implying set formation and set-switching in varied structures (figural, numerical and verbal) bound to switch costs of different levels that possibly invoking some measures to reduce costs and facilitating switching, the present study funnels to discrete statement. The present research aims at studying the generality of the cognitive phenomenon of set-switching in relation to various domains through different tasks (both verbal and non-verbal), its related aspects (such as switch costs in the form of perseverative errors) and effectiveness of intervention strategies (explicit and implicit) in individuals having difficulty in set-switching.