REVIEW AND PROBLEM
The present chapter reviews the studies of the related literature for the purpose of establishing, reading and assessing descriptions of studies that are related to the individual’s planned project. So in pursuance with the aim of the research, studies related to set switching, cognitive interference, temperamental traits mainly mobility and lability, numerical/mathematical and anagram solution, were collected through various sources. Related material was also searched online from various websites like Springer Link, Taylor and Francis Online, Google scholar, Pub MED, Sage Publication and others. The subject matter was searched many times by taking different key variables, i.e. set and task switching, set switching and cognitive interference, set switching and nervous system properties, numerical/mathematical, anagram tasks and task switching, mobility, lability, Pavlovian properties, set switching and temperamental traits. Along with this, American Psychological Abstracts (APAs) were scrutinized and studies mentioned in related books were also located and evaluated.

Many of the retrieved studies seemed to be out of the present context. Review presented here is not claimed as comprehensive; only studies relevant to test the relationship between tasks/ measures have been selected. Studies that have no direct bearing to the present research topic were screened out at first step.

To organize the available studies of different tasks/measures, studies of different measures are reviewed separately. Author(s), tasks/measures and main findings of the representative studies have been presented in tabular form (in increasing order of publication year, cluster of studies at
end in each table) for convenient and quick examination of the development and trend in the field. The sorting of the study and their placement in specific tables was as under:

Table 1  Studies related to the executive/cognitive process of task switching

Table 2  Studies attempting relationship between mobility, lability and task switching measures

Table 3  Studies representing relation between task switching and cognitive interference measures/tasks

Table 4  Studies related to task switching and numerical measures/tasks

Table 5  Studies associated to task switching and anagram solution tasks/measures

Table 6  Studies linked to cognitive/executive control training/intervention using task switching paradigms.

Description of studies via task/measures and their respective findings/conclusions have been presented in each table.

Table 2.1 Studies related to the executive/cognitive process of task switching

<table>
<thead>
<tr>
<th>Authors(s) / Year</th>
<th>Tasks/Variables</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Meiran, Chorev,</td>
<td>Enough time for preparation (above 600ms RSI)</td>
<td>Reduction in switch cost remains constant</td>
</tr>
<tr>
<td>&amp; Sapir (2000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Ruthruff, Remington,</td>
<td>Switch cost in terms of Reaction time</td>
<td>Performance was poorer on a switch trial as compared to a non-switch trial.</td>
</tr>
<tr>
<td>&amp; Johnston (2001)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Altmann, (2004a)</td>
<td>longer response-stimulus interval (RSI) and/or 25</td>
<td>Reduction in switch cost</td>
</tr>
</tbody>
</table>

Working memory (WM) & Switch Task (ST) - Variant of Strenberg memory task.

knowledge (by cueing or instructions) with an increase in number of items in WM, performance (speed) in form of switching to a secondary decision making task decreases.

5. Friedman et al. (2006)

Updating, shifting inhibition, Intelligence (fluid-Gf & crystallized Gc), WAIS

-latent variable analysis revealed that Gf was not significantly related to inhibition & shifting, but to Updating -EF and Gc correlation were significantly higher (updating with highest correlation, r = .68)

-SEM confirmed the strong relation of updating with Gf and Gc.

-updating was the only EF factor explaining variance.

6. Schiebener et al. (2013)

Game of dice task (GDT), Modified card sorting test (MCST), 3-back task, Working memory ability

-individuals with above average executive functions and above average working memory functions performed well on making decisions under overt risk conditions, independent of whether they have received any advice.

-individuals with lower abilities in working memory and executive functions make more disadvantageous decisions.

-advice improved the decision

Dual task (Game of dice task plus 2-back task, Modified card sorting test (MCST) & Balanced switching task (BST))

- Working memory (2-back task) scores correlate with concept formation (MCST) and monitoring (BST).
- No correlation between decision making under explicit risk (GDT) and executive functions (MCST and BST).
- Concept formation (MCST) and monitoring (BST) involved in the simultaneous performance of decision making under risk (GDT) and working memory task (2-back task).
- Mediation analysis revealed BST performance partially mediates the influence of MCST performance on the GDT plus 2-back task.

8. Santos et al. (submitted)

fMRI study, involve three conditions - High-switching condition-task alters 3 times in 6 trials, Low-switching condition-task changes one time in 6 trials, individuals who exhibited high anxiety also revealed a large boost in brain activation compared to individuals who exhibited less anxiety in low-switching and high switching conditions.

- a part of the PFC (BA9/46) concerned with shifting & attentional
Generally, the phenomenon of set switching requires an individual to switch as quickly as possible according to the situation demands; otherwise, he/she has more loss (switch costs) in the form of more time and more errors. Apart from the findings of task switching paradigms, some studies cited in the above literature clearly reveal that the switch costs can be reduced by providing long RSI and even by providing knowledge in the form of explicit instruction or cue. Other studies have provided an alternative explanation for switch costs in the form of cognitive load, i.e. increases in the amount of information in working memory puts an additional pressure/load on cognitive resources which ultimately leads to failure in switching to a different task. Developmental studies have clearly demonstrated that set switching abilities have developed in young adolescents and set maintenance in young adults. These studies also exhibited relation between anxiety, explicit advice/instruction and executive functioning (task switching conditions).
## Table 2.2 Studies attempting relationship between mobility, lability and task switching measures/tasks

<table>
<thead>
<tr>
<th>Authors(s)</th>
<th>Tasks/Variables</th>
<th>Findings/Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Klimov (1959)</td>
<td>Burdon’s Test of Letter cancellation (Mobility of Nervous system)</td>
<td>‘Mobile’ weavers try to perform their task rapidly; spent less time on orienting activity than ‘slow’ weavers, no difference in performance.</td>
</tr>
<tr>
<td>2. Krauski (1964); Alterations of signs of positive inhibitory stimuli and mobility</td>
<td>The more quickly both stimuli acquire new signal value, the more quickly the criterion CR is attained, the higher is mobility.</td>
<td></td>
</tr>
<tr>
<td>3. Mangan (1967c)</td>
<td>Transformation of mobility, perceptual flexibility, originality, fluency, extraversion, Neuroticism.</td>
<td>Because of strong inhibitory control, Mobile Ss seem able to change set more efficiently &amp; thus test out as more original, less fluent. Extraversion &amp; mobility were found to be significantly correlated.</td>
</tr>
<tr>
<td>4. Suzdaleva and Chuprikova (1974)</td>
<td>Associate RTs in 17 tasks and several measures of strength, lability &amp; mobility of the nervous system.</td>
<td>For each individual there is a characteristic associative RT that is a function of the lability of the NS. The Mo aspect influences the RT of those associations that involves additional information processing and decision making.</td>
</tr>
<tr>
<td>5. Strelau (1975)</td>
<td>Reports on Pavlovian studies</td>
<td>Mobility comprises the independent properties of capacity for reversal,</td>
</tr>
</tbody>
</table>
in Soviet universities speed of arousal, extinction and dynamism.

Extraversion was correlated with motor transformation mobility.

7. Strelau (1977) Behavioral mobility, flexibility, fluency of thinking (semantic and figural)
High flexibility & fluency go together with high behavioral mobility, and the reverse.

8. Mangan (1978) Transformation mobility (auditory & visual), Thinking flexibility, perceptual flexibility, originality, extraversion, neuroticism, spontaneous recovery, visual after image *
(Author considered VAIs, at that time to be a measure of mobility rather than lability).
-Es are more mobile than Is, less fluent and more original.
-Mobiles are more flexible, original, extraverts and less fluent.
-All the flexibility measures and alteration mobility inter-correlated.
-After image duration loads positively with neuroticism and negatively with perceptual flexibility.
Some of the data replicate earlier findings (Mangan, 1976c)

9. Strelau, Angleitner, & Ruch (1989) Review of 17 studies on relationship between STI measures (i) Strength of Excitation (SE) and mobility (Mo) i. All 17 studies (from 1974 and to 1987), reported positive correlations being .54; (.40 - .71) between SE and Mo.
ii. Weak positive relation-
(ii) Strength of Inhibition (SI) and Mo  
Critical frequency of light flickering, & motor skill alteration (between positive and negative signals).

Intelligence (Raven’s test), personality (PTS-mobility) and inspection time.

12. (i) Ravich Shcherbo & Schwartz (1959)  
Various indices of lability:  
i. Adequate Optical Chronaxie (AOC), critical flicker fusion frequency (CFFF).

(ii) Schwartz (1959)  
ii. CFF & speed of threshold restoration; CFF & (IU); CFF & Visual after Effect (VAEs).

(iii) Turovskaya (1963a)  
iii. AOC and CFF; CFF & IU.

(iv) Golubeva and Schwartz (1965)  
iv. CFF & threshold reestablishment (sensitivity

No significant correlation was reported between these characteristics of functioning of nervous system.

Mobility was found to be related with Performance IQ and Raven’s test scores.

Significant correlation were reported between lability and measures.
restoration (SR))
- Photic driving
indices & speed
of restoration
of sensitivity
after flooding.

(v) Golubeva
(1972 a, c)
v. photic driving
indices and
indices of lability
(CFF, SR, AOC).

Scanning of studies in Table 2.2 represents the ongoing trends of the studies. Studies related to mobility mainly attempted to study the association between mobility and strength of the nervous processes (particularly the strength of excitation); relationship with personality dimensions - extraversion, psychoticism and neuroticism; and association with behavioral expression. Lability has been studied more at psychophysiological level and less at behavioral level. However, many researches related to mobility and lability have been conducted with various other measures such as intelligence, personality, etc., but there exists a scarcity of studies related to executive functions, mainly task switching, set shifting, in national (India) as well as international level. Both the variables converge on common cognitive functioning and there seems to have potent stochastic dependence among set-switching performance, mobility (speed of transformation) and lability (speed of initiation and termination of excitatory or/and inhibitory processes).
<table>
<thead>
<tr>
<th>Authors(s) / Year</th>
<th>Tasks/Variables</th>
<th>Findings/Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Miyake et al. (2000)</td>
<td>Shifting task (Plus-minus, Number-Letter, Local-global task); Updating task (keep-track, tone monitoring, letter memory task); Inhibition task (Stroop, Antisaccade, Stop-signal task)</td>
<td>-CFA revealed 3 distinguishable functions: Inhibitory processes, shifting between varied task sets and updating information in working memory. -all 3 latent variables not completely independent (correlation ranging from .42 to .63), suggested some unity accounted by Inhibitory function (all executive processes entail some restraining processes to function properly). -interference correlated with perseverative errors.</td>
</tr>
<tr>
<td>2. Bull &amp; Scerif (2001)</td>
<td>WCST, Stroop task</td>
<td>-ADHD group exhibited poor performance on total errors and perseverative errors (WCST parameters). - ADHD group also have more interference and more inhibition.</td>
</tr>
<tr>
<td>3. Sinha, Sagar and Mehta (2008)</td>
<td>WCST, Color-Word Stroop test</td>
<td>-Regression analysis revealed that performance on insight problems was predicted by visual-spatial and</td>
</tr>
</tbody>
</table>
5. Zinke et al. (2012)

- Training groups reduced switch costs (in form of RT & error rate) in training session and diminished mixing costs (RT) on a similar task more in post training than the non-trained control group.
- Larger declines in RTs were reported in switch trials than non-switch trials.
- Intervention in the form of exercise

- Cognitive training task (vehicle task & car task), Acute exercise intervention (cycling for 20 minutes), Fitness assessment;
- 3 Transfer tasks – Task switching (Food task- size task & no. switch task), Updating verbal working memory, after partailling out of executive scores.
- No executive measure (switching and inhibitory function) were significantly related in predicting performance in insight problem solution.
- For non-insight problem, switching with visual-spatial & verbal working memory spans exhibited significant contribution in predicting solutions.
- It was reported that those Ss who performed well on switching task likely executed better on non-insight tasks in comparison to participants who did not perform well on switching task.

- 18 Non-insight tasks (e.g. tower of London, hobbit & Orcs, anagrams etc.), Verbal working memory (Sentence span and Operation span), Visual-spatial working Memory (visual pattern span & Corsi block), Inhibition (color and Number Stroop), Switching (Arithmetic & number-Letter switching)
6. Schiebener et al. (2014)

Game of dice task (GDT), color-word interference test (CWIT), Trail making test part B (TMT B), Modified card sorting test (MCST), Balanced switching task (BST)

- General control had a direct effect on decision making
- Effects of monitoring and concept formation on decision making under risk were mediated by general control function (ability to allocate attention according to a task rule and goal).
- Perseverative and non-perseverative errors (MCST) exhibited significant correlation with CWIT scores, TMT, GDT and BST scores.

7. Allport et al. (1994); Monsell, Yeung, & Azuma, 2000; Koch, Prinz, & Allport, 2005; Arbuthnott, 2008a; Yeung & Monsell, 2003a, 2003b

Color-word stimuli

- Higher switch costs on switching to stronger, more dominant task.
- Switch costs occur due to proactive interference (performance on a preceding competing task).
Inspection of above studies led us to summarize the following -

- Some studies exhibited a significant relationship between perseverative as well as non-perseverative errors and interference scores, i.e. more interference leads to poor performance (more switch cost).

- A few studies suggested the idea that cognitive interference in task switching resulted from proactive interference.

- Other studies involving training interventions exhibited promising results by showing that switch costs (in the form of RT and errors) can be reduced and also transfer of training may be possible for similar but limited tasks.

<table>
<thead>
<tr>
<th>Authors(s) / Year</th>
<th>Tasks/Variables</th>
<th>Findings/conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Jersild (1927)</td>
<td>Pure task block- same task was repeated within block, Mixed task block- alternate between two different task. Simple tasks like addition, subtraction &amp; writing the anatomy of an objective.</td>
<td>-performance was poorer on task switch trials relative to task repetition trials. -performance was poorer on blocks of trials where Ss alternate tasks on every other trial relative to blocks where they had to repeat the same task throughout the block.</td>
</tr>
<tr>
<td>2. Spector and Biderman (1976)</td>
<td>Addition and subtraction problems, without cue condition (e.g add or subtract the number 3 alternatively on each trial), Cue</td>
<td>Smaller switch costs were found when cue was present in comparison to when cue was absent.</td>
</tr>
</tbody>
</table>
condition (e.g., 47 + 3, 35 - 3, 18 + 3...)

3. Rourke (1993)  
Arithmetic tasks involving addition and subtraction

Children who exhibited difficulty in arithmetic problem solving with a pattern of neuropsychological weakness have difficulties shifting psychological sets.

A character pair (one letter and one digit) was presented on a quadrant of four square boxes. Ss had to classify the letter character as consonant/vowel and the digit as odd/even. Stimuli were presented on various RSIs ranging from 150 ms to 1200 ms.

- performance improved as the response stimulus interval (RSI) increased from 150 ms to 600 ms.
- a residual cost remained showing no reduction when the RSI was increased from 600 ms to 1200 ms.
- average RT was facilitated for the congruent character pair relative to incongruent character pair.

WCST, Corsi Block task, Group mathematics ability test (Young, 1970)

- Two latent variables were found. 1st was a set of general measure of performance related to set failure, nonperseverative error, total correct responses, and total no. of trials. 2nd variable was incorporated with measures of perseveration.

- children with lower ability mathematical group made more
perseverative and nonperseverative errors and more perseverative response even controlling reading and IQ differences.

-children who exhibited lower mathematical ability required more trials to complete the six categories.

percent perseverative responses correlated negatively with mathematical capability.

-higher mathematical ability also correlated positively with lower interference.

-interference/inhibition correlated positively with perseverative errors (WCST),

-no significant correlation between trails to complete first category & mathematics ability.

-perseveration and inhibition efficiency predicted a considerable amount of variance in mathematics ability.

performance on bivalent trials was impaired on both non-switch and switch trials relative to performance on univalent trials.
must be classified on a given trial while the other must be ignored. Univalent Trials – the presentation of a digit unambiguously signals the arithmetic task.

8. Derakshan et al. (2009)  One pair multiplication & division problem; other pair addition & subtraction; anxiety -participants who exhibited high anxiety made more errors and took more time in task switching conditions (subtraction problems) demanding shifting than participants who exhibited low anxiety. -high anxious participants exhibited a poor performance than low anxious group on cue absent conditions than cue present conditions.

9. Cooper et al. (2012)  WCST, Digit-switching task, 2-back task, go-no-go task -Significant inter-correlation among various measures (categories completed, correct, perseverative errors, non-perseverative errors). -performance on WCST (increase in perseverative, non-perseverative, number of trials to attain first rule and decrease in correct responses and categories completed) more effected by secondary task that
| 10. Karbach et al (2014) | Pretest- WM span task, task switching- single task & mix-task blocks, Stroop task, fluid intelligence, perceptual speed), German mathematics test & Knuspels Reading task; Training session - ‘Braintwister’ WM testing battery (farm task & safari task); Postest- WM span task, task switching- single task & mix-task blocks, Stroop task | involve set-shifting (digit-switching task) than by secondary task that involve executive function (2-back and go-no-go task). -participants who received adaptive WM training demonstrated more training gains in comparison to those participants who receive adaptive low-level training. -adaptive training’s gains were shifted to a different/new WM task and also to a standardized test of reading ability (Knuspels reading task) but no such gains were, observed to a inhibition task that involves task switching (i.e. German mathematics test) -transfer effect to new WM task were observed for more than three months -results showed compensatory effects with more gains in participants who exhibited poor performance on WM and reading tasks at pretest. |

| 11. Agostino, Johnson, & Pascual-Leone, 2010; Blair, Knipe, & Gamson, 2008; Clark, Pritchard, | Task switching & academic abilities | -shifting ability is essential for execution on multifaceted academic tasks that require shift between different facets of problems or arithmetical approaches. |
A keen observation of above studies indicates the growing interest of researchers towards the arithmetic ability and task switching paradigm. Above quoted studies emphasized mainly on the relationship of mathematical performance or academic achievement on mathematical tasks to perseverative and non-perseverative errors, interference/inhibition and other factors in normal population as well as population with mathematical difficulties. Studies also highlighted executive processes involved in performance of mathematical/numerical tasks and also the promising effects of executive/cognitive control training.
Table 2.5 Studies relating to task switching and anagram tasks/measures

<table>
<thead>
<tr>
<th>Authors(s) / Year</th>
<th>Tasks/Variables</th>
<th>Findings/Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mayzner &amp; Tresselt (1958)</td>
<td>Anagram task</td>
<td>-in certain type of anagram tasks high frequency solution word (high frequency of occurrence in language) took significantly less time to solve than low frequency solution words (word having a low frequency of occurrence in language).</td>
</tr>
<tr>
<td>2. Johnson &amp; Mondfrans, Ambiguous (1965)</td>
<td>anagram (with multiple solutions)</td>
<td>-solution word with the highest normal frequency of occurrence was responded first, then the next most frequent solution word and so on.</td>
</tr>
<tr>
<td>3. Dominowski (1966); Gilhooly &amp; Johnson, (1978)</td>
<td>Anagram- similarity to the word</td>
<td>-those anagrams whose letter sequence were more similar to the target stimuli were easily solved.</td>
</tr>
<tr>
<td>4. Nairne &amp; Widner (1987)</td>
<td>Anagram task : difficulty level</td>
<td>-when participants were asked to think about the procedures they have followed to solve simple anagram problems, difficult anagrams were solved more easily.</td>
</tr>
<tr>
<td>5. Foley &amp; Foley (2007)</td>
<td>Anagrams’ difficult &amp; easy (construction &amp; solving)</td>
<td>-when more focus was offered to the methods related to source monitoring judgments about solving vs. constructing anagrams, it was reported that source benefit was 42</td>
</tr>
<tr>
<td>Study</td>
<td>Task Description</td>
<td>Findings</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6. Goode, Geraci &amp; Roediger (2008)</td>
<td>Anagram solution - practice</td>
<td>-variable practice on different versions (different variations of anagrams that was later tested) led to improved test performance in relation to repeated practice (solving the same anagram that was later tested).</td>
</tr>
<tr>
<td>7. Novick &amp; Sherman (2008)</td>
<td>Anagrams task</td>
<td>-anagrams of two syllables took more time for solution than anagrams of one letter among good anagram solvers. -solution to anagrams appeared as a result of pop-outs (insight) more in skilled solvers.</td>
</tr>
<tr>
<td>8. Price (2010)</td>
<td>WCST-64, Stroop color-word interference test, Controlled oral word association test, Computation span task and anagram problems, Diseased</td>
<td>-Parkinson’s disease (PD) group had more problems in solving anagrams than healthy group. -when a cue was presented with anagram, PD group perform normally, but healthy group didn’t benefited.</td>
</tr>
</tbody>
</table>
and healthy group.

- Performance of both groups was better in cued condition.
- Performance on anagram was found to be associated with verbal fluency and inhibition, and not with working memory and set shifting.
- Priming of contextual cues with anagram facilitates PD patients to conquer the deficits with inefficient semantic generation and inhibitory processes.

From the above literature review, it is apparent that examination of human language - grammar (anagram here) has been a very significant interest area in theoretical as well as educational context of a very long time. Findings of anagram problems guide us to draw the following conclusions -

- That solution to an anagram problem involves two steps. First is, rearrangement of words and second is, matching of the rearranged words with related information already present in our cognitive system i.e. memory,
- That commonness/more usage/high frequency of a work make it to be solved easily than uncommon or low frequency occurrence words,
- That increase in the number of syllables/letters in anagram makes them more difficult,
- Training/intervention studies provide promising results even for individuals showing deficits in cognitive processes.
Table 2.6 Studies related to cognitive/executive control training using task switching paradigms.

<table>
<thead>
<tr>
<th>Authors(s) / Year</th>
<th>Tasks/Variables</th>
<th>Findings/Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mayr and Kliegl (2000)</td>
<td>Long RSI or explicit cuing of the task rules</td>
<td>-switch costs were higher when the switched-to task involve high retrieval demands such as episodic information than in the opposite case of semantic information. -with long RSI or explicit cuing, the retrieval-demand effect was eliminated.</td>
</tr>
<tr>
<td>2. Tornay and Milán (2001)</td>
<td>Bivalent stimuli (e.g., 5A, A7, 2B, P4...) presented in both predictable and unpredictable blocks of trials with a variety of RSIs (200 ms, 800 ms and 1200 ms)</td>
<td>-performance of unpredictable sequences was generally poorer with smaller switch costs. -longer the RSI, the faster the RTs -In unpredictable blocks of trials, switch costs were eliminated when a long RSI (1200 ms) was provided.</td>
</tr>
<tr>
<td>3. Monsell, Sumner &amp; Waters (2003)</td>
<td>High/low &amp; odd/even classification tasks. Varied interval between the task cue and stimulus presentation between blocks of trials. e.g. task switched predictably at 2, 4 or 8 trials in one task and at every fourth trial in other task.</td>
<td>- A significant decrease in RT between the 1st and 2nd trial of a run of equal size was observed. - No further improvements in RTs was found in the consequent trials.</td>
</tr>
</tbody>
</table>

5. Sohn & Anderson (2003) Partial overlap task switching paradigm, priming -it was reported that stimulus related priming is automatic and no direct control of executive functions exists and fades away when enough time between the two tasks take place. -stimulus related priming is not modulated by foreknowledge.

6. Waszak, Hommel & Allport (2003) Task switching paradigm, Stroop like task picture-naming & word-reading, priming -poor performance (more switch costs) to the stimuli which took place earlier in the competing task situation, although time gap (more than 100 intervening trials) between two events was very long.

7. Arrington & Logan (2005) Blocks of bivalent stimuli, instructions and explicit cue. -proportion of task repetitions and task alternations was not influenced by presence of an external cue that signaled the upcoming task. -participants took less time and made fewer errors to switch (smaller switch cost) when they had to select which task to execute than when the task was signaled by explicit cue.

8. Kiesel, Kunde & Task switching -those primes which are presently
<table>
<thead>
<tr>
<th>Study</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoffmann (2007)</td>
<td>paradigm, not related to stimulus categories. Unconscious revealed almost the same congruency priming as primes from the presently related stimulus categories. The dimension of the priming effects was not reliant on whether the S-R rules (i.e. task) of the preceding trial was repeated or switched.</td>
</tr>
<tr>
<td>Lau &amp; Passingham (2007)</td>
<td>fMRI study, task switching, unconscious priming. Compared to congruent trials, more activity in brain regions was observed in incongruent trials that were paired with the task signaled by subconscious prime. Diminished movement was observed in brain areas coupled with task that was signaled by visible instructions. Priming was most effective when prime visibility was minimum but vanished when Ss deliberately recognize the prime.</td>
</tr>
<tr>
<td>Karbach and Kray (2009)</td>
<td>Pretest session - task switching training results to more reduction in mixing costs as compared to single task training in posttest. Transfer of performance based on mixing cost was found significant in children &amp; older adults. Verbal self instruction did not support transfer of performance on task switching &amp; transfer was</td>
</tr>
</tbody>
</table>
Training session -
Single task training,
Task switching training,
task switching plus
verbal self-instruction
training, task switching
+ verbal self-instruction
+ training variability.
Posttest session -
all the groups were
tested again on all
tasks of pretest session.

11. Martinovic, Gruber & Muller (2009)
Task switching paradigm (covert naming or living/
non-living judgment;
priming
reported when there was a similarity between training & transfer task in verbal self-instruction group.
-as compared to single task training, task switching training, produced enhanced performance on verbal & spatial WM task, interference task, and even in fluid intelligence task.
-reported that transfer to similar and different/new tasks by executive control training can be attained not even in children and adolescents but up to old age.

-when image repetition took place in the task, then priming effects on accuracy (fewer switch costs) & RTs were observed for covert naming and categorization.
-covert naming revealed better priming effects as compared to categorization.
-covert naming exhibited early starting & persistent enhancement of ERPs i.e. more perceptual & semantic processing was revealed.
-covert learning also accounted more strong perceptual and semantic processing.
12. Cole, Bagic, et al., 2010
Task switching paradigm, RITL -framing
-rapid instructed task learning (RITL) involves a unique task set formation process that leads to an integrated task that can then be later retrieved during practiced task preparation (i.e. during typical task switching).

Backward masking paradigm, semantic or phonological task, explicit instruction & unconscious prime, SOA and similarity of priming
-when stimulus onset asynchrony (SOA) between prime & instructions was enough long (84 ms), primes that were similar to the task set instruction led to quicker responses compared to dissimilar primes.
-when (SOA) between prime and instructions was short (36 ms), no task set priming was reported.

14. Manly et al. (2014)
Set-switching task (word pairs), masked visual primes
-priming by cues that were beyond conscious awareness was shifted not only to the trained task but also to new task that require similar processes.
-individual differences on prime visibility (in form of lower priming) were not reported.

15. Shaffer, 1965, 1966 Meiran, 1996; Hoffmann, Kiesel, & Sebald, 2003; Koch, 2001; Dreisbach, Haider, & Kluwe, Task switching paradigm, task cueing performance was worse in switch trials, which revealed robust switch costs also in task cueing.
For adjusting to current situation demands, making intelligent decisions by maximizing the gains (less time and fewer errors) and minimizing the loss (switch costs here), we have to alter/modify (switching/shifting) our attention/action according to situational demands. A number of studies emphasizing on executive/cognitive control training revealed that-

- Training effects were not limited only to the trained tasks, but to other similar tasks, as well as, in some instances to a very different task also.
- Training effects are not restricted only to children and young adolescents, but up to old age also, showing cognitive plasticity. Cueing exhibited mixed effects on reduction of errors.
- Training effects take place for a longer time period also. Priming (sub conscious) effects reduced switch costs and even exhibited transfer effects.

In view of the above mentioned literature and considering the importance of executive functions, mainly set switching, and its related processes like interference, problem solving on numerical and anagram tasks and its temperamental bases; and checking the efficiency of intervention strategies for those having high switch cost, the following trends were visible:

1. Multiple tasking has been popular among researchers in the last twenty years, many variants of WCST implying executive functions are clubbed; quite a generality of effects have been obtained.
2. Though, individual differences variables have been taken up but age and abilities were over emphasized, personality and temperamental variables have been neglected.
3. Deliberate attempts to reduce switch costs (errors and RT) in recent studies in terms of training on similar and other tasks, external cueing and subconscious priming techniques happens to be focal research area; promising outcomes are reported, however, conclusive
evidences in terms of most effective intervention are awaited. A few attempts have been made of comparisons among the strategies across variants of task.

4. Hence, the present study review is suggestive of some hypotheses too.

**PROBLEM AND HYPOTHESES**

In current years, researchers have emphasized more on studying executive processes in relation to students' skills. Studies oriented towards this area/field emphasize not only on normal population, but also include sample with specific difficulties or problems such as learning disability, language or speech comprehension problems, arithematic problems, autism, ADHD or problems or deficits related to behavioural aspects (Lehto, 1995; Russell, Jarrold, & Henry, 1996; Swanson, Ashbaker, & Lee, 1996; Adams, Bourke, & Willis, 1998; Hughes & Richards, 1998; Bull, Johnston, & Roy, 1999; Cornoldi, Barbieri, Gaiani, & Zocchi, 1999; Lorsbach, McLean & Hitch, 1999; Ozonoff & Jensen, 1999; Swanson, 1993, 1999; Gathercole & Pickering, 2000a, 2000b). These studies have reported very impressive findings by revealing executive function's role in predicting cognitive performance. A number of other related studies to this area exhibited equivalent findings even when other possible illustrative cognitive factors, e.g. LTM (long term memory) retrieval, phonological processing and speed of information processing, have been controlled.

An important characteristic of executive processes is the ability to switch between different and complex tasks or approaches/strategies, e.g. WCST (Heaton et al., 1993). Although, many processes are required for the successful execution of this task, WCST also required understanding the rule/principle currently progressing to maintain that dimension, switching to new demands, inhibiting the old ones by evaluations of feedback and hence altering responses according to the new sorting criteria or according to the demands. A number of neuroimaging studies which reported that many cortical regions are involved in the execution of WCST (Berman et al., 1995), with other tasks of executive functions (Collette et al., 1999). Instead of process of 'updating' in working memory or inhibition, the ability to switch between strategies or procedures, was considered to be a best predictor of performance on this task (Miyake et al.,
Bull et al. (1999) and Rourke (1993) also stated that poor performance on mathematics and arithematic task was related to performance on WCST (more perseverative responses and difficulty in shifting set).

Another significant property of executive functioning is the ability to inhibit inappropriate information from entering working memory. This characteristic of executive functioning is assessed by other tasks such as random generation task (Baddeley et al., 1998), trail making test (Lezak, 1995), and the Stroop task (Stroop, 1935). Stroop task has been considered as the most representative tool for assessing inhibition/interference from many years and researchers have provided diverse explanations for inhibition/interference measured through this task. According to Luo (1999), Stroop task involves many processes beginning from the perception of stimuli to response output. Interference in the incongruent condition leads to slower performance may be due to diminished focus of attention to the related dimension (Pansky & Algom, 1999); enhanced automaticity or quicker speed of processing of the irrelevant dimension (MacLeod, 1991). A study conducted by Kohli and Kaur (2006) showed significant differences in scores of Indian and Western sample on Wisconsin card sorting test as the more cognitive interference was found in an Indian sample as compared to Western. Cognitive interference has neural basis as evidenced by clinical studies. Similar role of mobility and lability of nervous processes could be investigated where a wide gap exists.

In the review, it was observed that the age has been investigated through frequently (studies grouped at Sr. No. 9 in Table 2.1; studies grouped at Sr. No. 11 & Sr. No. 12 in Table 2.4 and at Sr. No. 10 in Table 2.6) but found that set-switching as an ability develops by adolescence and then almost remain at the remain same level. The age group selected in pre-test study belongs to that age level, however, further relevant due to its importance for academic achievement and problems faced by school children engaged in situations requiring serial tackling of similar problem and then shifting to different one (a very common situation during instructions as well as during evaluations) highlighted in large number of studies) cited and grouped at Sr. No. 11 & 12 in Table 2.4).
In view of the above findings, it was considered to examine the significance of executive functions through set switching in relation to other cognitive parameters and to investigate the role of set-switching on other tasks, e.g. verbal and non-verbal, could go a long way, in providing the insight into the general mediating role of intervention strategies in executive functioning. Thus the following problem was delineated for the present study.

**Problem:**
To study the phenomenon of Set-Switching under various task conditions, its correlates and some strategies to reduce switch cost.

**Objectives:**
The major objectives of the study were:
1. To study various facets of set-switching.
2. To identify the correlates (mobility, lability, cognitive interference, type of tasks-verbal and non-verbal problem solving) of set-switching.
3. To see the effectiveness of some selected moderating variables (explicit – implicit) as strategies among those having difficulty in set switching (high cost individuals) in relation to correlates.

**Hypothesis:**
Four empirical hypotheses were advanced as tagged to the objectives:
1. The task demands will modulate set-switching during task performance.
2. People high on cognitive interference, low on mobility and lability will have greater difficulties (in more errors, trials, less number of categories etc.) in set-switching across tasks.
3. Explicit and implicit intervention will reduce difficulty in set switching across tasks.
4. Explicit and implicit intervention will have different effect.