CHAPTER-I

INTRODUCTION

Cognition is an abstract property of advanced living organisms. It is the process by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used. Thus, it can be said that cognition is a group of mental processes including attention, working memory, producing and comprehending language, learning, reasoning, problem solving, and decision making. It is a set of abilities, skills or processes that are part of nearly every human action. It has to do with how a person understands and acts in this world. Cognitive abilities are the brain – based skills required to carry out any task from the simplest to the most complex. They have more to do with the mechanisms of how one learns, remembers, solves a problem, and pays attention rather than with any actual knowledge.

Cognitive processes involve:

1. the selection of information,
2. the making of alterations in the selected information,
3. the association of items of information with each other,
4. the elaboration of information in thought,
5. the storage of information in memory, and when needed,
6. the retrieval of stored information (Morgan, King, Weisz, and Schopler, 1993)

So, the concept of cognition is closely related to such abstract concepts as mind, reasoning, perception, intelligence, learning, and many others that describe numerous capabilities of the human mind and expected properties of artificial or synthetic intelligence.

However, of these abilities, attention is the basic cognitive skill on which other higher order mental processes depend. Of all the tasks the human brain performs, perhaps none is more consequential for the performance of other tasks than attention. When human beings attend, they perceive. When human beings attend and perceive, they remember.
When human beings attend, perceive, and remember, they learn. When human beings learn, they can act deliberately and with forethought (Parasuraman, 1998). While performing a task, one must, conversely, reduce the need for constant attention to some of its specific parts of components, allowing those components to be carried out automatically, yet the very act of pushing these elements into the background of consciousness occurs only because one must attend to something else. In short, perceiving, thinking, learning, deciding, and acting require that we budget our “attention”.

So, what is attention? The first psychologist who emphasized the importance of attention in cognition, particularly the close relationship between perception and attention was Wundt, who discussed the close relationship between the large number of stimuli that comprise the field of consciousness at any given time and the particular stimuli attended to within that field. He concluded that focusing attention on a particular element of the environment resulted in other elements becoming less clear, and fading into the background. In his view, attending is an active process, since attention to something involves a reduction in the intensity of one’s interaction with the rest of the world. Titchener (1908) proposed the ‘law of prior entry’, which states that a stimulus that is being attended to will enter conscious awareness prior to an un-attended stimulus. In a related vein, Kulpe (1901) proposed that when one is thinking about something, the content of one’s thought will determine what one will attend to next. William James (1890) described attention as “the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thoughts. It implies withdrawal from something in order to deal effectively with others, and is a condition which has real opposite in the confused, dazed, and scatterbrain state.” Pillsbury (1908, 1911) raised hypotheses about the physiological processes underlying attention. He assumed that two sorts of processes were involved in attention: reinforcement (also called facilitation or enhancement) and inhibition. In reinforcement, attention directed towards a stimulus results in an increase in neural activity related to it. At the same time, inhibition results in a decreased neural activity to stimuli not being attended to.
In recent times, many other psychologists have tried to define attention. Jahnke and Nowaczyk (1998) stated that attention is the study of the capabilities and limitations of the individual to select and process sensory information from the environment. Attention is also described as a brain neurocognitive state of preparing what precedes perception and action (Estevez-Gonzalez, Garcia-Sanchez, and Junque, 1997). Gazzaniga, Ivry, and Mangun (2002) defined attention as cognitive brain mechanism that enables one to process relevant inputs, thoughts or actions while ignoring irrelevant or distracting ones. It is a covert mechanism, meaning that it can operate without overt adjustments of external sensory structures. Lezak (1995) referred to attention as a set of several capabilities of different processes that are associated with how the human organism becomes receptive to stimuli and how it processes and responds to either internal or external stimuli. Groeger (2000) provides a general neurological explanation of attention as diffuse patterns of activation among distinct cortices during the performance of actual and imagined sensori-motor tasks like driving a car. According to Groeger, a motivation to attend and act begins in the cingulate cortex of the limbic system and passes to the prefrontal cortex to inaugurate planning before marshaling the resources of premotor, motor-sensory-cortices, and sensori-motors cortices. As the difficulty or novelty of the task increases, so does activity in the prefrontal cortex. Attention narrows as cognitive load increases.

On the basis of all these definitions, it is clear that “paying attention” encompasses dynamic processes that involve the enhancement or selection of particular information and the inhibition of other information. Attention is the means by which one actively processes a limited amount of information from the enormous amount of information available through one’s senses, one’s stored memories, and one’s other cognitive processes (Duncan, 1997; Posner and Fernandez-Duque, 1999). It may be thought of as a mechanism that controls processing so that human beings are not overwhelmed by too much information. But how does attention work? Many of the contemporary ideas of attention are based on the premise that there are available to the human observer, a myriad of cues that surround people at any given moment. Neurological capacity of human beings is too limited to sense all of the millions of external stimuli, but, even when these stimuli are detected, the brain would be unable to process all of them. Information-processing capacity is too limited. Sensory system, like other kinds of
communication conduits, functions quite well if the amount of information being processed is within its capability. System fails when it is overloaded. A number of studies have been conducted in the area of attention and on the basis of the findings of these studies, different information-processing theories have been attempted to capture the dynamics of attentional effects.

CONCEPTS AND THEORIES OF ATTENTION

Some pioneering experiments in the area of selective attention were done by E.C. Cherry (1953) by using the dichotic listening technique. Cherry discovered that when a different train of speech was played into each ear, and the subjects were asked to shadow what was played into only one ear at a time, the participants were very effective blocking out the unattended message. They were just able to remember something about the physical attributes of the nonattended message, but not much about its meaningful content. The findings of this study were also confirmed by many other researchers (Broadbent, 1954; Moray, 1959; Neisser and Becklen, 1975). British psychologist Donald Broadbent (1958) proposed a model to account for the findings with the shadowing task. The basic assumption of his information processing approach is that the capacity to perform cognitive operations is generally limited. He assumed that only one relevant input stimulus can be processed by the cognitive system at a time. In order to enable the system to deal efficiently with the relevant signals and achieve an optimized interaction with the environment, he postulated a filter that excluded all irrelevant information on the basis of purely physical characteristics like colour or localization. Only information passing the filter gets access to a higher conscious semantic processing, which means that this model principally excludes the parallel processing of more than one stimulus. According to Broadbent, solving divided attention tasks is only possible by switching quickly between the attentional foci of two different ongoing tasks.

Later, many theorists demonstrated experimentally that Broadbent’s model contradicts several empirical facts and cannot be upheld in its extreme form. First of all, Cherry (1953) and Moray (1959) noted that even though information coming into the unattended ear was not noticed in most circumstances, but if it contained information of high-enough priority to the subjects – for example, their own name – then they often
would be able to discriminate and orient to the higher – priority information. Gray and Wedderburn (1960) showed that there is an early semantic processing because participants were able to follow message which were presented to each ear in an alternating fashion. In another study by Treisman (1960), participants were instructed to listen through a set of headphones to two different messages, one played to either ear and they were asked to focus on the information that being played to one specific ear. After some time, the meaningful information in the attended ear changed in to meaningless talk, while the information making sense was presented to the other ear, which should be ignored. Contrary to the instructions, some participants reproduced the information presented in the “wrong” ear. Other researches challenged the single-channel theory on the basis of results from galvanic skin response (GSR). In these experiments, certain words presented in the attended ear were followed by an electrical shock. Following conditioning of the GSR, the subjects were asked to shadow a message. The conditioned word was presented occasionally in the unattended channel. Some found that change in GSR was produced when this occurred. In one experiment by Von Wright, Anderson, and Stenman (1975), the change in GSR resulted in presentation not only of the conditioned word, but also of synonyms and homophones of it. These results suggest that unattended signals are not only detected but also semantically processed.

In an attempt to accommodate the evidence against Broadbent’s filter theory, Treisman (1969) proposed a modified filter theory, one she called attenuation theory of attention, in which she postulated that selection takes place at a later stage than Broadbent had suggested. She hypothesized that the filtering is not all or none. Filter merely weakened (attenuated), rather than completely blocked unattended stimuli. This left open the possibility that an occasional exceptional stimulus in the non attended channel might be strong enough to reach consciousness or intrude into one’s speech stream during a shadowing task. This explained the semantic intrusions that occurred in Treisman’s 1960 study, and her finding that bilingual participants often noticed that the unattended message was the same message in their second language. The evidence that had led Treisman to a moderate revision of Broadbent’s theory brought Deutsch and Deutsch to the more radical conclusion that “all sensory messages which impinge upon the organisms are perceptually analyzed at the highest level”. In particular, Anthony
Deutsch and Diana Deutsch (1963) and later Donald Norman (1968) proposed models of attention that placed the signal-blocking filter later in the process, after sensory analysis and also after some perceptual and conceptual analysis of input had taken place. Their theory postulated that all inputs are unfiltered, unattenuated, and fully processed. Their hypothesis was that the capacity limitation is in the response system, not in the perceptual system.

A late selection model could explain a number of the findings from experiments on selective and divided attention, such as how people sometimes made the mistake of following the shadowed message into the wrong ear (Treisman, 1960). Since both messages were being analyzed for meaning, the continuation of the meaning of the shadowed message into the wrong ear would cause the individual to follow it. This view could also explain how a fluent bilingual could realize that the secondary message was a translation of the first (Treisman, 1964). If the meaning of both messages were being processed, then the semantic identity of the two messages (albeit in two different languages) would be easy for the participant to discover. Similarly, responding to one’s name in the secondary message was explained by assuming that the meaning of the message was processed, and that one’s name, once processed, caught one’s attention because of its importance. However, some experimental results did not fit the late-selection view. Moray (1959) found that the participant’s name was an effective stimulus for only about one-third of the participants. However, if the meanings of all stimuli are processed before selection, it becomes hard to understand how one’s name could be missed by two-thirds of the participants. Similarly, the finding that participants could detect a target word 87% of the time in the attended channel, but only 8% of the time in the secondary message (Treisman and Geffen, 1967) raised problem for late-selection views.

The controversy about early or late selection continued in attention research for a long time until Shiffrin and Schneider (1977) presented a two-process model of information processing, which partly solved the problem of early versus late selection. They proposed a distinction between controlled and automatic processing. They conducted experiments in which, on each trial, a set of target stimuli was presented to the participant, followed by one, two, or four comparison stimuli. The participant’s task
was to determine as quickly as possible if any of the targets were in the comparison display. The comparison display was made up of some combination of target/s and distractors. They examined two types of sequences, called varied mapping and consistent mapping condition. In varied mapping condition, the targets changed from trial to trial, so that a given letter could be a target on one trial and a distractor on the next. They varied the number of stimuli in the target and the display sets, and found that the time to respond correctly depended on the number of stimuli in each trial. The more targets a person had to detect, and the more items in the display set, the longer it took to make the judgment. Those results indicated that the display was being examined one letter at a time in order to determine if there were any targets in it. However, in a consistent mapping condition, the target set and the distractors stayed the same for many sessions on the task. It was observed that after a large number of trials, the amount of time to determine whether a target was in the display became more equal, even when the display set was made larger. With extensive practice in the consistent mapping condition, participants became capable of processing multiple target stimuli as quickly as single stimuli, indicating that the task had become more automatic, and required much less capacity. On the basis of these findings, Shiffrin and Schneider (1977) concluded that varied mapping produced an effortful, serial, and controlled search process whereas consistent mapping resulted in an effortless, parallel, and automatic search process. There have been numerous studies supporting many of these concepts (Schneider, Dumais, and Shiffrin, 1984) and others (Posner, 1978) have proposed similar concepts in their models of attention.

A number of researchers have abandoned the notion of a filter model and suggested that attention is needed to be viewed in terms of allocating cognitive effort or processing resources (Knowles, 1963; Moray, 1967; Kahneman, 1973; Norman and Bobrow, 1975; Wickens, 1984). These theories could be characterized as “capacity” or “resource” theories of attention. These theories have their origin in dual-task experiments (Kahneman, Beatty, and Pollack, 1967; Keele, 1973). The typical expectation of such experiments is that the participants will perform less well at either or both tasks when they are combined than when they are completed in isolation. Such a result is known as dual-task decrement. Daniel Kahneman proposed his model in a book published in 1973 known as “single resource model” to explain the dual-task decrement. Single resource
model assume that concurrent tasks compete for the same fixed pool of resources and therefore there should exist a trade off in performing the tasks when they are combined. If both tasks draw on the same pool of resources, there should be a dual-task decrement when the tasks are combined. Kahneman suggested that human beings allocate efforts to tasks depending on the level of arousal and also the difficulty of the tasks. An individual may not adjust resources properly at extremely low levels of arousal. On the other hand, at high levels of arousal, an individual may narrow his or her attention and be less focused on relevant information. When tasks are fairly simple and routine, then an individual can attend to more than one input. When a task is fairly complicated, then more processing resources are needed and fewer will be available for other inputs. Although the presence of a dual-task decrement fits comfortably with the idea of a fixed pool of common processing resources, but Navon and colleagues in a series of papers (Navon, 1984, 1985, 1990; Gopher and Navon, 1980; Navon and Gopher, 1979, 1980) have thoroughly picked away at this idea and have arrived at a quite different view of processing constraints. The conclusions drew by these researchers from their experiments do not fit particularly comfortably with the notion of attentional resources. Navon (1990) found in one of his experiment that even though task difficulty was varied on one task, there was no evidence of performance trade-offs. If there is only a single pool of resource, then increasing the difficulty of either task should have influence on the performance on the other task. They concluded that something else must be going on in the experiments than mere competition for some form of common resource and Navon and Miller (1987) named this particular type of task interference as “outcome conflicts”. They discussed several sorts of outcome conflicts and they defined them as arising when a particular task produces “outputs, throughputs, or side effects” that are harmful to the execution of another concurrent task. The conclusion that can be drawn from Navon’s papers is that the concept of attentional resource is both poorly specified and of little use, he was generally sympathetic to the idea that different tasks may place demands on different pools of resources and different processing mechanisms have their own processing characteristics and capacity limitations. Similar results as observed by Navon (1990) were also reported by some other researchers (Allport, Antonis, and Reynolds, 1972; Kantowitz and Knight, 1976; North, 1977; Wickens and Kessel, 1979). In addressing the possible reason for this, Wickens (1984), one of the most prominent capacity theorist stated that “the concept of processing
resources is proposed as a hypothetical intervening variable to account for variations in the efficiency with which time-sharing can be carried out; that is the degree to which two tasks can be performed concurrently as well as each can be performed in isolation”. Contrary to previous theories, Wickens’ assumed that there are multiple resources which can be allocated in order to deal with different tasks simultaneously. He set out a three-dimensional space of possibilities within which multiple resources may be defined. The dimensions reflect (I) early versus late processes, (II) separate modalities and finally, (III) processing codes. In first dimension, the division is between perceptual encoding/categorization and response selection and execution. The implication here is that any two tasks that place demands on the same stage of processing are likely to interfere with one another. For example, attempting to turn down the volume on the TV via the remote control and pick up the ringing phone places demands on the same response components. In second dimension, the implication is that tasks performed in different modalities are less likely to interfere than are tasks preformed within the same modality. Finally, the implication in third dimension is that tasks that give rise to different internal codes are less likely to interfere than tasks that generate the same sort of codes. It is without doubt, though, that Wickens has provided an entirely sensible framework for thinking about when and how concurrent tasks may interfere. However, it does not settle the deeper issue about whether there is a central processing constraint on attempting to do more than one thing at once.

In attempting to provide an integrative overview of the various kinds of theories of attention, Pashler (1998) provided an eventual model of attention. The model incorporates both a filtering mechanism and resource limitations. The filtering mechanism selects items for further processing and the selected stimuli may then compete for the limited capacity that underpins semantic analysis. If the demands placed on this pool of resources are within the capacity limitations of the system, then parallel processing of several stimuli is possible. However, if the system is overloaded then processing efficiency is compromised. That is, if too many stimuli are competing for resources, then processing will falter.

A theory which has a very different emphasis from ideas of bottlenecks, filters, and capacity and is mostly concerned with the role attention plays in selecting and binding
complex information was proposed by Treisman and Gelade (1980) known as “feature integration theory”. Her general idea is that human beings perceive objects in two distinct stages. In the first stage, which is preattentive, or automatic, human beings register features of objects, such as their color or shape. In the second stage, attention allows us to “glue” the features together into a unified object. Treisman reported several experimental results that support this theory. In one experiment (Treisman and Gelade, 1980), participants were presented with a series of simple objects (such as letters) that differed in several features (such as color or shape). Participants were asked to search for a particular object – for example, a pink letter or the letter T. If the item being searched for differed from the background items in the critical feature (e.g., a pink item among green and brown items, or a T among O’s), the target item seemed to pop out of the display, and the number of background items did not affect participants’ reaction times. They interpreted this pattern of results as evidence that the detection of individual feature is automatic – that is, requiring little attention of concentration and occurring in parallel. As a result, detecting a circle or the color blue or any other single feature is relatively easy. In another condition, participants were asked to search for an object with a combination of features- such as pink T- against a background of objects that had one or the other feature (in this example, both pink items that were not T’s and T’s that were not pink). In this condition, participants’ reaction time varied with the number of background items. Treisman and Gelade (1980) argued that searching for a conjunction, or combination of features requires controlled, nonautomatic processing.

Feature integration theory has illuminated other aspects of the way attention operates in visual search. One important finding is that human beings can search faster for the presence of a feature than for its absence (Treisman and Souther, 1985). This theory is also supported by some of the sorts of errors that occur when attention is overloaded or selection fails. For example, participants sometimes make illusory conjunctions, that is, incorrect combination of features (Treisman and Schmidt, 1982). There is also some neuropsychological support for Treisman’s model, for example, Nobel laureates David Hubel and Torsten Wiesel (1979) have identified specific neural feature detectors, which are cortical neurons that respond differentially to visual stimuli of particular orientations (vertical, oblique, or horizontal). More recently, Mortimer Mishkin and his colleagues (e.g., Mishkin, Ungerleider, and Macko, 1983; Bachevalier and Mishkin,
1986; Mishkin and Appenzeller, 1987) have identified additional cortical processes involved in the various distinct steps of feature integration required for such tasks as object recognition and visual discrimination. They observed that during visual search, differing neural activity appears to be involved in the relatively low level identification of features, as compared with the neural activity during relatively high-level feature integration and synthesis. But some findings from patients with hemispatial neglect presented a challenge to this theory. If the distinction between disjunctive and conjunctive search made by this theory is correct, then it can be predicted that neglect patients would be able to perform disjunctive search well, even when the target appears on the neglected side. But Behrmann, Ebert, and Black (2003) didn’t find this true in their study. Additionally, even behavioral studies with neurologically unimpaired participants have found that some conjunctions are easier to detect than a purely serial search model predicts (Nakayama and Silverman, 1986).

John Duncan and Glyn Humphreys (1989, 1992) have proposed an alternative explanation for many of the Treisman’s findings. According to them, the difficulty of search task depends on the degree of similarity between the targets and the distracters and on the degree of disparity among the distracters, but not on the number of features to be integrated. According to their similarity theory, Treisman’s data can be reinterpreted as being simply a result of the fact that as the similarity between target and distractor stimuli increases, so does the difficulty in detecting the target stimuli. Thus, targets that are highly similar to distracters are hard to detect and targets that are highly disparate from distracters are easy to detect. Another factor that facilitates the search for target stimuli is similarity (uniformity) among the distracters. Searching for target stimuli against a background of relatively uniform distracters is fairly easy, but searching for target stimuli against a background of highly diverse distracters is quite difficult.

Kyle Cave and Jeremy Wolfe (1990) have proposed an alternative to Treisman’s model, which they term guided search. According to these researchers, the guided-search model suggests that all searches, whether feature searches or conjunction searches, involve two consecutive stages: (1) in a parallel stage, the individual simultaneously activates a mental representation of all the potential targets, based on their possession of each of
the features of the target; and (2) in a serial stage, the individual sequentially evaluates each of the activated elements, according to the degree of activation, and then chooses the true targets from the activated elements. According to their model, the activation process of the parallel initial stage helps to guide the evaluation and selection process of the serial second stage of the search. This model predicts that why some conjunction searches are easier than others as found by Nakayama and Silverman (1986). Cave and Wolfe found support for their model by creating computer simulations of their model and then comparing the performance of the simulations with the actual performance of participants carrying out searches. Under most circumstances, the simulations of their model produced results that were very similar to those of the actual participants.

McLeod, Driver, Dienes, and Crisp (1991) found a feature that shows paradoxical effects when it is combined with other features: movement. They found that when movement is conjoined with a distinctive feature of a target, search occurs more easily and speedily than in the search for distinctive feature alone.

Most recent theory known as “perceptual load theory” in the area of attention is put forward by Lavie (2000). Lavie distinguished between two types of control mechanisms, namely passive and active mechanisms. She conducted so many experiments to test her theory. In her task, the participants were asked to press one key if a target z was present and a different key if a target x was present. Response-relevant items were presented randomly at one of six pre-defined positions in a central row of the computer display. In the S1 condition, there was only ever a single target present. In the S6 condition, the target was embedded in a row of six characters. Also, on every trial a non-target character was randomly positioned in the periphery of the display. This non-target could either be compatible with the central target, or could be incompatible with the target, or it could be neutral with respect to either response. In general terms, two effects were of initial interest: first, whether the compatibility of the non-target would influence responses to the target; and second, whether there would also be an effect of display size on responses. More interesting, though, was what the combined effect of these two factors would be. The results of the experiment were relatively clear-cut. Responses were shorter on trials containing a small number of items than large. Although this factor has been referred to display size, Lavie termed this factor “perceptual load”.

12
her experiment, the critical finding was that the standard compatibility effect only arose for the low perceptual load condition. There was no corresponding effect for the high perceptual load condition. She explained this particular pattern of effects by reference to her perceptual load hypothesis. If the load on perceptual analysis (passive mechanism) is slight, then filtering is unnecessary and both targets and non-targets are processed. However, when perceptual analysis is made more demanding, then full (perceptual) capacity will be devoted to detecting targets. Given that all resources are dedicated towards target detection, none of the non-targets will be processed further. The perceptual analysis of the target is so demanding that the perception of the non-targets is said to be excluded. It was found that sometimes both relevant and irrelevant items exit from the perceptual analysis stage, and then the active mechanisms now come into play in an attempt to discriminate the relevant from the irrelevant. On these grounds, if the active mechanisms are overloaded, then any detrimental effect of irrelevant items might then be exacerbated. So, whereas overloading the passive (perceptual) mechanism results in a lessening of interference from non-targets, completely the opposite is predicted if the active (central) mechanisms are overloaded. If the central mechanisms are overloaded, then, even in cases where the perceptual load is slight, the prediction is that interference from non-targets should be substantial. This second strand to the theory has been supported by De Fockert, Rees, Frith, and Lavie (2001).

**TYPES OF ATTENTION**

According to modern neuropsychological concepts, attention is not regarded as a unitary function. Recent theories postulate that attention can be subdivided into different components that interact with each other and with other psychological functions. Parasuraman (1998) stated, “Attention is not a single entity but the name given to a finite set of brain processes that can interact, mutually and with other brain processes, in the performance of different perceptual, cognitive, and motor tasks.” In this context, studies of cerebral injury revealed that lesions in specific networks may impair specific attentional functions. Especially the work of Posner and his group exerted great influence on the development of multidimensional attention concepts (Posner and Boies, 1971; Posner and Rafal, 1987; Posner and Petersen, 1990).
NETWORKS OF ATTENTION (POSNER, 1971; 1984; 1990, and 1994)
Posner and colleagues have intensively studied attentional processes since the early 1970's. Posner and Boies (1971) were the first to describe different subsystems of attention. Based on their findings, as well as other scientific evidence, Posner and Petersen (1990) postulated three networks of attention: The network of visuospatial orienting, the network of executive attention, and the alertness network.

The network of visuospatial orienting
The network of visuospatial orienting controls overt and covert orienting of visual attention. Three specific processes, which are assigned to corresponding anatomical correlates, are supposed to be involved in visuospatial orienting. First, attention needs to be disengaged from its current fixation point. This is supposed to be a function of the right posterior parietal lobe. Patients with lesions in this area are massively limited in their ability to disengage their attention in order to move it to another locus in space (Posner, Walker, Friedrich, and Rafal, 1984). Thus, visuospatial neglect is the most common consequence of right-hemisphere parietal lesions. After disengaging the focus of attention from its current locus, it needs to be moved to its new target locus. Movement of attention is supposed to be a function of the superior colliculi (SC) in the midbrain and can either be performed overtly or covertly. In the first case, attention and eye movement are coupled, in the second case, attention is moved away from the current locus while the eyes remain fixed. Patients with degeneration in the SC show slowed shifting of attention and animal studies suggest that unilateral SC lesions result in neglect of the contralesional hemispace (Ogourtsova, Korner-Bitensky, and Ptito, 2010). Upon detection of the target, attention needs to be engaged to the new focus of attention. The anatomical correlate of the engage function is supposed to be the pulvinar in the midbrain which is involved in selecting relevant information for further processing. Lesions in the pulvinar result in deficits of engaging attention to a target in the contralesional field. Thus, the posterior parietal lobe, the SC and the pulvinar form an anatomical circuit or network for covert shifts of visual attention to spatial targets (Posner and Raichle, 1994). Lesions in either part of this network can result in deficits of visuospatial orienting, apparently with a greater incidence following parietal lesions.
The network of executive attention

The function of the network of executive attention is to transfer objects into conscious processing (Posner and Raichle, 1994). After an object has been processed by the orienting network, it needs to be identified and potential actions need to be prepared. Executive attention is a function of the frontal lobe, more precisely the cingulate gyrus. Especially bilateral lesions in these areas can prevent patients from executing intentional actions.

Figure 1: The network of visuospatial orienting (from Posner and Raichle, 1994).

Figure 2: The network of executive attention (from Posner and Raichle, 1994).
The alerting network
The alerting network establishes and keeps up the alert state of the mind and increases responsiveness and action preparation. The alertness network appears to be strongly lateralized to the right hemisphere, more specifically to the right frontal lobe and it depends physiologically on the noradrenergic pathways arising from the brainstem. Posner and Petersen (1990) proposed this asymmetric processing of alertness in the right frontal cortex and pointed out how lesions in this area are often associated with alerting deficits. Moreover, Posner and colleagues (1984, 1990, and 1994) emphasized that these three networks of attention cannot be considered to be isolated, but proposed that they interact with each other. Especially the alerting network and the network of visuospatial attention are supposed to interact within the right cerebral hemisphere by joint modulation through noradrenergic afferences from the locus coeruleus (LC) (Morrison and Foote, 1986; Posner and Petersen, 1990).

![Image of the brain showing the alerting network](image.png)

Figure 3: The alerting network (from Posner and Raichle, 1994).
A THEORITICAL FRAMEWORK OF ATTENTION (VAN ZOMEREN AND BROUWER, 1994)
Van Zomeren and Brouwer (1994) divided the concept of attention into two main aspects which include specific attentional functions. However, they stressed that their assumptions should be merely regarded as a theoretical framework rather than a model “carved in stone” and that the subcomponents are not independent but partially overlapping. They subdivided the concept of attention into the aspects of selectivity and intensity. In their model, the aspect of selectivity covers functions of focused attention and divided attention. The term “focused attention” describes tasks where attention has to be concentrated on one source or kind of information while others must be excluded. In “divided attention” tasks, attention is divided or shared between two or more information channels, or two or more mental operations. The intensity aspect is represented by the components “alertness” and “sustained attention” which describe basic processes to maintain a certain level of attentional activation for a short or long time period. Additionally, Van Zomeren and Brouwer postulated a “supervisory attentional control”, which can either modulate the selectivity and the intensity aspect of attention.

![Diagram of the theoretical framework of Van Zomeren and Brouwer](image)

**Figure 4:** A schedule of the theoretical framework of Van Zomeren and Brouwer
SOHLBERG AND MATEER’S CLINICAL MODEL OF ATTENTION (2001)

According to Sohlberg and Mateer, the basis for their model of attention stems from analyzing task performances, errors, and subjective reports by individuals with brain injuries. They conceptualized attention as hierarchical and consisting of five components, with each level seen as more complex and demanding more effective functioning than the previous level. Their assumption is that focused attention is the most basic form, followed by sustained, selective, alternating, and divided attention.

1) **Focused Attention:** This is the ability to respond discretely to specific visual, auditory, or tactile stimuli.

2) **Sustained Attention:** This refers to the ability to maintain a consistent behavioral response during continuous and repetitive activity.

3) **Selective Attention:** This level of attention refers to the capacity to maintain a behavioral or cognitive set in the face of distracting or competing stimuli. Therefore, it incorporates the notion of “freedom from distractibility”.

4) **Alternating Attention:** It refers to the capacity for mental flexibility that allows individuals to shift their focus of attention and move between tasks having different cognitive requirements.

5) **Divided Attention:** This is the highest level of attention and it refers to the ability to respond simultaneously to multiple tasks or multiple task demands.

STURM’S TAXONOMY OF ATTENTION (2007)

Sturm (2005, 2007) synthesized Van Zomeren and Brouwer’s model and Posner’s assumptions by keeping the dimensions intensity and selectivity and adding spatial attention (orienting) as a separate entity. Moreover, Sturm suggested further differentiations of the intensity aspect by discriminating between intrinsic, tonic, and phasic alertness as well as by delineating vigilance as compared to sustained attention. Finally, Sturm (2005) distinguished the formerly equivalent terms “focused attention” and “selective attention”. The attention domains based on Sturm’s (2007) taxonomy have been shown in figure 5.
Alertness (intrinsic, phasic, tonic)
Alertness is the ability to control arousal and response readiness. Tonic alertness describes the variability and changes in arousal at different times of the day, while phasic alertness marks the rapid mobilization of resources to process an expected stimulus if a warning stimulus precedes. On the other hand, the level of alertness can be modulated by intrinsic cognitive control even in the absence of external cues. Therefore, Sturm, De Simone, Krause, Specht, Hesselmann, Radermacher, Herzog, Tellmann, Muller-Gartner, and Willmes (1999) introduced the term “intrinsic alertness” which represents the internal (cognitive) control of wakefulness and arousal.
Sustained attention/ Vigilance
Sustained attention tasks require attention to be directed to one or more sources of information over long and generally uninterrupted periods of time for the purpose of detecting and responding to small changes in the information presented. Sturm (2005) discriminated between sustained attention and vigilance by assigning long-time tasks with a high stimulus rate to sustained attention and long-time tasks with a low stimulus rate to vigilance. Therefore, vigilance delineates the process of paying close and continuous attention in very monotonous (boring) situations.

Visual-spatial attention
Posner and Petersen (1990) demonstrated that shifting visual-spatial attention can be subdivided into three processes: (a) “disengage” the current attentional focus; (b) “shift” the focus and (c) “engage” it on a new target stimulus. Interestingly, all processes are linked to specific neural structures.

Selective attention/ Focused attention
Selective or focused attention describes the ability to focus attention on specific parts of a task while irrelevant stimuli have to be ignored. Selective attention increases the responsiveness to specific stimuli by giving them a higher priority in further processing. A special case of attentional selectivity is focused attention and describes the process of isolating a certain fragment of the environment in order to analyze it. It is important to maintain the focus and to suppress interference due to simultaneous and automatic processing even if there are many distractors (Sturm, 2007).

Divided attention
Divided attention describes the ability to respond simultaneously to two (or more) different tasks or multiple task demands. Attention has to be divided between these tasks and mental resources have to be allocated to each of them. The better parts of the tasks have been learned (which means that information processing is more automated) the less attentional capacity is needed. The ability to shift the focus of attention and to move it between different tasks having different cognitive requirements is called “mental flexibility” or “alternating attention”.
From the above discussion, it can be inferred that attention is the focus of consciousness, which is compared with a stream that flows constantly. All our thoughts, sensations, ideas, and experiences constitute this stream of consciousness. The psychological phenomenon of attention allows using limited mental processes judiciously. By dimming the lights on many stimuli from outside (sensations) and inside (thoughts and memories), one can highlight the stimuli that interest him/her. This heightened focus increases the likelihood that one can respond speedily and accurately to interesting stimuli. Heightened attention also paves the way for memory processes. When attention malfunctions, its importance to normal cognition and behavior is apparent. When attention fails, there would be no perception, no learning from experiences, no intellectual functioning, and no development of language as attention enables the individual to gain these experiences.

The ability to show attention to certain things is vital to life. It is necessary to keep individuals from becoming overloaded with information (Reed, 2004). Attention is needed to carry out any task from the simplest to the most complex. It increases our efficiency to do any task. Sensory discrimination can also be improved by attention. Attention is a prerequisite for acquisition of any kind of skill. Thus, every act needs attention for its successful performance. In addition to the overall value of attention, conscious attention serves three purposes in playing a causal role for cognition: (1) monitoring one’s interactions with the environment, which maintains one’s awareness of how well one is adapting to the situation in which one find oneself; (2) linking one’s past (memories) and one’s present (sensations) to give a sense of continuity of experience, which may even serve as the basis for personal identity; and (3) controlling and planning for one’s future actions, based on the information from monitoring and from the links between past memories and present sensations.

But today’s world is changing rapidly. The period of accelerating changes human beings are now witnessing has put a strain on individuals and entire societies. People feel bombarded with change from every direction. They are busier than ever, always trying to do two or more things at the same time. Most people can handle a certain amount of change, but the problem is, people are increasingly being overloaded with more changes that one can handle. In 1970, futurist Alvin Toffler described the effects of “too much change in too short a period of time” in his contemporary classic “Future
shock”. At that time, he predicted that people exposed to these rapid changes of modern life would suffer from “shattering stress and disorientation”. Thus, in order to gain success in this rapidly changing world, one needs to be able to focus one’s mind, and to calm down its restlessness and tendency to constantly shift from one subject to another. Therefore, it is the need of the modern world to think about the ways through which attentional processes can be enhanced.

Currently, there are a number of pharmaceuticals available that have potential to enhance cognitive functioning. There are a lot of studies showing these pharmaceutical drugs to be effective in enhancing attentional processes.

Modafinil, a novel psychostimulant, was found to be a promising countermeasure for sleep loss. It sustained alertness and performance of pilots in a helicopter simulator during a 36 hour period of continuous wakefulness (Caldwell, Caldwell, Smythe, and Hall, 2000). In healthy human volunteers, modafinil (100-200 mg) improved subjective attention and alertness, but also spatial learning, stop signal reaction time, digit span, and visual pattern recognition memory (Turner, Robbins, Clark, Aron, Dowson, and Sahakian, 2003). Marchant, Kamel, Echlin, Grice, Lewis, and Rusted (2009) found in their study that modafinil improved rapid switching of attention in conditions that are most demanding.

Improvement in attention was also found with flumazenil. Flumazenil and placebo were analyzed according to a double – blind, crossover design. Flumazenil improved event – related brain potential indicators of selective attention and induced feeling of activation and extraversion in healthy young men (Smolnik, Pietrowsky, Fehm, and Born, 1998). Dehghanpisheh, Kazemi, and Amini (2010) conducted a randomized, placebo-controlled, double – blind study to compare the effects of flumazenil versus aminophylline and placebo on level of consciousness and neuromotor emergence after isoflurane anesthesia. They reported that flumazenil improved recovery of vigilance (p<0.001) and neuromotor functions (p<0.001) sooner than aminophylline and placebo.

Memantine, another drug, has also found to have some vigilance enhancing effects. The effects of memantine (20 mg, single dose application) on the quantified EEG were
investigated in 16 elderly healthy subjects in a randomized, twofold, crossover design vs placebo under double – blind conditions. EEG was recorded before medication and 2 and 4 hours after medication under reaction time and resting conditions. The results showed that a time dependent decrease in vigilance occurred under placebo which was counteracted by memantine (Schulz, Jobert, Coppola, Hermann, and Pantev, 1996). Wesnes, Aarsland, Ballard, and Londos (2014) also reported that memantine improved attention and verbal episodic memory in patients of parkinson’s disease dementia and dementia with lewy bodies.

Another drug, caffeine, a stimulant, has also found to improve performance on a divided attention task. The effects of caffeine, alcohol, and methylchloride were investigated on the performance of a 25 minutes dual task involving compensatory tracking and auditory vigilance. The subjects after ingestion of 3 mg/kg caffeine, showed a significant improvement (approximately 10% fewer errors) in tracking performance, with no significant effect on the speed of detections in the vigilance task (Putz – Anderson, Setzer, and Croxton, 1981). In one study, it was found that caffeinated gum (40 mg) was associated with a more positive mood and better performance on tasks requiring sustained attention (Smith, 2009).

Another drug, Methylphenidate, has also found to have attention – enhancing effects. Sykes, Douglas, and Morgenstern (1972) conducted a study to investigate the effect of this drug on the performance of 23 hyperactive children by using a double – blind, cross over design. Performance on four tasks measuring different aspects of attention was investigated. The drug was found to produce a significant improvement on all the tasks. Another study reported that the administration of this drug (10mg) on the children with ADHD showed significant improvements in their performance on measures of cognitive attention skills compared to controls (Hood, Baird, Rankin, and Isaacs, 2005).

Nicotine, and other nicotinic agents have also been found to improve performance on attention and memory tasks. Lawrence, Ross, and Stein (2002) found in their study that nicotine enhanced activity in several brain areas associated with visual attention and arousal during performance of the rapid – visual – information processing task. Oral doses of 1.0 mg and 2.0 mg nicotine reduced the size of the stroop effect in both
deprived smokers and non smokers, indicating enhanced selective attention for relevant information and suppression of irrelevant information (Wesnes and Warburton, 1978)

But inspite of having higher cognition enhancing properties, the use of these modern CNS acting drugs is often accompanied by side effects like insomnia, mood change, dizziness, respiratory depression, irritability, nausea, rash, and clumsiness etc (Sharma, Sahu, Khemani, and Kaur, 2013). Notable side effects related to memantine are dizziness, headache, and constipation (Stahl, 2005). Methylphenidate has been found to be associated with a “less than expected” growth trajectory for both height and weight during childhood and adolescence (Charach, Figueroa, Chen, Ickowicz, and Schachar, 2006; Faraone and Giefer, 2007). Ballon and Feifel (2006) conducted a systematic review of modafinil and reported that most commonly found side effects associated with this drug are headache, nausea, diarrhea, nervousness, anxiety, dyspepsia, and insomnia. Besides these side effects, these drugs need to be taken regularly and if stopped abruptly, have potential danger of triggering the recurrence of the disease. Moreover, the cost of these drugs is very high, and also it will take almost a decade to develop a new drug. Therefore, finding out a new safe and cost–effective treatment approach to enhance the cognitive processes especially the attentional processes is the dire need of the modern world.

An alternative that is claimed to be safer is the discipline of Ayurveda that has existed in India from millennia. Therefore, the whole world is looking towards ancient science of Ayurveda to explore safe, alternative, cost effective treatment as well as reliable cure with no or minimal side effects for cognition enhancement.

**AYURVEDA**

Ayurveda, the ancient science of life has been serving the mankind since antiquity. It has a very special approach towards the disease, the patient, and the science of medicine itself. The meaning of the word “Ayurveda” is self – explanatory (Ayu = life, Veda = Science). Life has been described as the complex combination of Body (Sarira), Senses (Indriyas), Mind (Sattva), and Soul (Atma) (Acharya, 2008). The objective of Ayurveda is to accomplish physical, mental, social, and spiritual well – being by adopting
preventive, health promoting, and holistic approach towards life (Patwardhan, Warude, Pushpangadan, and Bhatt, 2005).

The knowledge of Ayurveda was comprehensively documented in Charaka Samhita and Sushruttha Samhita. According to Ayurveda, health is considered as a pre-requisite for achieving the goals of life- dharma, Arth, Kama, and Moksha and all objects and living bodies are composed of five basic elements, the Panch Mahabhootas, namely; Prithvi (earth), Jal (water), Agni (fire), Vayu (air), and Akash (ether). The philosophy of Ayurveda is based on fundamental harmony between universe and man, a healthy balance between macrocosm and microcosm. Ayurveda believes in the theory of Tridoshas: Vata (ether + air), Pitta (fire), and Kapha (earth + water). These three doshas are physiological entities in living beings. The mental characters of men are described by Satva, Rajas, and Tamas. Ayurveda aims to keep these structural and functional entities in a state of equilibrium which signifies good health (Swastha). Any imbalance due to internal or external factors causes disease and the treatment consists of restoring the equilibrium through various techniques, procedures, regimen, diet, and medicine.

The treatment in the Ayurveda system is holistic and individualized having two components: preventive and curative. The preventive aspect of Ayurveda is called Svasthvrit and includes personal hygiene, regular daily and seasonal regimen, appropriate social behavior, and rasayana sevana i.e. use of rejuvenative materials/food and rasayana drugs. The curative treatment consists of three major categories of procedures, Aushadhi (drugs), Anna (diet), and Vihara (exercise and general mode of life). Ayurveda largely uses plants as raw materials for the manufacture of drugs. Plant alkaloids are the primary active ingredients of Ayurvedic drugs. These drugs are prepared from the leaves, roots or some other part of herbal plants. Some herbal plants are used as a whole. In ayurveda, 314 plants are listed, which are used as medicines in India (Subhose, Srinivas, and Narayana, 2005).

The efficacies of some of these plants have been validated by scientific findings. Medicinal plants such as Bacopa Monniera (Singh and Dhawan, 1997; Joshi and Parle, 2006), Acorus calamus (Vohora, Shah, and Dandiya, 1990), Celastrus paniculata (Nalini, Karanth, Rao, and Aroor, 1995; Bhanumathy, Harish, Shivaprasad, and Sushma, 2010),
Centella Asiatica (Agarwal and Singh, 1998; Nalini, Aroor, Karanth, and Rao, 1992), Withania Somnifera (Kumar and Kumar, 2008), and Convolvulus pluricaulis (Singh and Mehta, 1977, Sinha, Dixit, Madnawat, and Sharma, 1989; Sharma, Bhatnagar, and Kulkarni, 2010) have been used for centuries in India as cognition enhancers.

**SHANKHAPUSHPI**

Shankhapushpi is a reputed drug of the Ayurvedic system of medicine, which has been mentioned as under “Medhya Rasayana” means “rejuvenating to intellect or brain. Shankhapushpi belongs to the family of convolvulaceae. It is a prostrate spreading perennial wild herb commonly found on sandy or rocky ground under xerophytic conditions in northern India. The herb produces flowers during the months of September and October, which are while to light pink in colour (Dandiya and Chopra, 1970). The shape of the flower is like a Shankh giving it the name is Shankhapushpi. Its branches are spread on the ground and can be more than 30 cm long. Leaves, which are elliptic in shape (2mm), are located at alternate positions with branches or flowers. All the parts of the herb are known to possess therapeutic effects. It is believed to be the only herb that is capable of enhancing all the aspects related to brain power, such as learning, memory, and the ability to recall. It is considered as the most wonderful gift of nature to the mankind.

However, controversy still reigns regarding its botanical identity. Description given in Ayurvedic texts and in various other literatures suggest a number of plant species being used under the name Shankhapushpi. Literature, coupled with the existence in various drug markets, the following plant species are regarded as Shankhapushpi (Shah and Bole, 1961).

(a) Evolvulus alsinoides Linn,

(b) Convolvulus pluricaulis Choisy,

(c) Clitorea ternatea Linn,

(d) Canscora decaussate Schultz

Convolvulus pluricaulis is used as a source plant in northern, central, and western India (Singh and Chuneker, 1972), Evolvulus alsinoides in Karnataka (Chuneker, 1982), and Clitora ternatea in Kerala (Moose, 1978). Irrespective of the source, the drug shows
therapeutic effects on CNS disorders. Studies based on relative efficacy and usage suggest that Convolvulus pluricaulis can be considered as the actual source, while Evolvulus alsinoides and Clitora ternatea as the alternative sources of Shankhpushpi (Nair, Nair, and Nair, 1997). The Indian council of Medical research has also given quality standards for Convolvulus pluricaulis drug in its publication (Gupta, Tandon, and Sharma, 2005). Many formulations such as “Abhrak bhasma”, “Brahmi ghrita”, “Brahmi vati”, Brahmi rasayan”, “Dimagheen”, “Manasmrita gutika”, “Mukta vati”, “Memorex tablets”, “Stress guard capsules”, and “Shankhpushpi syrup” containing Shankhpushpi as a single drug or in combination with other drugs are available in the Indian market and Shankhpushpi is routinely advertised for memory enhancement in the print and electronic media in India.

CHEMICAL CONSTITUENTS OF SHANKHAPUSHPI
The plant contains carbohydrate – D – glucose, maltose, sucrose, starch, rhamnose, and other carbohydrates (Deshpande and Srivastava, 1969; Bisht and Singh, 1978; Shah and Quadry, 1990; Singh and Bhandari, 2000). It contains proteins, aminoacids, and the alkaloid shankhpushpine (C_{17}H_{25}NO_{2}), having a melting point of 162-164°C. The most notable constituents are tropane alkaloids. Only convolamine has been identified (Singh and Bhandari, 2000). The fresh plant contains volatile oils, fatty acids, fatty alcohols, and hydrocarbons i.e. myristic acid (30.9%), palmitic acid (66.8%), linoleic acid (2.3%), and straight chain hydrocarbon hextriacontane (Deshpande and Srivastava, 1969; Srivastava and Deshpande, 1975). The whole plant of Convolvulus pluricaulis contains scopoletin, β- sitosterol, and ceryl alcohol (Deshpande and Srivastava, 1969). The flavonoid-kampferol and steroids-phytosterol, β-sitosterol were also found in major amounts (Singh and Bhandari, 2000). The chloroform fraction of this plant contains 20-oxodotriacontanol, tetratriacontanoic acid, and 29-oxodotriacontanol. These components were proved to be potent insect antifeedant constituents (Bhakuni, Tripathi, Shukla, and Singh, 1996).

CLINICAL AND PRE-CLINICAL APPLICATIONS OF SHANKHAPUSHPI
Convolvulus pluricaulis has been widely screened for its various pharmacological activities. It has relatively well documented neuropharmacological actions such as nootropic, antistress, anxiolytic, antidepressant, anticonvulsant, tranquilising, and
sedative activities which justify its use in CNS disease in the Ayurvedic system of medicine. It has antimicrobial, antipyretic, anti-inflammatory, analgesic, diuretic, antidiabetic, and insecticidal properties.

Convolvulus pluricaulis was found to have a positive effect on cognitive functions as it improved spatial memory in experimental animals (Rawat and Kothiyal, 2010; Kothiyal and Rawat, 2011). The plant has shown a promising memory enhancing effect in both young and aged mice. Significant increase in AchE activity in CA3 area of Convolvulus pluricaulis fed animals was evident, suggesting altered cholinergic functions in this area (Sharma, Bhatnagar, and Kulkarni, 2010). Pretreatment with Convolvulus pluricaulis extract, is known to significantly decrease norepinephrine level in limbic region of rat brain which may be suggestive of its memory enhancing effect (Joshi, Balasinor, and Nayampalli, 1995). Dietary feeding of this plant increased protein synthesis in the hippocampus, which is indicative of enhanced learning and memory in experimental animals (Sinha, Dixit, Madnawat, and Sharma, 1989). Besides these animal studies, a number of studies conducted on humans also reported the memory enhancing activity of this plant (Priyanka and Batra, 2003; Priyanka and Batra, 2004; Kapse and Nesari, 2005; Batra, 2008; Batra, Kumar, Rawat and Batra, 2008; Shweta and Batra, 2012).

This plant has also found to have neuroprotective potential. Shankhapushpi has been found to improve cognitive functions such as attention, initiation/perseveration, and conceptualization in patients of dementia, same study has also reported that Shankhapushpi also improved the quality of life, self-esteem, positive affect, and feelings of belongingness of dementia patients (Rajesh and Batra, 2009). Amnesia, induced by scopolamine was significantly mitigated by the aqueous extract of this plant (Bihaqi, Singh, and Tiwari, 2011; Bihaqi, Singh, and Tiwari, 2012). Dhuna, Dhuna, Bhatia, Singh, and Kamboj, 2012 conducted a study which established the protective effect of methanolic extract of Convolvulus pluricaulis on IMR 32 human neuroblastoma, study further reported that the cytoprotective effect of this plant was due to the induction of antioxidant machinery of the cell, hence holds therapeutic value in the treatment and prevention of neurodegenerative disorders. A study conducted in 2012 by Mathew and Subaramanian offered direct evidence on the influence of the extracts from Convolvulus pluricaulis in favour of Aβ-centric therapy for Alzheimer’s disease.
Hypotensive action of this plant has also been reported. The ethanolic and methanolic extract of the whole plant reduced spontaneous motor activity, potentiated pentobarbitone hypnosis and morphine analgesia, reduced fighting response, abolished the conditioned avoidance response, and antagonized convulsive seizures and tremorine induced tremors (Sharma, Barar, Khanna, and Mahawar, 1965; Mudgal, 1975). Barbiturate hypnosis potentiation and antihypertensive activity of this plant has also been confirmed by some other studies (Mudgal, Singh, Srivastava, and Udupa, 1977; Shukla, 1979). A total water soluble fraction of this plant caused a marked and prolonged hypotension in dogs and inhibited the frog’s myocardium (Rakhit and Basu, 1958; Chaturvedi, Sharma, and Sen, 1966; Mudgal and Udupa, 1977; Singh, Agarwal, and Mehta, 1977).

This plant appears to be a centrally active anti-anxiety agent. Singh and Mehta (1977) reported that one month treatment with this drug provides significant relief in symptoms besides a quantitative reduction in anxiety level and neuroticism leading to improved mental functions studied in terms of mental fatigue and immediate memory span. The treatment has also produced reduction in the level of cortisol and urinary catecholamines. A study conducted by Subramani, Anand, and Murlidharan (2008) also confirmed that the methanolic extracts of Convolvulus pluricaulis inhibited the marble burying activity without any significant decrease in the locomotor activity in experimental animals, which is a favourable criterion in the treatment of obsessive compulsive disorder (OCD). Sharma, Arora, Rana, and Bhatnagar (2009) reported that the petal extract of this plant exerted antianxiety effect in mice on elevated plus maze. Ethylacetate and aqueous fraction of the ethanolic extract showed an anxiolytic effect, as well as reduced the neuromuscular coordination, indicative of the muscle relaxant activity of this plant (Nahata, Patil, and Dixit, 2009).

Chloroform fraction of total ethanolic extract of this plant elicited a significant antidepressant like effect in mice by interaction with adrenergic, dopaminergic, and serotonergic systems (Dhingra and Valecha, 2007). Sethiya, Thakore, and Mishra (2009) conducted a study which also confirmed the antidepressant effect of this plant. In their study, they found that one month treatment with the methanolic extract of
Shankhapushpi (100 mg/kg body weight) in rats provided significant relief in symptoms leading to improved mental functions studies in terms of stress in conditioned avoidance response.

Convolvulus pluricaulis has also been shown to possess a potent anticonvulsant activity. Animals treated with the methanolic extracts of stem callus, leaf callus, and whole plant of Shankhapushpi showed significant protection against tonic convulsions induced by transcorneal electroshock (Ahmad, Zafar, and Sahid, 2007). Ratha and Mishra (2012) also found in their study that Convolvulus pluricaulis in the dose of 400 mg/kg body weight administered in combination with phenytoin sodium (135 mg/kg) showed significant inhibitory effect on strychnine induced convulsions. The study concluded that Convolvulus pluricaulis could be acted as co-therapeutic agent of phenytoin sodium for arresting seizures induced by strychnine Hcl. Verma, Sinha, Kumar, Amin, Jain, and Tanwar (2012) also reported that at the dose of 500 and 1000 mg/kg, this plant didn’t abolish the hind limb extension, but reduced the mean recovery time from convulsions. Joshi, Kamat, Mohan, Chintalwar, and Chattopadhyay (2003) also concluded from their study that Convolvulus pluricaulis might emerge as potent antioxidant/radioprotector, capable of scavenging singlet oxygen, hydroxyl radical, as well as other stable radicals, ABTS and DPPH.

The antiulcerogenic effect of this plant was found to be due to augmentation of mucosal defensive factors such as mucin secretion, life span of mucosal cells, and glycoprotein rather than on the offensive factors like acid pepsin (Sairam, Rao, and Goel, 2001). Shankhapushpi root extract seems capable to ameliorate hyperthyroidism in mice as it could decrease the concentration of the most potent thyroid hormone, T₃, in hyperthyroid animals (Panda and Kar, 2001). The alcoholic extract of Convolvulus pluricaulis was found to possess potent antifungal activity (Gupta and Mudgal, 1974). Verma, Sinha, Singh, Tanwar, and Godara (2011) also reported that the methanolic extract of this plant exhibited prominent antimicrobial activity against two bacterial strains viz. E.coli and S.aureus.

Convolvulus pluricaulis appears to be an effective remedy for the treatment of diabetes (Alam, Siddique, and Hussain, 1990). Patel, Chandola, Baghel, and Joshi (2012) found
in their study that Shankhapushpi improved all the symptoms of type-II diabetes, reduced serum cholesterol and LDL, serum triglyceride, and VLDL. Urine sugar was found to be decreased with better percentage relief. Renal profile showed significant decrease in fasting blood sugar and post prandial blood sugar. 800 mg/kg of this plant exhibited significant antihyperglycemic activity in normal and streptozocin-induced diabetic rats. They also showed improvements in parameters like body weight and serum lipid profiles and so might be of value in treatment of diabetes (Agarwal, Sharma, Jain, Fatima, and Alok, 2014). Sharma, Verma, Yashwant, and Prasad (2013) reported that methanolic extract of Shankhapushpi can be a potential source of anti-obesity phytomedicine. An ethanolic extract of the plant when administered to cholesterol fed gerbils, reduced serum cholesterol, LDL Cholesterol, triglycerides, and phospholipids significantly after 90 days (Chaturvedi, Mali, and Dixit, 1997).

There are many medications and polyherbal formulations currently available in India mixing numerous plants extracts or powders with two or three medhya plants including Shankhapushpi. These formulations are complex preparations of compound medicines and involve a number of processes. Some preparations have been subjected to clinical trials.

Abana, a herbomineral compound which contains Shankhapushpi is claimed to be effective in a variety of cardiac disorders such as coronary heart disease, angina pectoris etc. Oral administration of abana reduced the frequency and intensity of anginal pain and decreased the pulse rate. Similarly total lipids, triglycerides, and serum cholesterol levels also showed significant decrease. Epinephrine and norepinephrine levels also fell in the treated group (Chandra and Kumar, 1986; Dubey, Agarwal, and Udupa, 1986; Tiwari, Shukla, Agarwal, and Dubey, 1990). Bala compound, another ayurvedic recipe which has Shankhapushpi in it, was found to improve and increase the immunity of neonates to combat the infections and to decline infant mortality rate (Rao, Sharma, Katiyar, and Prasad, 2009). Manas miyanak yoga, antoher ayurvedic compound, which has Shankhapushpi as an ingredient, has shown statistically significant improvement in the symptoms of ADHD i.e. inattention, impulsiveness, and hyperactivity (Ojha, Kumar, and Rai, 2007). An ayurvedic formulation which consisted of Shankhapushpi, Brahmi, Malkangni, and Jatamansi was found to be better as compared to imipramine and
sertraline for the treatment of patients with mild to moderate depression, due to its lesser side effects (Bhargava and Khan, 2012).

In this way, it has become very interesting to see the surprising effect of this herb on cognition especially attention. But before that, it is important to go through the research work already done in this area.