CHAPTER-I

INTRODUCTION

Consciousness previously viewed as “pure phenomenology” is now being increasingly reviewed from a cognitive perspective, as it is found necessary for cognitive functions. The operational form of consciousness is thought of as “reflective consciousness” or “access consciousness” and can be defined by its functional rather than phenomenal features. For this school of thought, consciousness has access to output mechanisms and verbal report ability.

The neural mechanism of consciousness is some sort of global workspace with wide cognitive and behavioral linkages. Information becomes conscious and enters the workspace only through top-down frontoparietal attentional selection (c.f. Revonsuo, 2010). We understand that once the information enters into consciousness its gets perceived as mindfulness.

In fact, all the basic insights of neural context of consciousness have been later found to be relevant for understanding mindfulness. Therefore, it is necessary to understand consciousness empirically to figure out the concept of mindfulness in its correct perspective, in line with Brown and Ryan (2003).

Damasio (1994) proposed the concept of “core consciousness” which represents the here-and-now, online relations between the core self and the objects (object images) present now for the core self. Extended consciousness, in contrast to the previous theories, operates across autobiographical history and presents the temporally continuous autobiographical self and its relations to past and future objects. According to this theory, core consciousness depends on brain structures that are phylogenetically, old such as the brainstem and the somatosensory and cingulated cortices which map the organism’s body and emotions. The early sensory cortices provide the images of objects. The neural patterns underlying core consciousness engage a large scale network that combine the image for the self and the images of objects.
Specifically, in order to gain insight into the mindfulness aspect of consciousness, empirically based theories as under can be followed. Baars (1988) proposed a global workplace theory which is one of the earliest cognitive insights into consciousness in terms of processing mechanisms which he referred to as “modules”. A module, according to Baars, is a processing mechanism that is specialized to handle only one type of information and only the relevant information can be taken as input by this module. He proposed that the mind is an information processing system that can be divided into two different types of processing architectures. The first consists of many specific cognitive modules that analyze sensory input, and the second consists of a more unified central system of higher cognition.

These individual modules are understood as entering the central unifying system of consciousness and then each module starts to compete with the other for “global access” i.e. for dominating position in the network. The winner of this competition gets its message globally broadcast and the message thereby forms the momentary contents of consciousness. The messages that win the competition must have a minimum duration of at least 50-250 ms as the messages that are broadcast for a shorter duration do not seem to have the time to spread across the whole workspace and therefore fade before they become conscious. The neural explanation of Baars theory is that two components are required for consciousness to operate i.e. sensory cortex where the stimuli are represented as cortical activation patterns and activities in the reticular formation and the thalamus. The sensory cortical activation can be connected with the thalamus through thalamocortical feedback loops. The thalamus in turn has massive connections to the whole cortex as well to subcortical mechanisms. This is the system where neural activation patterns get widespread access, thus resulting in neural global workspace.
Crick and Koch (1988), on similar lines, put forth a neurobiological theory of consciousness. They proposed that the sensory cortex contains “essential nodes” which are neural populations that express one particular aspect of sensory perception. Thus, these essential nodes are the neural basis for the phenomenal aspect of consciousness to exist. However these cannot perform the function in isolation and require a “coalition” i.e. a collection of a number of essential nodes in a distributed network. Only when the coalition becomes active as a whole, probably the synchronicity of all its member neurons builds a perceptual representation with a potential to become a content of consciousness. Consciousness is understood as working in a “winner takes all manner” so that the winning coalition subsequently expresses the actual content of consciousness. The winning coalition recruits neural populations widely in the cortex, thalamus and other networks. The winning coalition also activates the context or background. This background includes many such things and is popularly known as “fringe” of consciousness.

Figure I: Global Workspace as described by Bernard Baars (1988)
Tononi (2009) proposed the Integration theory and put forth the idea that the emergence of consciousness is based on how much the information generated by the system is integrated, unlike the Global Workspace Theory. The level of consciousness or the quantity of consciousness generated by the system is directly proportional to the degree of information integration in the system and the quality of consciousness is determined by the internal informational relationships within the system.

Llinas (2001) proposed a thalamocortical binding theory. He reaffirmed the proposition of information integration and binding and gave a detailed account of the neuroanatomical and neurophysiological features of the thalamocortical system that are, in his view, responsible for generating consciousness and binding it together. An important feature of thalamocortical connectivity emphasized in this theory is its bidirectionality. Herein, thalamic nuclei receive reciprocal pathways from the same cortical areas that they project to. The distributed neural representations of simultaneous perceptual features or events could be related to each other within the thalamocortical so as to bind input from different sensory modalities into a single perceptual event. The thalamocortical system is a plausible candidate for playing a role in the binding or integration of multiple distributed representations to a coherent perceptual world. Llinias theory is based on two facts i.e. there are abundant reciprocal thalamocortical connections that establish large scale reverberating activity between the thalamus and the cortex and some cortical and thalamic neurons are capable of generating intrinsic 40 Hz oscillations.

Lamme (2000) proposed a recurrent processing theory to understand consciousness. The speed and the direction of processing in the visual cortex is crucial for consciousness. The speed of processing can be measured as the time of arrival to a cortical area of the first signals from a visual stimulus. The different cortical areas processing visual stimuli can be ordered into a temporal hierarchy or a series of levels according to how long it takes for them to become activated by the stimulus. As short as 10 ms is stipulated for the signal to
rapidly proceed from area to area through all feedforward connections and only 100-150 ms for the stimulus to reach the motor cortex in the frontal areas through the visual cortex. The visual information is first processed rapidly but non-consciously through fast feedforward pathways in 30-100 ms from stimulus onset. Then it is proceeded “backwards” and more slowly through recurrent connections and in this process, the information becomes conscious at around 100-300 ms from stimulus onset. Thus Lamme distinguishes between attention and consciousness and puts forth the idea that attention operates with “depth” of processing.

![Figure II: Lamme’s Model of Visual Consciousness (2000)](image)

According to Lamme’s model of visual consciousness, visual information is first processed rapidly but non-consciously through fast feedforward pathways in 30-100ms from stimulus onset. Then it is processed “backward” and more slowly through recurrent connections, and in this process the information becomes conscious at around 100-300ms from stimulus onset.

Microconsciousness theory given by Zeki (2003) however, argues the completely opposite of the above mentioned theories. It states that consciousness is generated already at a stage where only the elementary features of perception
are first processed. This theory proposed that consciousness is fundamentally disunified and that its neural correlates are distributed over the sensory cortex and that there is no single unified neural mechanism of consciousness.

It has been found that consciousness precedes attention and attention, is crucial to our successful interaction with the environmental stimulation and serves as a gatekeeper for the rest of cognition (MacLeod and MacDonald, 2000).

Cattell, 1886 (c.f Cohen et al.,1990), described some processing situations as automation running off essentially without attention whereas others demanding attention. This eventually led in the 1970s to the distinction between “automatic” and “controlled” processing, wherein automatic processing developed through practice and required little attention, but controlled processing required attention to perform less practiced algorithms (Posner et al., 1975; Shiffrin et al.,1977). Given the above mentioned opposing forces, a conflict situation arises and conceptual Stroop effect outshines itself to be classic illustration of the same, named after the psychologist J.R Stroop who created the task as a part of his doctoral dissertation (MacLeod, 1991).

Beginning with Klein’s rediscovery and extension of the effect (Klein, 1964), literally thousands of studies have explored this deceptively simple yet provocative phenomenon since Stroop’s original dissertation.

This asymmetry of the interference – words interfere with color naming but colors do not interfere with word reading – suggests that reading words is more automatic (more obligatory and ballistic) than naming colors. This traditional Stroop asymmetry refers to the imbalance in performance wherein irrelevant words slow down naming, but irrelevant colors do not slow word reading. (Melara et al., 2003).

In line with the imbalance in performance, Shiffrin et al.,(1977) explained that the differences in processing speeds suggested by Stroop interference are
consistent with a distinction between the two types of cognitive processes as mentioned above i.e. controlled and automatic. However, a connectionistic explanation of the Stroop interference proposes that automaticity is a continuum, and the Stroop interference depends on the relative degree of learning of the respective tasks. According to this view, asymmetries in performance such as those observed in the Stroop task are accounted for, by differences in experience. (Cohen et al., 1990).

The localization of the Stroop effect in the human brain points majorly towards the anterior cingulate cortex and proposes that its function is to maintain the goal of attending to and responding to color (MacLeod and MacDonald, 2000). Findings in the Stroop task research indicate that the increased activation in the anterior cingulate is accompanied by decreased activation in other regions (i.e. the posterior cingulate, superior temporal cortices, parietal association cortex and striate and left extrastriate cortex) have been interpreted as evidence that the anterior cingulate performs a gating function as well (Bench et al., 1993; Carter et al., 1995). Research evidences that the anterior cingulate has a greater activation in the congruent and incongruent conditions relative to the neutral condition (Ploghaus et al., 1999).

The proposed role of anterior cingulate in the Stroop task is not at odds with conclusions drawn from the literature. The view that the anterior cingulate performs executive functions in directing attention to a goal, even in the absence of conflicting information, is additionally bolstered by findings of increased anterior cingulate activation in anticipation of a task (Murtha et al., 1996; Ploghaus et al., 1999). It has also been, not surprisingly, implicated in other related processes such as error detection and monitoring, working memory and conflict or competition monitoring (Bush et al., 2000).

There have been various cognitive explanations for the Stroop effect. Fundamental to the Stroop effect is the notion of competition, which was initially regarded as a competition between the color and the word stimuli (e.g.
speed of processing expressed in terms of output latencies). MacLeod (1991a) opines that the idea of response competition is an important component of Stroop interference. The idea is that the decision point at which competition occurs is at the response end of the pathway. This end of notion is strongly favored by response set effects in Stroop experiments and also by the stimulus responder compatibility effects (Flowers et al., 1979).

Melara and Mounts (1993), however, argued that the asymmetry found in Stroop interference could be attributed to the mismatching of relative salience’s of the color and verbal information and that this Stroop interference can be eliminated if there is a matching of the relative salience of the color and the verbal information.

The relative salience is defined in terms of Garner interference. The Garner interference is defined as the cost of making discriminations on one dimension when there is variation in another (irrelevant) dimension. Reducing the text size would be sufficient to shift the balance, both of Garner interference and of Stroop interference, in a button pressing task using Stroop like stimuli.

The notion of automaticity is commonly attributed to verbal processing in Stroop interference and Cohen et al., (1990) developed a connectionist model of the Stroop effect. They modeled a two color system and showed that by simply strengthening the pathways between the verbal stimuli and the correct output responses, one can produce patterns of performance that approximate human reaction time (RT) data in a Stroop task. Although there have been several critiques of the details of the model (Kanne et al., 1998; Mewhort et al., 1992), yet the basic idea put forth is clearly on track which simply posits that irrelevant information traveling along strong pathways can interface with target information traveling along weaker ones. A limit of this model, however, is its inflexibility with respect to asymmetry i.e. Cohen et al., (1990) model only describes how Stroop asymmetry can arise from pathway strength but does not explain the difference between the normal Stroop task and reverse Stroop task
paradigm. Hence, it is often concluded with regard to this model that it is not an explanation of the direction of asymmetry, because it determines this asymmetry merely by positing an asymmetry in pathway strength.

However, Kornblum (1992) proposed a dimensional overlap model which indicates two sources of interference. It posits that on one hand there is a competition between the target stimulus and the distracting stimulus as in the classic Stroop task (the distracting stimulus is a color word whereas the target stimulus is the sensory color) and on the other hand, the response compatibility effect is also operational such as the response itself i.e. naming the target color is compatible with the distracting information. Kornblum referred to these instances of competition and compatibility as varying in dimensional overlap. In the oral Stroop task, Kornblum, pointed out that this dimensional overlap is not only between the target and the distractor stimuli, but also between these stimuli and the set of responses.

Glaser and Glaser (1989) proposed a translation model which suggests that, along the pathway from stimulus to response, the form of internal representation employed by cognition may change. It proposes that the delay in the cognitive output latency can be accounted by the efforts required at the translation of the lexical information to sensory (imagistic) color information. If the task requires lexical information, as in the color naming task, lexical stimulus information will have an advantage because it requires little or no translation during processing. However, if the task has sensory (imagistic) color information, that information will require translation.

Another model to explain the classic Stroop effect is the speed of processing of linguistic information relative to perceptual information (Schooler et al., 1997).

A central component in all these models is a "conflict" between the information derived from the linguistic component of a stimulus and its perceptual component (Pothos and Tapper, 2009). A classic Stroop effect simply
implies a fight for attention, commonly referred to as the selective processing of one aspect while ignoring the other irrelevant aspect. About one million fibers leave human eye, meaning that we have to deal with about one megabyte of raw data each second (Koch and Tsuchiya, 2006).

Information processing capacity involved in the control of higher level cognition and behavior is limited, attention facilitates which stimuli and actions get access to these capacity limited processes. Therefore, attention must be flexibly and cognizantly applied to different processes (Kahneman, 1973; Moors and DeHouwer, 2006).

Moors and DeHouwer (2006) pointed out that the early stages of information processing (sensory analysis) generally require no attention, whereas later stages require an increasing amount. Given that attention is a limited resource, some of these later processing stages do indeed continue because enough attention is devoted to them, whereas, other processes are “filtered out” by lack of attention. Whether this incoming information is attended to or not i.e. whether it is processed at the higher stages, is determined by both bottom up and top down processes (Corbetta and Schulman, 2002; Dehaene et al., 2006; Koch and Tsuchiya, 2006) where bottom up processing refers to the exogenous or the involuntary attention processes and the top down processing refers to the endogenous or the voluntary attention processes.

As a general rule, attention in the service of goals involves two interconnected faculties that usually act in close harmony: stability or focus (the ability to keep information active for action or for further processing) and flexibility (the ability to be flexible enough to switch to, and take advantage of contextual variations). The balance between focus and flexibility is crucial for goals to do their work effectively. Disturbance of this balance, however, leads to inferior performance (Aston – Jones Cohen, 2005).

The Load theory (Lavie, 1995) posits that distracter rejection depends on the level and type of load involved. This theory resolves the long standing early
versus late selection debate and clarifies the role of cognitive control in selective attention. It suggests that two selective attention mechanisms are operational i.e.:

(a) perceptual selection mechanism serving to reduce the distracter perception in situations of high perceptual load that exhaust perceptual capacity in processing relevant stimuli and

(b) cognitive control mechanism that reduces interference from perceived distracters as long as cognitive control functions are available to maintain current priorities (low cognitive load).

The first i.e. the perceptual selection mechanism allows for excluding irrelevant distracter stimuli from perception under situations of high perceptual load. This is rather a passive mechanism, whereby irrelevant distracter interference is prevented simply because the distracters are not perceived when there is insufficient capacity for their processing. The second mechanism is a more active mechanism for attentional control that is needed for rejecting the irrelevant distracters even when these are perceived (in situations of low perceptual load). This form of control depends upon higher cognitive functions, such as working memory, that are required for actively maintaining current processing priorities to ensure that low processing stimuli do not gain control of behavior. Thus a high load on these cognitive functions should drain the capacity available for active control and result in increased processing of irrelevant distracters.

A balance is thus required to be maintained between focus and flexibility and this brings in the functional role of consciousness. However, functionally defining consciousness has been a complex issue with which the psychologists have struggled for a long time. Conscious processes can be understood as the processes that are accompanied by awareness of certain aspects of the process or awareness of the relevant contents (Dijksterhuis and Aarts, 2010). In experimental research, this conscious awareness of process or content can be assessed by investigating whether people are able to verbalize the processes or
contents. It is also felt that it is enough to be aware of some aspect of the process for it to qualify as a conscious process (Dijksterhuis, 2009).

There has been overwhelmingly increasing interest amongst the psychologists on the content of consciousness – thought, emotion and so on, rather than the context in which those contents are expressed i.e. consciousness itself (Hayes et al., 1999; Rychlak, 1997) and mindfulness seems to be a fundamental quality of consciousness (Brown et al., 2007).

The concept of mindfulness is most firmly quoted in Buddhist psychology, but it shares conceptual kinship with ideas advanced by a variety of philosophical and psychological traditions, including ancient Greek philosophy, phenomenology, and naturalism in later Western European thought and transcendentalism and humanism in America.

Mindfulness is rooted in the fundamental activities of consciousness: attention and awareness. “Awareness” is a conscious registration of stimuli, including the five physical senses, the kinesthetic senses and the activities of the mind. It is our direct, most immediate contact with reality and when a stimulus is sufficiently strong, attention is engaged, which is manifest as an initial “taking notice” of or “turning toward” the object (Nyaniponika, 1973). Thus, these basic features of consciousness are of basic decisive importance to determine the quality of experience and action. Commonly, sensory objects are held in focal attention only briefly, if at all, before some cognitive and emotional reaction to them is made.

These kinds of rapid perceptual reactions have several characteristics of relevance to subjective experience and functioning. They are of discriminative nature in which the primary appraisal of the object is made. They are usually conditioned by past experience of the sensory object or other objects of sufficient similarity to evoke an association in memory and such kind of perceptual experience is easily assimilated through further cognitive operations upon the object, made to assimilate into existing cognitive schemas. The
consequence of such kind of processing is that concepts, labels, ideas and judgments are often imposed automatically on everything that is encountered (Bargh and Chartrand, 1999). Such processing has certain adaptive benefits which includes the establishment and maintenance of order upon events and experience of relevance to the self and the facilitation of goal pursuit and attainment. It also implies that sensory objects and events are rarely seen impartially, as they truly are, but rather through the filters of prior conditioning, thereby running the risk of furnishing superficial, incomplete and distorted pictures of reality.

In contrast, however, to the conceptual mode of processing a mindful mode of processing involves a receptive state of mind, wherein attention is kept to a bare registering of the facts observed. When used in this way to prolong that initial contact with the world, the basic capacities for awareness and attention permit the individual to “be present” to reality as it exists, rather than to react to it or habitually process it through conceptual filters (Brown et al., 2007).

Mindfulness when manifested in the form of meditation is distinguished from concentration based forms of meditation that train participants to focus attention on a single stimulus e.g. an object or a word. By contrast, mindfulness meditation involves a broader observation of one’s present moment experience, that is physical sensations, thoughts and feelings (Baer, 2003).

Mindfulness derives from the Pali language word “sati” meaning “to remember”; but as a mode of consciousness it commonly signifies presence of mind (Bodhi, 2000; Nyaniponika, 1973). It is a receptive attention and awareness of present events and experience (Brown and Ryan, 2003).

As mentioned earlier, mindfulness is a quality of consciousness and so in its relation to the contents of consciousness, has several overlapping and mutually supportive characteristics which cannot be regarded as distinct components and which appear relevant to its empirical study.
Mindfulness concerns itself with a clear awareness of one’s inner and outer world, including thoughts, emotions, sensations, actions or surroundings as they exist at any given moment. For this reason, it has been termed as “bare” attention (Gunaratana, 2002) and pure and lucid awareness (Das, 1997, Gunaratana, 2002) which reveals what is occurring before or beyond ideas about what is or has taken place (Welwood, 1996). A Zen metaphor likens this state to that of a polished mirror, wherein the mind simply reflects what passes before it, unbiased by conceptual thought about what is taking place. This unbiased receptivity of mind is also thought to facilitate insight into reality wherein phenomenon that would have otherwise remained hidden from view are seen or known with increasing clarity.

This direct contact with reality as seen in a mindfulness state is also characterized by its nonconceptual and nondiscriminatory awareness. Unlike the cognitive processing style, in which attention and cognition are tightly intertwined, the mindful mode of processing is a pre or para conceptual (c.f Marcel, 2003), it does not compare, categorize or evaluate nor does it contemplate, intercept, reflect or ruminate upon events based on memory (Brown and Ryan, 2003; Teasdale, 1999). It concerns a non interference with experience, by allowing inputs to enter awareness in a simple noticing of what is taking place.

Another key feature of mindfulness is its flexibility regarding awareness and attention. One can be mindfully aware of all that is currently salient, and one can also be mindful of something in particular-focusing attention towards a stimulus or phenomenon (Kornfield, 1993).

Evidence suggests that mindfulness is associated with attentional control and other indicators of concentrative capacity (Brown, 2006). However, some evidence suggests mindfulness and concentration to be unique capacities (Dunn et al., 1999). To support this distinction, they endorse the view that the primary difference between concentration and mindfulness is that concentration entails a
restriction of attention to a single interoceptive or exteroceptive object, leading to a withdrawal of sensory and other inputs (Engler, 1986). By contrast, in its fullest expression, the mindful mode of processing involves a voluntary, fluid regulation of states of attention and awareness.

Mindfulness also has an empirical stance towards reality, implying that the mindful state of being is inherently empirical in which it seeks possession of the “full facts” in a manner similar to that of the objective scientist seeking accurate knowledge of some phenomenon (Smith and Novak, 2004). It has also been described as an “alert participation in the ongoing process of living” (Gunaratana, 2002). A mindful state is actively engaged, not passively resigned or dissociated from the observed experience (Baer et al., 2006). It also emphasizes a present oriented consciousness. It is considered as an inherent capacity of the individual (Brown and Ryan, 2003; Goldstein, 2002; Kabat-Zinn, 2003). But it nevertheless varies in strength. In a rudimentary form, mindful states may be fleeting or infrequent but in a fuller form, they are more frequent and a continuous steadiness of awareness and attention help to eliminate opportunities for concepts, ideas and associated emotions to be blindly or automatically tacked onto bare facts (Smith and Novak, 2004). Such steadiness also facilitates the recognition of being caught up in conceptual thoughts or emotions rooted in past experience or anticipated future and the return to an awareness of what is currently taking place. Mindfulness can be understood as noticing what is present, including noticing that is no longer present. Recognizing that one is not being attentive and aware is itself an instance of mindfulness. This continuity of mindfulness also helps to ensure that attention can move from narrow focus to broad vista without distraction or loss of collectedness.

There have been a variety of conceptualizations of mindfulness e.g. it being a self regularity capacity (Brown and Ryan, 2003), as an acceptance skill (Linehan, 1994) and also as a meta-cognitive skill (Bishop et al., 2004).
Bishop et al., (2004) were the pioneers to propose the first formal definition of the cognitive mechanisms as part of a two component operational definition of mindfulness involving (1) the self regulation of attention so that it is maintained on immediate experience and (2) the adoption of an open, curious, accepting awareness of experiences in the present moment. Specifically, Bishop et al.,(2004) proposed that mindfulness involves sustained attention to maintain awareness of current experience, attention switching to bring attention back to the present moment when it wanders, inhibition of elaborative processing to avoid dwelling or ruminating on thoughts or feelings that are outside of the present moment and non directed attention to enhance awareness of present experience, unfiltered by assumptions or expectations.

Further, Bishop et al., (2004) view mindfulness as an attentional state that can be evoked when attention is purposefully brought to the present moment while fostering an open orientation to experience.

Anderson et al., (2007) reasoned that mindfulness training entails an extended practice of the attentional control abilities, and practice generally improves attentional control (Cepeda et al.,2001 and MacLeod,1991) mindfulness training should be associated with increased mindfulness and correspondingly improved performance on tasks that measure these abilities.

The attentional control taught in various mindfulness training programs, seems to be functionalizing even in situations wherein mindfulness is induced. Mindfulness seems to however, maintain a balance between the two modes of mind by cultivating the ability to shift modes as an essential first step to be able to hold all experience (sensory and conceptual) in a wider awareness that is itself neither merely sensory or conceptual.

During mindfulness practice, the participants have additionally to hold in their working memory two meta intentions (a) to notice mind wandering and return intention to the intended focus and (b) explore sensations and
acknowledge mind wandering with an attitude of and compassion rather than comparison, analysis and judgment.

A lot of empirical research is being carried out with regard to mindfulness based intervention strategies as well as dispositional mindfulness. Attempts are being made to uncover the underlying neural correlates of dispositional mindfulness. Affect labeling has been understood as the mechanism for the effects of reduction in pathological, mental and physical health symptoms as a result of mindfulness. Various experimental attempts have been made to bring mindfulness under experimental control in the laboratory settings. The prefrontal cortical activation is associated with dispositional mindfulness during affect labeling with reduced bilateral amygdala activity (Creswell et al., 2007).

Since mindfulness is also an index of cognition in view of the conflict caused by distractions in the path of inputs and outputs, it is understandable that such types of cognitive tasks conflict have been extensively used to measure the efficiency with which control of action is exerted (Botvinick et al., 2001). In this context, Stroop task which is an important task to measure the selective attention has been extensively used.

In the recent years, there has been a growing interest in the neuroanatomy of mindfulness Creswell et al. (2007) showed in their study that dispositional mindfulness is associated with enhanced prefrontal cortical regulation of affect through labeling of negative affective stimuli.

However, there has also been a considerable interest in the effect of emotional information on the capture of selective attention. e.g. Kitayama and Howard (1994) suggested that emotional stimuli can amplify attentive processing and that under certain stimulus conditions, negative stimuli tend to preferentially capture attention. Although the findings of the relative effects of positive and negative information on attracting attention have often been mixed e.g. Fazio et al., (1994); Hansen and Hansen (1988). Herein comes the role of anxiety in inhibiting or facilitating the various aspects of selective attention.
The cognitive theories of anxiety have emphasized the role of biases in attentional processes in the aetiology and maintenance of anxiety states (e.g. Eysenck, 1992; Mathews, 1990; Williams et al., 1988, 1997).

Eysenck (1992) advocated a hypervigilance theory which proposed that an attentional bias for threat underlies vulnerability to clinical anxiety, and that this bias should be particularly evident in anxiety prone individuals under condition of stress. This selective hypervigilance for threat may also maintain anxiety states, because anxiety prone individuals would be more likely to detect potentially threatening cues in their environment, which would enhance their view of the world as being unduly dangerous place.

However, Mathews (1990) suggested that anxiety is associated with a specific mode of operation within the cognitive system that serves to determine the processing priorities. Specifically, as per Mathews, anxiety is characterized by a hypervigilant mode in which the person scans the environment for threat related stimuli, with priority of processing being allocated to the initial encoding of threat. He further suggested that individuals in their readiness to adopt a vigilant processing mode for threat have a greater tendency to direct processing resources towards danger relevant stimuli.

Williams et al., (1988, 1997) also proposed that automatic vigilance for threat reflects a cognitive vulnerability factor for clinical anxiety i.e. the individuals who have a bias to direct their attention towards threat are more susceptible to the development of anxiety disorders when under stress.

According to Williams et al.,(1988) model, an Affective Decision Mechanism assesses the threat value of environmental stimuli and its output feeds into a Resource Allocation Mechanism which determines the allocation of processing resources. This RAM (Resource Allocation Mechanism) is influenced by trait anxiety i.e. high trait anxious individuals have an enduring tendency to orient attention to threat, whereas low trait anxious individuals have an opposite tendency to be avoidant of threat. Thus, as state anxiety (stimulus
threat input) increases, high trait anxious individuals should become more vigilant, whereas low trait anxious individuals become more avoidant of threat. So, this model was of the notion that attentional biases are an interactive function of trait anxiety and threat input. Williams et al., (1997) updated their 1988 model while drawing on the Parallel Distributed Processing (PDP) model of Cohen et al.,(1990). Within this connectionist framework, the operation of the Affective Decision Mechanism was conceptualized instead of activation of input units that are associatively “tagged” with the threat value. Resource allocation mechanism was viewed as a task demand unit in PDP terms. However, it was proposed that the direction of the attentional bias for threat provides an index of vulnerability to generalized anxiety.

However Mogg and Bradley (1998) explained the cognitive mechanisms of anxiety as follows:

![Figure III: Cognitive mechanisms of Anxiety, Mogg and Bradley (1998)](image)

**Figure III** : Cognitive mechanisms of Anxiety, Mogg and Bradley (1998)
However, such cognitive accounts of anxiety as those of Williams et al., (1988, 1997) had problems in explaining attentional biases for severe threat stimuli because they lead to counterintuitive predictions for low trait anxious individuals. According to their view, as activation of threat input units increases, low trait anxious individuals become more avoidant of threat. The activation level of these input units depends on a range of variables including state anxiety and stimulus threat value. However, it is clearly important from the evolutionary perspective that an effective threat detection system would have to ensure that attention is directed to real or severe threats. Thus, low trait anxious individuals should show greater vigilance for severe threat than for the mild threat stimuli.

It has been argued that there are two stages of attentional competition, with early perceptual competition preventing distracters from being processed further when the perceptual load of the primary task is high and with active recruitment of control mechanisms being required to prevent salient distracters from competing for further processing resources when the perceptual load is low (Lavie, 2005).

Mogg and Bradley (1998) model of cognitive anxiety proposes a more comprehensible view of the mechanisms that may underlie attentional biases in anxiety taking into account the various factors like situational context, biological preparedness, prior learning and state anxiety that tend to play an important role in determining an anxious individual’s reaction to a stimulus. This model refers to a complex interplay of the abovementioned confounding variables and proposes a Valence Evaluation System which is responsible for assessing stimulus threat value. Its function corresponds largely to the stimulus appraisal processes as described in an earlier model in earlier Le Doux’s (1995, 1996) neural model of anxiety and includes not only automatic, rapid analysis of crude stimulus features but also the integration of more detailed information. Thus various factors besides just the nature of the stimulus, its context, interoceptive information about current arousal level and previous learning experiences also
play a determining role in influencing the output valence of evaluation system which in turn determines the goal engagement system i.e. the allocation of processing resources.

This cognitive motivational view as described by Mogg and Bradley, (1998) also recognizes the individual differences in the sensitivity of valence evaluation processes to threat stimuli as a key factor underlying trait anxiety. It proposes that the valence of the threat stimulus and the tendency of the allocation of the resources by a high anxiety individual could be quite complex as he might be overwhelmed by a mild threat stimuli and over appraise it as moderately high threat value stimulus resulting in increased allocation of resources, whereas a low trait anxiety individual would evaluate the stimulus as having trivial threat value and would disregard it as compared to a more hedonically positive stimulus. However, as threat value increases further, even low trait anxious individuals should show an increased tendency to allocate attention towards, rather than away from, stimuli with higher threat value. Thus, as per this model for threat stimuli in a mild to high range, it is expected that increasing threat value would be associated with increasing vigilance in both low and high trait anxious individuals (Mogg et al., 2000).

Another influential cognitive model of attentional bias for selective processing in anxiety is described by Wells & Matthews (1994). Within a more general processing framework termed the self regulatory executive function, Wells and Matthews attributed attentional bias to top down processes and related it to the individual plans and goals. Phenomena such as emotional Stroop interference are attributed to a voluntarily executed plan, which specifies the monitoring of negative stimuli that intrude into awareness. Another model of anxiety and attention proposed by Öhman (1993) puts forth the idea that the incoming information is first analyzed by feature detectors, before being passed on to a nonconscious “significance evaluating system”.

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Researchers have also put across the view of understanding the performance on cognitive tasks to be associated with evaluation anxiety. Those who endorse this view understand evaluation anxiety as a particular form of anxiety that typically occurs during situations in which individual’s performance is being evaluated in social, academic or work settings. Evaluation anxiety is composed of both affective and cognitive components (Deffenbacher, 1980). Researchers refer to the cognitive aspect of evaluation anxiety as worry and consider it aversive (Borkovec, 1994). Worry occurs in reaction to either evaluation or failure related concerns (Borkovec, 1994). Negative self statements and task irrelevant thoughts are often the content of worry (Sarason, 1984, Sarason and Stroops, 1978).

As with general anxiety, researchers have found a reliable association between evaluation anxiety and performance on cognitive tasks (Zeidner and Mathews, 2005). Researchers have generated several explanations to understand how evaluation anxiety and cognitive processes interact. Two such explanations are Cognitive Interference Theory, CIT (Sarason, 1984) and Attentional Control Theory, ACT (Eysenck et al., 2007).

Both these theories use the Tripartite Model of working memory to provide a mechanistic view of how anxiety impairs cognitive performance. The Tripartite Model of Working Memory as proposed by Baddeley (1986) posits that working memory is comprised of three subsystems: the phonological loop, the visuo-spatial sketch pad and the central executive. The phonological loop is involved in processing the auditory information whereas the visuo-spatial sketch pad processes visual information. The central executive though initially was described in vague terms, it was later said to control the two systems through the allocation of attentional resources. However, the investigators have lately started to identify three more clear functions of the central executive which are: inhibition, shifting and updating. Inhibition refers to an intentional effort to suppress a near automatic response. Shifting is the ability to change the
cognitive sets when signaled by environmental contingencies. Updating is the process of maintaining information in short term memory while performing an unrelated operation. Inhibition and shifting rely heavily on voluntary, controlled attention processes while updating is largely independent of those processes (Eysenck et al., 2007)

The Cognitive Interference theory posits that negative self statements frequently accompany evaluation anxiety and may interfere with working memory processes. More specifically, processing negative self statements diverts attentional resources from task processing, resulting in decrements in task performance. Moreover, CIT predicts that components of the working memory subsystems are differentially affected by negative self statements. According to CIT theorists, negative self statements are automatically processed by the central executive. The result is that the central executive is left with fewer resources to devote to task demands. In addition, given the verbal nature of negative self statements, the phonological loop functioning is likely to be impaired. The model posits that visuospatial sketch pad functioning should not be impaired by anxiety.

Northern (2010) found support for the CIT model. Specifically anxiety provoking instructions were found to be associated with an increase in evaluation anxiety. Subsequently, evaluation anxiety was related to an increase in negative self statements. Higher levels of evaluation anxiety were found to predict poorer performance on phonological loop and central executive tasks, but not on visuospatial sketchpad tasks. Finally, negative self statements were found to almost completely mediate the relationship between evaluation anxiety and phonological loop performance.

Attentional Control theory is an alternative theoretical framework that is helpful in understanding how anxiety affects cognitive performance (Eysenck et al., 2007). According to this model, two attentional systems exist and together form the basis of central executive functioning. One system is goal directed and
is associated with deliberate, intentional control of attention. The other subsystem is stimulus driven and is controlled primarily by automatic processes. Typically, both systems function in a state of balance, using about equal cognitive resources. Threatening conditions however, lead to an imbalance such that cognitive resources are diverted from the goal directed system to the stimulus driven system. Fewer resources are available for the system associated with voluntary control of attentional processes. As anxiety detracts from the resources available to control attention, ACT theorists propose that executive functions that largely rely on attentional control (e.g. inhibition and shifting) are more likely to be adversely affected by anxiety. Several studies support these claims using various measures of inhibition (e.g. Stroop task) and shifting (e.g. Wisconsin Card Sort task). Updating functioning could theoretically be impaired if conditions were extremely stressful. A differentiation between processing effectiveness and processing efficiency is an important theoretical underpinning in ACT (Eysenck, 1992). Effectiveness refers to an individual's performance on a task in terms of correct answers. Efficacy refers to the degree of cognitive resources that are devoted to achieving a given level of effectiveness. Longer response latencies on cognitive tasks are a typical measure of efficiency. ACT predicts that efficiency will always be impaired by anxiety. In fact a mild level of anxiety may not have any impact on effectiveness according to ACT. ACT theorists argue that effectiveness and efficiency are two different constructs and this distinction is important to observe.

Several studies have been carried out in the recent past using Stroop task as a measure of attentional bias and their proper effects (interference or facilitation of identification for multi dimension stimuli) result from the semantic relationship of one dimension of the stimulus, e.g. a word and another, e.g. ink colour (Stroop, 1935; MacLeod and MacDonald, 2000).

The performance of the subject on Stroop task is basically a cognitive task performance and there have been various studies in the literature to suggest
the facilitating and inhibiting effects of various types of music on each cognitive task performance.

The Stroop task performance is a task of collective attention and music is described in the literature to have beneficial effect on agitation, social behavior, mood, relaxation and attention (Aldridge, 2007).

Music is a powerful tool for maintaining and restoring health, it can be used to induce relaxation, alter moods, and create distraction (Aldridge, 2000; Aldridge and Aldridge, 1992). Historically, music has been a useful tool for learning. The literature has indicated that it is the left hemisphere of the brain that analyses the structure of music while the right hemisphere focuses on the melody, thus music synchronizes the left and the right hemispheres of the brain. It is also recently been reported that rhythm acts as a hook for capturing attention and stimulating one’s interest. Once a person is motivated and actively involved, learning is optimized (Davies, 2000). It is also said that music rhythmically and harmonically stimulates essential patterns of brain growth (c.f. Davies, 2000). It is also believed to have beneficial effects just like meditation, yoga and biofeedback as well as to unify the mind and the body. Music with a pulse of 60 beats per minute is believed to shift consciousness from the beta towards the alpha range, enhancing alertness and general well being. Jensen (1996) reported that music can facilitate in the stimulation of creativity, thinking and sensitivity, rhythm can influence the heartbeat and also it can increase the molecular energy.

Hanschumaker (1980) summarizes succinctly regarding what music can do for young children and that can be generalized to all school aged children. As per this viewpoint music has the ability to facilitate language acquisition, reading readiness and general intellectual development to enhance creativity and to promote social development, personality adjustment and self worth. Music therapy can help reduce levels of anxiety (Hendricks et al., 1999). Layman et al.,(2002) indicated that it helps with problems of impulsivity and self regulation, as well.
Music therapy appears to be especially effective with adolescents because they relate extensively to the music of their peer culture and it is a familiar medium to them. It can readily provide a common starting place for discussion and self expression. The non verbal aspect of music makes it an excellent resource for facilitating self expression through alternate means of communication (McIntyre, 2007).

There exist a variety of studies analyzing the effect of instrumental music and classical music on children. Especially after Rauscher et al. (1993, 1995) studies, whose results evidenced that listening to Mozart resulted in an improvement in spatial IQ, the amount of research on this topic has been increased greatly (e.g. Crncec et al., 2006). Majority the studies have focused on adults but there are various researchers who emphasize that music may assist children in their spatial and other cognitive abilities (Rauscher, 1999; Shaw, 2000).

However, there are mixed schools of thoughts on the effects of music. There are many studies supporting Mozart effect (Van der Linde, 1999; Riddoch and Waugh, 2003) but, there are many other studies claiming that many effects are over exaggerated and indeed do not exist at all (Smith and Davidson, 1991; Hallam, 2000; Fioranelli, 2001; Crncec et al., 2006). Those in favor of the beneficial effects of music opine that instrumental music is brain food. It has positive effects on cognitive development in children. People perform logic tasks better in the presence of instrumental music as opposed to vocal music. It is also opined that instrumental music also helps people perform better in problem solving tasks.

Leng et al., (1990) provided a neuroscientific framework for the relationship between music and spatial cognition in the form of a cortical model. This neuronal model opined that certain overlapping neural firing patterns organized in a spatial temporal code over large regions of cortex are found to be activated both in musical and spatial reasoning tasks. They proposed that this
spatial temporal neuronal firing pattern has the inbuilt capacity to recognize, compare and find relationships among patterns. Such neuronal performance is responsible for performance on cognitive tasks with spatial background. The authors further proposed that music cognition also requires these temporal sequences of neural activity. Leng and Shaw (1991) further proposed that exposure to music might excite and enhance the cortical firing patterns used in spatial temporal reasoning thus affecting cognitive ability in tasks that share this complex spatial temporal neuronal code.

There have been studies to analyze the impact of background music. With the advent of electronically reproduced music, background music has become increasingly prevalent in our society. It can be defined as any music played while the listener’s attention is focused primarily on a task or activity other than listening to the music (Radocy and Boyle, 1988). The function of the background music varies with the individual listener and the nature of the task or activity in which the listener is involved. Such a task or activity could be studying or other academic preparation or a performance on any other cognitive task. Students of all ages have claimed that they can study and learn more effectively while listening to music. Indeed, some researchers have explored the possible transfer of cognitive abilities to other curricular areas by theorizing that exposure to music, through participation and formal instruction, can facilitate nonmusical learning (Madsen, 1987; Radocy & Boyle, 1988; Wolfe, 1983).

The possible effects of exposure to music and music instruction on nonmusical learning have received some attention from the music education research community. Researchers have also studied the effect of background music on various types of anxiety. There are differing conclusions on the effect of music on state and trait anxiety. Davis and Thaut (1989) reported that listening to background music resulted in a decrease in state anxiety and an increase in relaxation in a pre-post setting. Similar results were obtained by
Stoudenmire (1975). He found that music relaxation and background music reduced state anxiety, but neither treatment reduced trait anxiety.

Recent developments in neuroscience have reinforced these benefits, for instance among young people who have suffered severe trauma and brain impairment at an early age, rhythm exercises have also been found to act in support of the regulation of homeostatic states (Perry, 2007). Extensive engagement with music induces cortical reorganization producing changes that assist in brain in processing and storing information (Schlaug et al., 2005).