The Importance of Memory in Mental Training

There is little direct commentary on the function of memory in the Buddha's teaching; it is taken for granted that our existence is accumulative: nothing is really forgotten, and our present state is continually filtered through the effects of the past. The Buddha explains memory's dual importance. First, we have consistently seen the importance that the Buddha attributed to habituation and schemata in the operation of the cognitive apparatus which creates our reality. Without memory we cannot establish a habit. Also, memory is essential in learning new habits and pursuing the Buddha's teachings. For example, there are two aspects of Right mindfulness (alternative wordings are "right memory", "right monitoring" and "right attention"): the aspect of mindfulness of awareness and the aspect of mindfulness of remembering the instructions in following the Eightfold Path teachings. The Buddha laid out an extensive change program on how to reach the goal of Nibbana. Since memorizing and reciting the texts were, and still are, a method of instruction and teachings, an effective memory was essential. A wise meditator must remember the instructions and act on them with diligence or "Right Effort." These two aspects of mindfulness, remembering and monitoring the knowledge and application of the instruction, are essential in the direct application of the Buddha's teachings.

For meditators to practice mindfulness means that, while monitoring their thoughts, they become aware of an unwholesome mental state, the skillful application of a learned intervention to cease the defilement is applied, but if the unwholesomeness begins to continue to take hold, a stronger method is used to evict and replace it since unwholesome states rob us of our peace, wisdom and happiness. In fact, teachings need not only to be recalled but also monitored and given full awareness related to the application of the

teachings. This process creates an imprint or a new memory and later a habit in our mind. The more we do this the more a teaching becomes easier to remember and the new wholesome mental states are established.

So, we see that the Buddha's psychology recognized memory as an essential learning function. Also, science now confirms that memory is a powerful influence on our perception of the world and ourselves. Our memories are not 'objective' or unbiased but instead they are easily influenced by personal feelings, interpretations, or prejudice. As Damasio states, "*Our memories are prejudiced, in the full sense of the term, by our past history and beliefs. Perfectly faithful memory is a myth, applicable only to trivial objects. The notion that the brain ever holds anything like an isolated 'memory of the object' seems untenable. The brain holds a memory of what went on during an interaction, and the interaction importantly includes our own past,[...]*"[1] Our past, as memory, constantly influences us, persistently filters and guides our feelings and thoughts, and we often follow them seemingly blindly. When we worry, for example, the root conditions of the worrying lie in the past. Even our views are generated and perpetuated by these latent tendencies deeply stored in our unconscious. In the end, the original direct experience has been overlaid by ideation and the original datum is comprehended through dense layers of ideas and views, like the moon through a thick layer of clouds. The Buddha calls this process of mental elaboration papañca, or "conceptual proliferation." The foundations for this process of fabrication, are unconscious memories hidden from view; the latent tendencies. So even though we usually assume that we are always directly aware of the present, without bias or interpretation, this is an inaccurate belief. In ordinary consciousness our mind has an initial impression of the given moment, but it does not stay that way. Instead the immediate impression becomes a springboard for building mental constructs which obscure it from the original datum because, as we have seen, the cognitive process is interpretative. Then, immediately after grasping the initial impression, the sense datum is made intelligible. Its own categories and assumptions organize by joining concepts into constructs — sets of mutually corroborative concepts — then weaving the constructs together into complex interpretative schemas.

Nevertheless, memory is essential for our ability to survive. It is so important that without memory we would not be able to perform basic functions or to have abstract thought or create our own identities and

communicate with others. Memories are the foundation of our habits and schemas. In fact, much of what we presently are is what we have learned and thought. We have the advantageous ability for our survival to recall memories in order to imagine the future and to plan future courses of action. So how does memory work?

The Memory System

Memory is our ability to encode, store, retain and subsequently recall information and past experiences. Memory is not a single, simple function. It is a complex system of diverse components and processes throughout various areas of our brains. For the brain to process information, it must be stored. First, information is encoded. There are types of encoding specific to each type of sensory stimuli. The memory systems operate in parallel to support behavior. The various specific memory systems can be distinguished in terms of the different kinds of information they process and the principles by which they operate. Sherry and Schacter (1987) suggested that multiple memory systems have evolved because they serve distinct and functionally incompatible purposes. There are multiple types of memory, including sensory information storage (SIS), working or short-term memory (STM), and long-term memory (LTM).[2]

Once information is stored, it must be maintained. Each memory type differs with respect to function, the form of information held, the length of time of retained information, and the amount of information-handling capacity. There is not yet a universally accepted knowledge organization model, because each one has strengths and weaknesses. Some animal studies suggest that working memory, which stores information for roughly 20 seconds, is maintained by an electrical signal looping through a series of neurons for a short period of time. Information in long-term memory is hypothesized to be maintained in the structure of certain types of proteins. Researchers also believe in the existence of an interpretive mechanism and an overall memory monitor or control mechanism that guides the interaction among various elements of the memory system.

Once stored, memories eventually are often retrieved from storage. However, remembering past events is not like watching a recorded video. It is,

rather, a process of reconstructing what may have happened based on the details the brain chose to store and was able to recall. Recall is triggered by a retrieval cue, an environmental stimulus that prompts the brain to retrieve the memory. Evidence shows that the better the retrieval cue, the higher the chance of recalling the memory. It is important to note that the retrieval cue can also make a person reconstruct a memory improperly. Memory distortions can be produced in various ways, including varying the wording of a question. For example, merely asking or suggesting to someone whether a red car had left the scene of a hit-and-run can make the person recall having seen a red car during later questioning, even if there was never a red car.

Sensory Information Storage

As we have seen in an earlier chapter on perceptual processes, the stimuli detected by our senses either can be not attended to and remain undetected, or they are perceived and enter our sensory memory. This selection process is usually outside of conscious controls: the brain must filter information that is unconsciously judged by us as necessary or not. When information is perceived, it is automatically stored in sensory memory. However, sensory memory degrades very quickly and cannot be prolonged even via rehearsal. Sensory information storage (SIS) holds images for several tenths of a second after they are received by the sensory organs and before fading. This allows the brain to process a sensory event for longer than the extremely short duration of the contact. This explains why a movie shot at 16 separate frames per second appears as a continuous movement. So even though it lasts for a short time, sensory information storage is an essential first step for storing information in short-term memory.

Short-Term Memory

Most neuroscientists would agree that information passes from SIS into short-term memory (STM) via the process of attention (the cognitive process of selective concentration on one aspect of the environment of interest which ignores other things) where again it is held for only a short period of time-a few seconds or minutes, pending further processing. Whereas SIS holds the

complete image, STM stores only an abstraction of the image. This processing includes judgments about meaning, relevance, and significance, as well as the cognitive processing necessary to integrate information into long-term memory. If we immediately forget some information just received or given, this is because it was not transferred from short-term to long-term memory. Short-term memory acts for temporary recall of the information which is being processed at any point in time. Also, an important element of STM is the limitation of its capacity (typically around 7 items or even less) of keeping information in mind in an active, readily-available state for a short period of time (typically from 10 to 15 seconds, or sometimes up to a minute). What is actually held in short-term memory, though, is not complete concepts, but rather links or pointers (such as words) which the brain associates from other stored knowledges. So, when we choose where to focus our attention, we can concentrate on remembering or interpreting or taking notes on information received just a moment ago, or we can pay attention to immediately received information. Since the information has never left the conscious mind, retrieval of information from STM is direct and immediate; therefore, information can be maintained in STM by a process of over and over repetition called 'rehearsal'. But while rehearsing, we cannot simultaneously add new information so there are strict limitations on the amount of information retainable in STM at any one time.

Long-Term Memory

Some information retained in STM can become long-term memory through the process of consolidation. The information of past experiences is filed away in the mind for a long period of time and must be retrieved before it can be used. Long-term memory actually decays very little over time, and it can store a large amount of information almost indefinitely. While long-term memory mostly encodes information for storage based on meaning and association, it does encode to some extent by sound. While not completely understood, a physiological process called long-term potentiation establishes long-term memory. It involves a process of physical changes in the structure of neurons or nerve cells in the brain. When something is learned, circuits of brain neurons, known as neural networks, are created, altered or strengthened.

These neural circuits are composed of a number of neurons that communicate with one another through special junctions called synapses. The communicative strength of certain circuits of neurons is reinforced through recurrent use, involving the creation of new proteins within the body of neurons, and the electrochemical transfer of neurotransmitters across synapse gaps to receptors. The efficiency of these synapse connections then increases, facilitating the passage of nerve impulses along particular neural circuits, which may involve many connections to the visual cortex, the auditory cortex, the associative regions of the cortex, etc.. Forgetting occurs in long-term memory when the formerly strengthened synaptic connections among the neurons become weak, or when the activation of a new network is superimposed over an older one causing interference in the older memory.

Yet, a recent study now suggests that traces of a lost memory might remain in a cell's nucleus, perhaps enabling future recall or at least the easy formation of a new, related memory. In the new study, researchers at the University of California, Los Angeles, found results that are surprising because it suggests that a nerve cell body 'knows' how many synapses it is supposed to form, meaning it encodes a crucial part of memory. The researchers also ran an experiment in which they found that a long-term memory could be totally erased (as gauged by its synapses being destroyed) and then re-formed with only a small reminder stimulus—again suggesting that some information was being stored in a neuron's body.[3]

While these three memory processes (SIS, STM, LTM) comprise the storehouse of information or database that we call memory, the total memory system includes other features as well. To explain the operation of the total memory system, while little agreement exists on many critical points, most psychologists posit the existence of an interpretive mechanism that operates on the data base, a sort of monitor or central control mechanism that guides and oversees the operation of the whole system.

Organization of Information in Memory.

On average, human brain has about 100 billion neurons (or nerve cells) and many more neuroglia (or glial cells) which serve to support and protect the neurons. Each neuron may be connected to up to 10,000 other neurons, passing

signals to each other via 1,000 trillion synaptic connections. Computational neuroscientists estimate of the human brain's memory capacity vary from 10 terabytes to 2.5 petabytes (or a million gigabytes). A few months after birth, no new brain cells are formed, although existing ones may increase in size until the age of about eighteen years. They are designed to last a lifetime, so memory records a lifetime of experience and thought. The neurons are capable of storing information. Each neuron has long, feathery filaments attached to the cell body called the dendrite and a special, extra-long, branched cellular filament called the axon, as in Figure 1.

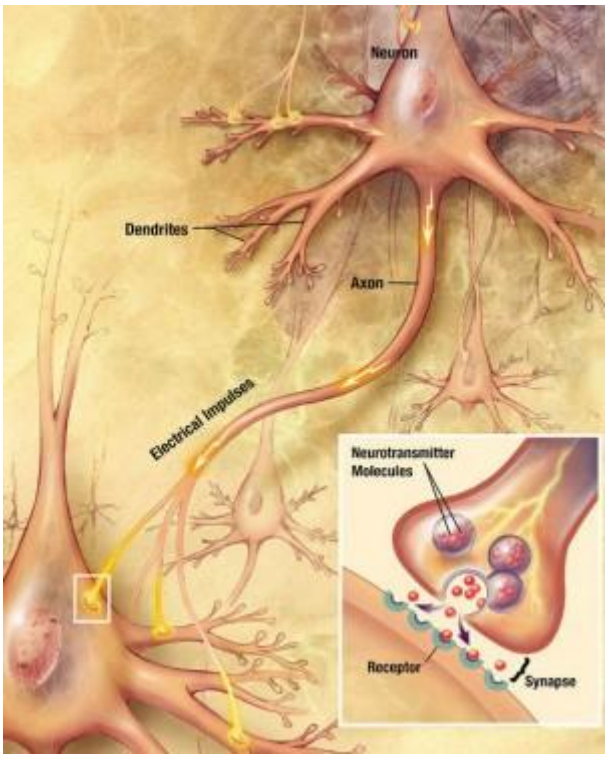

Figure 1 Synaptic transmission
Picture from Wikipedia
(http://en.wikipedia.org/wiki/Chemical_synapse)

Information transmission within the brain, which takes place during the processes of memory encoding and retrieval, is achieved using a combination of chemicals and electricity. It is a very complex process involving a variety of interrelated steps. A very brief review of that process shows that electrical

impulses flow through the dendrites and axons and are carried by neurotransmitters of various types across what is called the synaptic gap between neurons. Memories are stored as patterns of connections between neurons. When two neurons are activated, the connections or 'synapses' between them are strengthened. The whole process takes less than one five-hundredth of a second. A message within the brain is converted, as it moves from one neuron to another, from an electrical signal to a chemical signal and back again, in an ongoing chain of events which is the basis of all brain activity. For example, reading this page is physically changing your brain. George Johnson states, "*In a matter of seconds, new circuits are formed that can change forever the way you think about the world*."[4] This massive system must have an organizational structure, an indexing system; otherwise information that enters the system could never be retrieved.

Most current research focuses on which sections of the brain process various types of information (Broca's area of the brain is primarily involved in speech, and language processing as opposed to Wernicke's area, which is involved in language comprehension)but none of the current theories explains the full complexity of memory processes, which include memory for sights and sounds; for feelings; and for belief systems, that integrate information on a large number of concepts. However, to simply illustrate its interconnectedness and complexity, imagine memory as a massive, multidimensional spider web. It is possible to start at any one point in memory and follow a complex path to reach any other point on the web tracing through the network of interconnections to the place where the memory is stored. Retrievability is influenced by the number of locations in which information is stored and the number and strength of pathways from this information to other concepts that might be activated by incoming information. The more frequently a path is followed, the stronger that path becomes and the more readily available the information located along that path. Once people have started thinking about a problem one way, the same mental circuits or pathways get activated and strengthened each time they think about it. This facilitates the retrieval of information. These same pathways, however, also become the mental ruts that make it difficult to mentally reorganize the information so as to see it from a different perspective. If one has not thought about a subject for some time, it may be difficult to recall details. After consciously thinking our way back into the appropriate context and finding the general location in our memory, the

interconnections become more readily available. Hence, we begin to better remember what was apparently forgotten.

Factors That Influence What Is Remembered

Factors that influence how information is stored in memory and that affect future retrievability include: being the first-stored information on a given topic, the amount of attention focused on the information, the credibility of the information, and the importance attributed to the information at the moment of storage. By influencing the content of memory, all these factors also influence the outcome analysis. Bias describes how availability in memory influences judgments of probability. The more instances a person can recall of a phenomenon, the more probable that phenomenon seems to be. This is true even though ability to recall past examples is influenced by vividness of the information, how recently something occurred, its impact upon one's personal welfare, and many other factors unrelated to the actual probability of the phenomenon.

Memory Rarely Changes Retroactively

The records of memory act as structures in facilitating the repetition of mental processes by which they were formed. The formative process has a self-developing tendency to develop structures which facilitates its own development. If these memory systems did not facilitate their own development, there would be disorder. Hence, the record of the past tends to dominate the present. This process is a development of continuing adjustment. Receiving new information should, logically, cause these processes to automatically update the credibility or significance of previous information. Ideally, the earlier information should become more salient and readily available in memory. But it does not work that way. Instead, every perception is influenced by all that has gone before. Mental processes become habitual and automatic and memories are seldom reassessed or reorganized retroactively in response to new information. The difficult task of learning new schemata usually requires the unlearning of existing ones. In fact, it is always easier to learn a new habit than to unlearn an old one. Understanding how memory works provides insight into the nature of creativity, openness to new information, and breaking mind-sets. All involves spinning new links in the

spider web of memory-links among facts, concepts, and schemata that previously were not connected or only weakly connected.

Schemas

From a Cognitive psychology approach (understanding the internal processes of the mind), which has become highly influential in all areas of psychology, our responses to natural and social stimuli are mediated through an established cognitive framework or concept that helps organize and interpret information- referred to as schema. Schemas are necessary because through them we create shortcuts in interpreting the vast amount of information that is available in our environment. As a result, these cognitive frameworks cause us to focus mainly on things that collaborate our already existing biases and ideas. They contribute to maintaining stereotypes and any new information that does not conform to our established ideas about the world is often difficult to retain. Schemata give a sense of order and predictability to the world because they organize our current knowledge and provide a framework for understanding future inputs.

Schemas are stored in long-term memory and exercise a powerful influence on the formation of our perceptions from sensory data. A schema describes a pattern of relationships among the information stored in memory that are often compared to other links in the 'spider web' of memory that are connected so strongly that they can be retrieved and used more or less as a single unit. Any memory point may be connected to many highly complex different overlapping schemata. This concept of a schema emphasizes the important point that memory does have structure. A recent research carried on by the Gallant Lab has shown that mental categories are organized in the brain by following the principle of semantic similarity: objects and concepts which have something in common are physically stored closely within the brain circuits, as shown by Figure 2, where colors and shades of colors represent semantic areas (ex: green/yellow = living beings, pink/purple = non-living objects, etc.). On the right, a flattened map of the cerebral cortex shows where such category are represented in the brain circuits.[5]

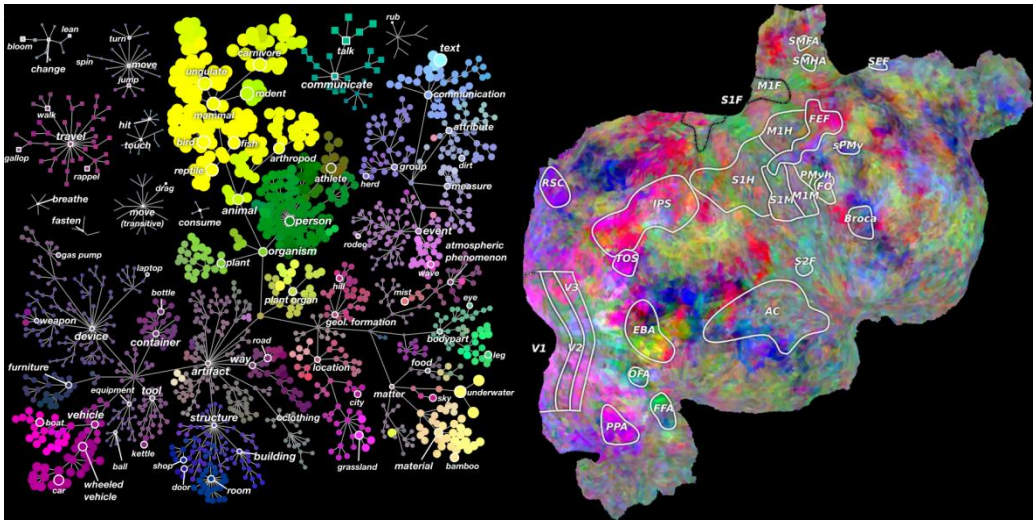

Figure 2: Representation of objects and actions across the cerebral cortex.

This also shows that the way knowledge is connected in memory is very important in determining what information is retrieved in response to any stimulus and how that information is used in reasoning. Schemas are the organizing framework that allow us to direct our attention to information that is consistent with an established schema, and to process information more quickly, and have greater recall for schema-consistent versus schema-irrelevant information. This ability to immediately perceive patterns enables us to more efficiently process many bits of information together as a coherent pattern. If information does not fit into what we know, or think we know, we have greater difficulty processing it. They help us to filter the information we get from our environment in order to make sense of it. "*A schema is a structure for screening, coding, and evaluating the stimuli that impinge on an organism.*"[6]; so schemas are a key factor because they determine "*what we notice, attend to, and remember of our experiences*."[7]. Even though concepts and schemata begin development in response to life events during childhood, long-term memories are neither fixed nor inflexible but are constantly being adjusted as our schemata evolve with experience.

There are several metaphors that commonly described how schemas shape how we view ourselves and the world. They are illustrated in the figure below: Schemas are like lenses; a metal crusher; a cut-out; magnet and a prism.

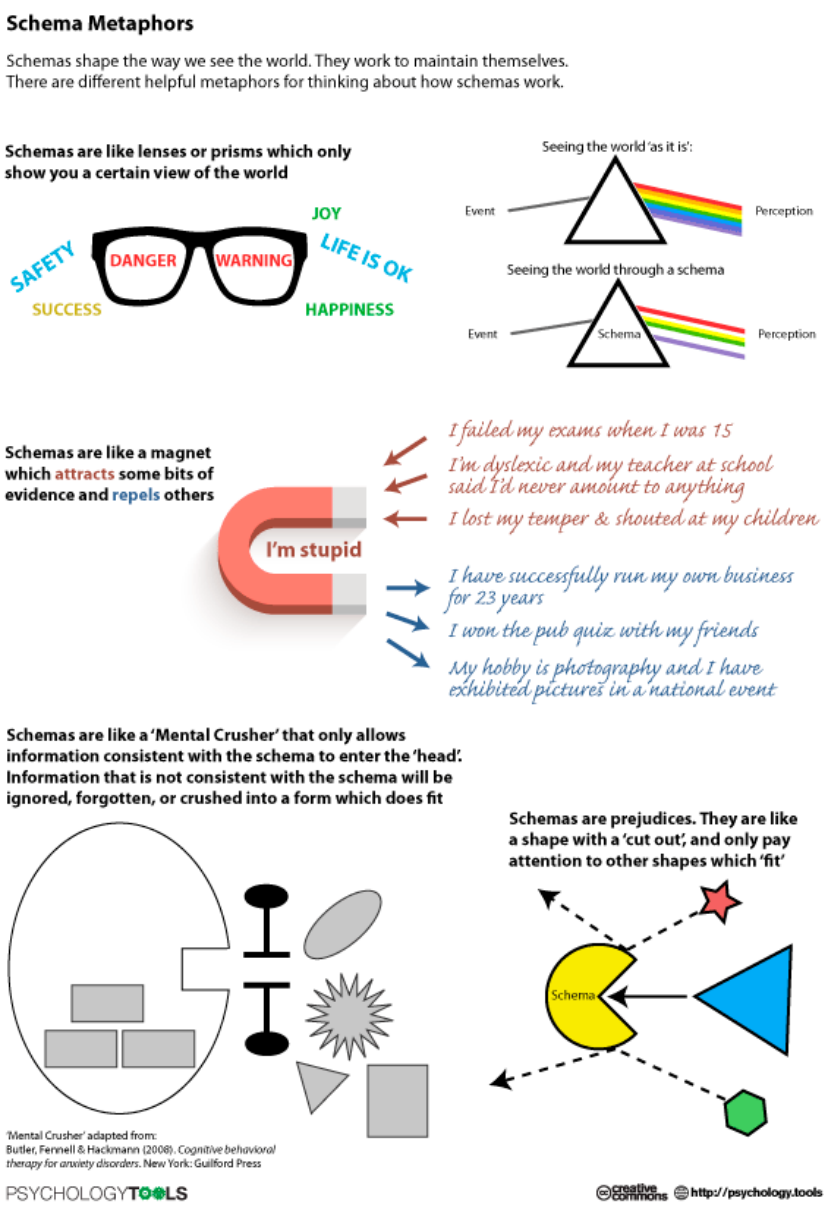

Figure 3 Graphic illustration of the way schemas work through the use of metaphors

In other words, schemas are the cognitive foundation of purposive thought and action. They are considered active structures that shape perceptions, memories, emotional and behavioral responses. Often, they are categorized three ways: 'self-schemas', 'other-schemas', and 'world-schemas' - these structures help a person to describe themselves, others and the world around them. Self-schemas processes, integrate and summarize an array of information and experience of the large amount of self-relevant stimuli often encountered. Through self-schemas, we construct stable knowledge structures

about our 'self'. In fact, the structure of different schemas that presently mould and inform our cognition have played an indispensable role, over the long term, in shaping human culture and behaviors and the 'worlds' humans have experienced and built. Throughout the history of the human experience, each generation's cognitive based worlds have been platformed on the schemata of previous countless generation's experiences and activities and these will continue. So here we see the application of volition, kamma and the fruits of kamma based on a broader societal and cultural level.

People not only have available in memory conceptions of who they were in the past and are in the present, but also visions of who they might be in the future. Less fully elaborated self-conceptions may fluctuate in their accessibility in response to the current social context. The self-concept refers to a person's total collection of cognitions about the self, including self-schemas, possible selves, and other less fully elaborated self-images. So we see that the Buddha's teachings and Cognitive psychology with its empirical background of analysis proposes a similar framework of understanding how the mental processes of humans work. And we see that it is like the Buddha's perceptual process comprising six stages.

From a cognitive perspective then, self is a fluid construct continually being re-constituted in interactions. The self-concept is the set of all an individual's beliefs about his or her personal qualities and visions of what the self is differs across cultures. In cultures emphasizing individuality, the individual characteristics are emphasized; in cultures emphasizing interdependence, the social roles are more important. In all cases, the self concept as a schema provides the structural foundation of the information processing sequence that serves as a guide in adaptation which directs the focus of attention and serves as the internal framework shaping interpretation and response to incoming stimuli. A person's construction of an imagined self-image is created mostly unconsciously and unintentionally, for example, we are usually not consciously aware that we often try to conform to the image that we imagine other people want from us. Finally, the construct of the working self-concept emphasizes the importance of the environmental, social, and cultural impact on a person's emotional and behavioral responses.

What is different from the Buddha's insight of no-self is that, according to psychology, the conviction of an inherent and substantial self is not a

quandry. In fact it is not engaged at all. Paradoxically, while significant psychological literature explains that the self is a cognitive construct like any other, the same literature goes on about protecting and promoting a healthy 'self'. The fact that we are taking a process, a fabrication and creating it into a substantial object in our minds is simply not addressed. Nevertheless, the belief that this organizing process is a real, permanent 'me' can diminish with insight and then the recognition becomes clearer that what is identified as 'self'is indeed only an abstraction built on the sense of agency.

The Buddha's Eightfold Path is a training or purification of the mind, involving a range of unconscious processes, by creating new schemata and then reinforcing those new mental codifications with habituation. The techniques he taught help us recognize and then transform our codified perceptual and cognitive biases and unwholesome and unskillful habits of mind. With the recent discovery of synaptic plasticity and how connections between neural systems are constantly being changed by experience, we now appreciate how bhavana or mental culture promotes learning. By changing our perspective of an object (physical or mental), we change our mental state. This might mean changing a negative view to a positive one. So, as we become more aware or mindful of our patterns of reactivity and then change a reaction, such learning, has physiological consequences and, with habituation, lasting change in the neural substrate does occur. We have seen in the Buddha's psychology that the mind is conditioned by the objects of attention. We attend which conditions our emotional response- we desire or don't desire it – then we identify with it or reject it. While objects which are physical are more common place, abstract things like ideas or concepts can be powerful in conditioning our mental states. With intensive training, humans can become free agents, able to choose their own destiny and to become aware of and act according to a moral and ethical framework. The Buddha gives us a clear insight into the possible development of uplifting potentialities of inherent in our nature.

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