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Scientific Research Validates Auditory (Binaural Beats) Benefits

Science ushered in a new era in our ability to learn, be creative, remember, control our moods, reduce stress, resolve unwanted behavior patterns, and a host of other desirable ends, with the appearance of a remarkable paper by Dr. Gerald Oster, of Mt. Sinai Medical Center, in the October 1973 issue of *Scientific American*.

Oster's paper, entitled "Auditory Beats in the Brain," described how pulsations called binaural beats occurred in the brain when tones of different frequencies were presented separately to each ear. As a result, the entire brain became entrained to a frequency equal to the difference between the two tones and began to resonate to that frequency. In other words, Oster discovered a method for what is called *entrainment* of brain wave patterns. (1)

Simultaneously, Robert Monroe, of the Monroe Institute of Applied Sciences, was also investigating binaural beats. In thousands of experiments, using an EEG machine to monitor subjects' electrical brain wave patterns, Monroe also concluded that he could entrain brain wave patterns using binaural beats. In addition, he noted that the response did not happen only in the area of the brain responsible for hearing, or only in one hemisphere or the other, but rather, the entire brain resonated. The waveforms of both hemispheres exhibited identical frequencies, amplitude, phase, and coherence.

Since then, many researchers have verified this phenomenon. Language and speech pathologist Dr. Suzanne Evans Morris, Ph.D., reports

Research supports the theory that different frequencies presented to each ear through stereo headphones... create a difference tone (or binaural beat) as the brain puts together the two tones it actually hears. Through EEG monitoring the difference tone is identified by a change in the electrical pattern produced by the brain. For example, frequencies of 200 Hz and 210 Hz produce a binaural beat frequency of 10 Hz. Monitoring of the brain's electricity (EEG) shows that the brain produces increased 10 Hz activity with equal frequency and amplitude of the wave form in both hemispheres. (2)

Research by Dr. Lester Fehmi, director of the Princeton Behavioral Medicine and Biofeedback Clinic, and perhaps the foremost authority on hemispheric synchronization in the brain, also confirms that hemispheric synchronization and brain entrainment can be induced by binaural beats. (3)

Dr. Arthur Hastings, Ph.D., in a paper entitled "Tests of the Sleep Induction Technique" describes the effects of subjects listening to a cassette tape specially engineered to create binaural beats in the brain. In this case, the sounds on the tape were designed to slow the brain wave patterns from a normal waking *beta* brain wave pattern to a slower *alpha* pattern, then to a still slower *theta* pattern (the brain wave pattern of dreaming sleep), and finally to a *delta* pattern, the slowest of all, the brainwave pattern of dreamless sleep. Hastings says:

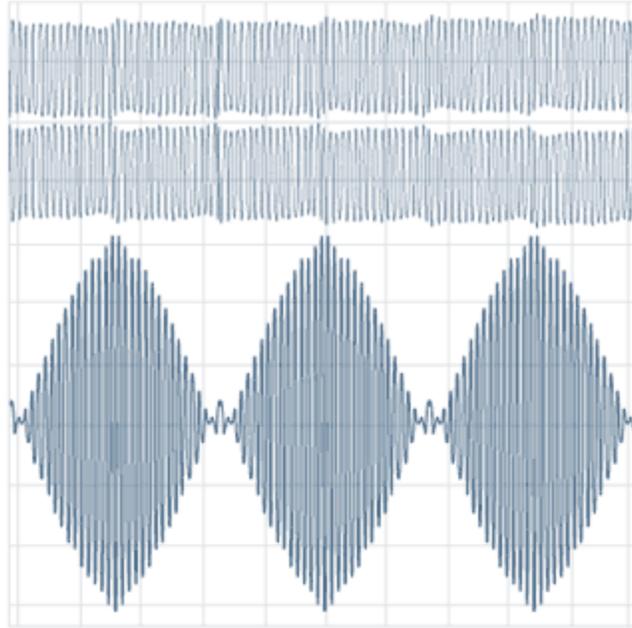
We were able to test the effects of the sleep tape on brain waves with an EEG machine through the courtesy of the researchers at the Langely-Porter Neuropsychiatric Institute, part of the University of California Medical School in San Francisco. Dr. Joe Kaniya, Director of the Psychophysiology of Consciousness Laboratory, monitored the brain-wave frequencies of one subject as he listened to the sleep tape.

The chart recording showed a typical sleep onset pattern: initial alpha waves, then a slowing of the brain waves with sleep spindles, and finally a pattern of stage 2 and 3 sleep brain waves in the low theta range . . . the patterns in the various stages suggested that the tape was influencing the subject's state. (4)

Dr. Bill D. Schul also refers to the phenomenon of brain entrainment:

[P]hased sine waves at discernible sound frequencies, when blended to create 'beat' frequencies within the ranges of electrical brain waves found at the various stages of human sleep, will create a frequency following response (FFR) within the EEG pattern of the individual listening to such audio waveforms. The FFR in turn evokes physiological and mental states in direct relationship to the original stimulus. With the availability of this tool, it becomes possible to develop and hold the subject into any of the various stages of sleep, from light Alpha relaxation through Theta into Delta and in REM (dreaming). (5)

Schul concluded that "Binaural beat-frequency stimulation creates a sustaining FFR that is synchronous in both amplitude and frequency between the brain hemispheres." (5)



Sine waves combine to produce beats in this illustration based on oscilloscope traces. The two waves at the top are of slightly different frequency; when they are combined, the resulting wave at the bottom varies slowly in amplitude. The variations are beats and would be perceived acoustically as modulations in loudness. If the two signals were presented separately to each ear, binaural beats would be heard. These differ in character from monaural, or ordinary, beats and are generated within the brain.

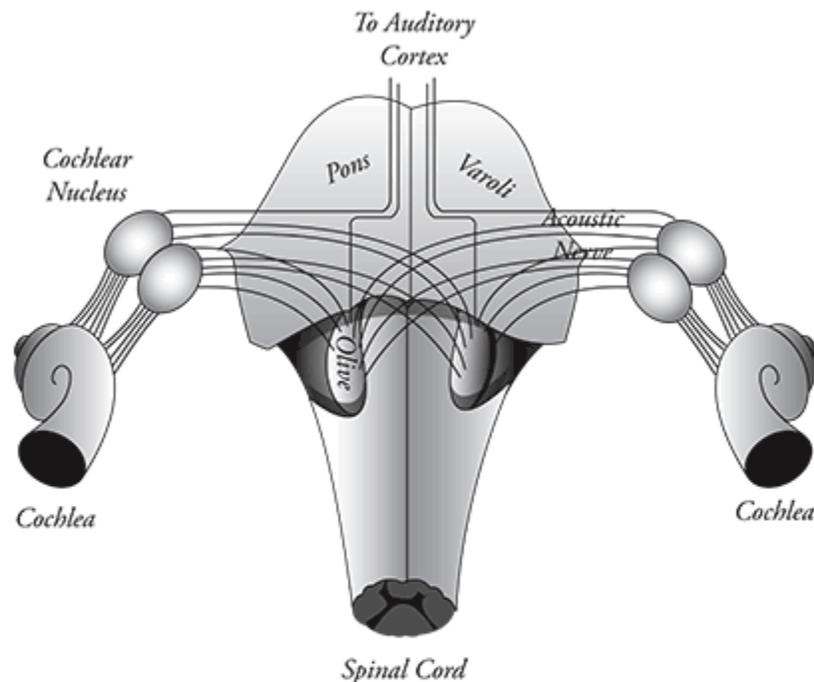
"Auditory Beats in the Brain" by Gerald Oster. Scientific American, Oct. 1973, (used with permission).

F. Holmes Atwater of the Monroe Institute describes the neurophysics of the binaural beat brain entrainment process:

Within the sound processing centers of the brain, pulse stimulation provides relevant information to the higher centers of the brain. In the case of a wave form phase difference the electron pulse rate in one part of a sound-processing center is greater than in another. The differences in electron pulse stimulation within the sound processing centers of the brain are an anomaly. This anomaly (the difference in electron pulse stimulation) comes and goes as the two different frequency wave forms mesh in and out of phase. As a result of these constantly increasing and decreasing differences in electron pulse stimulation, an amplitude modulated standing wave (the binaural beat) is generated within the sound processing centers of the brain itself. It is this standing wave which acts to entrain brain

waves. (6)

Atwater further states, "A conventional binaural beat generates two amplitude modulated standing waves, one in each hemisphere's olivary nucleus. Such binaural beats will entrain both hemispheres to the same frequency, establishing equivalent electromagnetic environments and maximizing interhemispheric neural communication" (6).



Lower Auditory Centers of the brain are in the medulla oblongata, viewed here schematically from the back of the neck. Nerve impulses from the right and left ears first meet in the left or right superior olivary nucleus. These structures are part of the olive, an organ that in this view lies behind the brain stem. It is probable that binaural beats are detected here.

"Auditory Beats in the Brain" by Gerald Oster. Scientific American, Oct. 1973, (used with permission).

Not Just a Pretty Picture

The ability to entrain brain wave patterns opens up an exciting world of mind-boggling possibilities. Researchers in neuroscience could not contain their excitement.

"It's difficult to try to responsibly convey some sense of excitement about what's going on," said UCLA neurophysiologist John Kiebeskind. "You find yourself sounding like people you don't respect. You try to be more conservative and not say such wild and

intriguing things, but damn! The field is wild and intriguing. It's hard to avoid talking that way...We are at a frontier, and it's a terribly exciting time to be in this line of work" (7).

Neurochemist Candace Pert, of the National Institute of Mental Health, had this to say:

There's a revolution going on. There used to be two systems of knowledge: hard science—chemistry, physics, biophysics—on the one hand, and, on the other, a system of knowledge that included ethology, psychology, and psychiatry. And now it's as if a lightning bolt had connected the two. It's all one system neuroscience...The present era in neuroscience is comparable to the time when Louis Pasteur first found out that germs cause disease. (8)

David Krech, Ph.D., a University of California at Berkeley psychologist, predicted almost twenty-five years ago: "I foresee the day when we shall have the means, and therefore, inevitably, the temptation, to manipulate the behavior and intellectual functioning of all people through environmental and biochemical manipulation of the brain." (9)

That day may very well be here now, and the gentle altering of brain wave patterns using sound may be the easiest, most potent, and safest way to do it. Centerpointe Research Institute currently uses a sound technology called Holosync to entrain brain wave patterns, giving us the ability to influence or create tranquility, pain control, creativity, euphoria, excitement, focused attention, relief from stress, enhanced learning ability, enhanced problem-solving ability, increased memory, accelerated healing, behavior modification, and improvements in mental and emotional health.

Michael Hutchison, in his book *Megabrain Power*, sums up this revolution in neuroscience: "...[N]ew breakthroughs in neuroscience and microelectronics have permitted scientists to 'map' the electrical and chemical activity of the brain in action. Scientists have used the new technology to monitor the brains of those meditators, artists, and other rare individuals who are able to enter peak domains at will and to map their brain activity during those peak states." (10)

According to Hutchison, these scientists' first findings were that those peak states are not mysterious and unpredictable phenomena, but are clearly linked to specific patterns of brain activity. These patterns include dramatic changes in brain wave activity, hemispheric symmetry, and rapid alterations in the levels of various neurochemicals. If we could learn to produce these patterns of brain activity, they reasoned, we should be able to produce the peak states they are associated with. "...They found that by using types of mechanical stimulation, such as...precise combinations of pulsating sound waves...they could actually produce those same 'peak state' brain patterns in ordinary people..." (10)

The Well-Balanced Brain

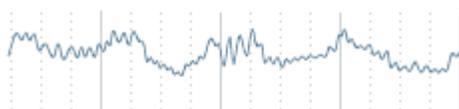
Just as we exercise our bodies to feel better and improve our physical health, stimulating the brain in this manner "exercises" the brain, bringing better mental and emotional health and increased intellectual functioning. Researcher Robert Cosgrove, Jr., Ph.D., M.D., and an authority in pharmaceuticals and biomedical engineering, noted that technologies that alter brainwave patterns

... with appropriately selected stimulation protocols [have] been observed by us to be an excellent neuro-pathway exerciser. As such we believe it has great potential for use in promoting optimal cerebral performance... Furthermore, the long-term effects of regular use... on maintaining and improving cerebral performance throughout life and possibly delaying for decades the deterioration of the brain traditionally associated with aging is very exciting. (11)

There are four categories of brain wave patterns. The most rapid brain wave pattern is that of beta, from about 14 Hz to more than 100 Hz. This is the pattern of normal waking consciousness, and it is associated with concentration, arousal, alertness, and cognition, while at higher levels, beta is associated with anxiety. As we become more relaxed, the brain wave activity slows into the alpha range, from 8 to 13.9 Hz. These are the brain wave patterns of deep relaxation, and of what has been called the *twilight state* between sleep and waking, while the higher end of alpha represents a more relaxed yet focused state.

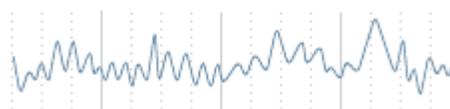
Slower still are theta waves, between 4 and 7.9 Hz. This is the state of dreaming sleep and also of increased creativity, super-learning, integrative experiences, and increased memory. The slowest brain wave pattern is delta, that of dreamless sleep, below 4 Hz. Generally people are asleep in delta, but there is evidence that it is possible to remain alert in this state—a very deep trance-like, non-physical state. It is in delta that our brains are triggered to release large quantities of healing growth hormone (12).

Four Categories of Brain Wave Patterns



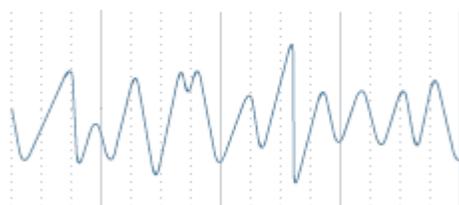
Beta (14-30 Hz)

Concentration, arousal, alertness, cognition
Higher levels associated with anxiety, disease, feelings of separation, fight or flight



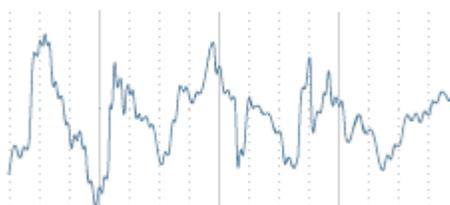
Alpha (8-13.9 Hz)

Relaxation, superlearning, relaxed focus, light trance, increased serotonin production
Pre-sleep, pre-waking drowsiness, meditation, beginning of access to unconscious mind



Theta (4-7.9 Hz)

Dreaming sleep (REM sleep)
Increased production of catecholamines (vital for learning and memory), increased creativity
Integrative, emotional experiences, potential change in behavior, increased retention of learned material
Hypnagogic imagery, trance, deep meditation, access to unconscious mind



Delta (.1-3.9 Hz)

Dreamless sleep
Human growth hormone released
Deep, trance-like, non-physical state, loss of body awareness
Access to unconscious and "collective unconscious" mind, greatest "push" to brain when induced with Holosync®

As we slow the brain wave patterns from beta to alpha to theta to delta, there is a corresponding increase in balance between the two hemispheres of the brain. This more balanced brain state is called brain synchrony, or brain synchronization. This balancing phenomenon was noted in early EEG studies of experienced meditators in the 1970s. In deep meditative states, their brain waves shifted from the usual asymmetrical patterns, with one hemisphere dominant over the other, to a balanced state of whole-brain integration, with the same brain wave frequency throughout. As we will see, various mental abilities and experiences are induced naturally in these different brain wave patterns, and many of these abilities and experiences are quite remarkable.

Robert Monroe of the Monroe Institute reported that inducing brain wave patterns through the creation of binaural beats in the brain caused a wide range of effects, including "focusing of attention, suggestibility, problem solving, creativity, memory, and learning... sleep induction, pain control... and enhanced learning..." (13).

Other scientists have noted that these slower brain wave patterns are accompanied by deep tranquility, flashes of creative insight, euphoria, intensely focused attention, and enhanced learning abilities. Dr. Lester Fehmi, director of the Princeton Biofeedback

Research Institute, has said that hemispheric synchronization represents "the maximum efficiency of information transport through the whole brain" and "[it] is correlated experientially with a union with experience, and 'into-it-ness.' Instead of feeling separate and narrow-focused, you tend to feel more into it—that is, unified with the experience, you are the experience—and the scope of your awareness is widened a great deal, so that you're including many more experiences at the same time. There's a whole-brain sensory integration going on, and it's as if you become less self-conscious and you function more intuitively." (14)

Super-Learning

One of the observed effects of this type of sound-induced brain synchronization is increased learning ability. What is now known as superlearning began in the late 1960s and early 1970s with the work of Bulgarian psychiatrist Georgi Lozanov. Lozanov used deep relaxation combined with synchronized rhythms in the brain to cause students to produce alpha waves. He found that students when in this state learned over five times as much information with less study time per day, with greater long-term retention. In some cases, as much as thirty times as much was learned.

Speech-Language pathologist Suzanne Evans Morris, Ph.D., describes the relationship between different brainwave patterns and learning, as well as other related states such as concentration, problem solving, receptivity, and creativity.

Receptivity for learning is related to specific states of consciousness. Predominant brainwave patterns are associated with different states of consciousness or awareness. For example, beta frequencies ranging from 13–26 Hz are associated with concentration, and alert problem solving; alpha frequencies (8–13 Hz) occur when the eyes are closed and a state of alert relaxation is present; theta (4–7 Hz) is associated with deep relaxation with a high receptivity for new experiences and learning... (15)

Morris also describes how audio soundtracks containing binaural beat signals can be used to "create the ability to sustain this theta period of openness for learning." (15)

Morris goes on to say that "[t]he introduction of theta signals... into the learning environment theoretically allows for a broader and deeper processing of the information provided by the teacher... [and] increases... focus of attention and creates a mental set of open receptivity." She notes that in the use of such binaural beat signals in a classroom setting, children exhibited "improved focus of attention" and "a greater openness and enthusiasm for learning." (15)

Morris further describes what happens in the brain that makes this type of accelerated learning so effective:

The presence of theta patterns (4–7 Hz) in the brain has been associated with states of increased receptivity for learning and reduced filtering of information by the left hemisphere. This state of awareness is available for relatively brief periods as the individual enters a state of reverie or passes in and out of the deep sleep phase of the 90 minute sleep cycle. [Binaural beat] signals, however, can facilitate a prolonged state of theta to produce a relaxed receptivity for learning . . . [These signals] create a state of coherence in the brain. Right and left hemispheres as well as subcortical areas become activated in harmony, reflected by equal frequency and amplitude of EEG patterns from both hemispheres. This creates an internal physiological environment for learning which involves the whole brain. The linear, sequential style of problem solving preferred by the left hemisphere is brought into balance with the global, intuitive style of the right hemisphere and limbic system (subcortex). This allows the learner to have greater access to internal and external knowledge and provides a milieu for expanding intuition in problem solving. One of the by-products of hemispheric synchronization appears to be a highly focused state of attending. The ability to reduce ‘mind chatter’ and focus the attention is critical for efficient learning (16).

Binaural beat signals have been used in the classroom to enhance learning ability. Teachers in the Tacoma, Washington, public schools, under the direction of psychologist Devon Edrington, used audio tapes containing a binaural beat sound technology to influence the learning ability of students. They found that students who were taught, studied, and took tests while these tapes were playing did significantly better than a control group not using the tapes. (17)

The theta state also seems to be one where behavior and belief system changes can more easily be made. Suzanne Evans Morris discusses the work of neurotechnology and biofeedback researcher Thomas Budzynski, (1981) in which he described the theta state as

...a transition zone between wakefulness and sleep in which one can absorb new information in an uncritical, non-analytical fashion. [Budzynski] speculated that this allows new information to be considered by the right hemisphere through bypassing the

critical filters of the left hemisphere. Thus, information leading to a change in self-concept would become more available; modification of habitual behaviors or consideration of one's belief system could occur more easily if alternatives were presented during a period of theta activity. (18)

Medical researcher Dr. Gene W. Brockopp also believes behavior modification is enhanced when the subject can be placed in slower, more receptive brain wave patterns. He speculates that using technology to induce brain wave changes can

...actively induce a state of deactivation in which the brain is passive, but not asleep; awake, but not involved with the 'clutter' of an ongoing existence. If this is true, then it may be a state in which new cognitive strategies could be designed and developed... [i]f we can help a person to experience different brain-wave states consciously through driving them with external stimulation, we may facilitate the individual's ability to allow more variations in their functioning through breaking up patterns at the neural level. This may help them develop the ability to shift gears or 'shuttle' and move them away from habit patterns of behavior to become more flexible and creative, and to develop elegant strategies of functioning (19).

Many other researchers have described the benefits of alpha and theta brain wave states. Budzynski has done extensive research on learning and suggestion when the brain is in a theta state. Theta, Budzynski suggested, is the state in which superlearning takes place—when in theta, people are able to learn new languages, accept suggestions for changes in behavior and attitudes, or memorize large amounts of information. He says, "We take advantage of the fact that the hypnagogic [theta] state, the twilight state... has these properties of uncritical acceptance of verbal material, or almost any material it can process." In this state, Budzynski says, "a lot of work gets done very quickly." (20, 21)

Budzynski and psychobiologist Dr. James McGaugh of the University of California at Irvine have both found that information is also more easily processed and recalled in a theta state. Noted researchers Elmer and Alyce Green, of the Menninger Foundation, have also studied this phenomenon, finding that memories experienced in a theta state "were not like going through a memory in one's mind but rather like an experience, a reliving." Individuals producing theta waves also had "new and valid ideas or synthesis of ideas, not primarily by deduction but springing by intuition from unconscious sources."

In their seminal book, *Beyond Biofeedback*, the Greens further discussed many remarkable effects of the theta brain wave state. They found that those producing theta

waves became highly creative. They had life-altering insights, what the Greens called "integrative experiences leading to feelings of psychological well-being." On psychological tests, subjects scored as being "psychologically healthier, had more social poise, were less rigid and conforming, and were more self-accepting and creative." Another remarkable effect was that these subjects became very healthy. Emotionally, these people had "improved relationships with other people as well as greater tolerance, understanding, and love of oneself and of one's world" (22).

Alpha and theta states have also been shown to facilitate addiction recovery. Dr. Eugene Peniston and Dr. Paul Kulkosky, of the University of Southern Colorado, trained a group of alcoholics to enter the alpha and theta states. These alcoholics showed a recovery rate many orders of magnitude greater than a control group. Thirteen months later, this alpha-theta group showed "sustained prevention of relapse," and these findings were confirmed in follow-up study three years later. In addition, this group showed a marked personality transformation, including significant increases in qualities such as warmth, stability, conscientiousness, boldness, imaginativeness, and self-control, along with decreases in depression and anxiety. (23)

At the brain wave pattern at the juncture between the alpha and theta rhythms, often called the *crossover point* by neuroscientists, subjects have experienced some remarkable changes. Houston therapist William Beckwith has reported that in his clients the experience of this crossover point is often accompanied by "the seemingly miraculous resolutions of complex psychological problems." (24)

Other studies have suggested that states of brain synchronization increase memory. McGaugh's research on memory and theta waves showed that "the more theta waves appeared in an animal's EEG after a training session, the more it remembered. This was true in all cases... Apparently, the best predictor of memory was the amount of theta waves recorded in the animal's brain. [Theta waves] show that the brain is in the right state to process and store information." (25)

Scientists have discovered that for memories to form, the brain must undergo a process called long-term potentiation (LTP), involving electrical and chemical changes in the neurons associated with memory. Without LTP, incoming information is not stored, but rather quickly and totally forgotten. Neurophysiologist Dr. Gary Lynch and associates at the University of California at Irvine discovered that the key to LTP is the theta brain wave pattern. "We have found the magic rhythm that makes LTP. There's a magic rhythm, the theta rhythm." According to Lynch, this is the natural rhythm of the hippocampus, the part of the brain essential for the formation and storage of new memories and the recall of old memories (26).

Other studies have confirmed the incredible benefits of the theta state. In experiments conducted at the Monroe Institute of Applied Science, subjects who produced theta waves (as measured on an EEG) in response to binaural beats "invariably emerged from the experience reporting all the mental phenomena associated with the theta state, such as

vivid hypnagogic imagery, creative thoughts, integrative experiences, and spontaneous memories" (27).

How do these amazing mental and emotional changes take place? Many researchers believe that different brain wave patterns are linked to the production in the brain of various neurochemicals associated with relaxation and stress release, increased learning and creativity, memory, and other desirable benefits. These neurochemicals include beta-endorphins, acetylcholine, vasopressin, and serotonin.

Dr. Margaret Patterson, in collaboration with biochemist Dr. Ifor Capel, at the Marie Curie Cancer Memorial Foundation Research Department, in Surrey, England, has shown that certain frequencies in the brain dramatically speed up production of a variety of neurotransmitters, different frequencies different brain chemicals. For instance, a 10 Hz (alpha) brain wave pattern boosts the production and turnover rate of serotonin, a chemical messenger that increases relaxation and eases pain, while catecholamines, vital for memory and learning, respond at around 4 Hz (theta).

According to Capel, "...as far as we can tell, each brain center generates impulses at a specific frequency based on the predominant neurotransmitter it secretes. In other words, the brain's internal communication system—its language, if you like—is based on frequency... Presumably, when we send in waves of electrical energy at, say, 10 Hz, certain cells in the lower brain stem will respond because they normally fire within that frequency range." (28)

Dr. William Bauer, one of the foremost experts in the field of electromedicine, elaborates:

What I think is happening... is that by sending out the proper frequency, proper waveform and proper current... we tend to change the configuration of the cell membrane. Cells that are at sub-optimal levels are stimulated to 'turn on' and produce what they're supposed to produce, probably through DNA, which is stimulated through the cell membrane... You're charging the cells through a biochemical process that can possibly balance the acetylcholine or whatever neurotransmitter needs to be turned on . . . (29)

The increased production of these different neurochemicals can greatly enhance memory and learning. A research team at the Veterans Administration Hospital in Palo Alto found that a group of normal human subjects, when given substances that increased acetylcholine production in the brain, showed great improvement in long-term memory, while at MIT, students taking acetylcholine enhancers experienced improved memory and increased ability to learn lists of words. (30) Researcher Lester A. Henry noted that acetylcholine "is essential to such higher mental processes as learning and memory." (31)

Recent studies show that insufficient acetylcholine causes memory loss and reduces learning and intelligence. Lack of acetylcholine been linked in part to confusion and memory loss in patients Alzheimer's disease (32, 33). Other studies have shown that when individuals are given substances that increase the amount of acetylcholine, they show significant increases in scores on memory and intelligence tests (34, 35).

Acetylcholine has also been associated with a greater number of neurons in the cortex and also with greater brain size, with humans having the highest density of acetylcholine in the brain. UC Berkeley researcher Mark Rosenzweig has shown a direct connection between acetylcholine and intelligence. (36)

Other neurochemicals that are produced in the brain in response to binaural beats have been associated with increased memory, learning, and other benefits. Men in their fifties taking vasopressin, a neurochemical closely related to the endorphins, showed significant improvement in memory, leaning, and reaction time. In another study, sixteen normal, healthy subjects of average intelligence were given vasopressin several times, after which they showed dramatic improvement in their ability to learn and remember. (37) Dutch scientists further found that vasopressin had a long-term "cementing effect on consolidation of information." (38)

At the National Institute of Mental Health (NIMH), research has indicated that vasopressin boosts memory, enabling subjects to "chunk" and encode information better. (Chunking refers to the ability to group large amounts of information together into more easily remembered bits). NIMH found that decreasing vasopressin is associated with memory deficits. Vasopressin is also associated with and enhances production of theta waves that are associated with increased access to memories and increased creativity. Vasopressin also stimulates the release of endorphins and has restored memory in amnesia victims (39, 40).

The Endorphin Connection

Scientists have also found that the endorphins released when the brain is exposed to alpha and theta binaural beat patterns enhance many mental functions. Endorphins have a powerful strengthening effect on learning and memory, for instance, and have been known to reverse amnesia. Researcher David de Weid found that rats injected with endorphins remembered things longer. Dr. Andrew Schally, 1977 winner of the Nobel Prize for medicine, found that rats receiving injections of endorphins showed improved maze-running abilities. (41)

Why do endorphins increase learning and memory? Neuroscientists believe that in humans the places in the brain that produce the most endorphins, and contain the greatest concentration of endorphin receptors, are the same areas of the brain involved most intimately with learning and memory. Dr. Aryeh Routtenberg, of Northwestern University, located these pleasure centers in the brain and noted

[T]he evidence clearly shows that the brain reward pathways play an important role in learning and memory . . . I have speculated that the pathways of brain reward may function as the pathways of memory consolidation. By this I mean that when something is learned, activity in the brain reward pathways facilitates formation of memory... Evidence for the reward effects of localized electrical stimulation... and for the association of reward paths with memory formation indicates that the neural substrates of self-stimulation play a vital role in the guidance of behavior. (42)

Scientists now know of at least seven chemicals in the endorphin family that have effects on memory and learning. Endorphins, according to neuroscientists, "serve as the body's 'natural reward system,' providing us with a rush of pleasure whenever we learn something or act in some way that is conducive to our survival as a species." (43) This means that new belief systems designed to effect desirable behavior changes, if presented to the mind when it is flooded with endorphins, may be perceived as beneficial and adopted as such—a powerful boost to any behavior modification protocol.

Dr. Candice Pert of NIMH, the discoverer of the opiate receptor, has also described this process, noting that "the endorphins, our natural opiates, are a filtering mechanism in the brain. The opiate system selectively filters incoming information from every sense—sight, hearing, smell, taste, and touch—and blocks some of it from percolating up to higher levels of consciousness." (44)

Scientists now believe that the moment when learning takes place—the "aha" moment—is that moment when a particular reality has been selected and filtered by our endorphins and is suddenly apprehended by our brain in such a way that we learn something new. This learning being rewarded by a flood of endorphins along our pleasure-learning pathways. (45)

The production in the brain of alpha and theta patterns is also correlated with the *relaxation response* —the mirror image of the more well known fight or flight response. The fight or flight response takes blood flow away from the brain and toward the periphery of the body, floods the bloodstream with sugar, and increases heart rate, blood pressure, and respiration rate in order to prepare one for defense or flight. In this state, learning ability, as well as other mental functions including problem solving and reasoning ability, are inhibited.

The relaxation response, on the other hand, mobilizes us for inward activity by reducing heart rate and blood pressure, relaxing muscles, and increasing the percentage of oxygen flowing to the brain. As one might expect, the fight or flight response is accompanied by low-amplitude, high-frequency beta brain wave patterns, while the relaxation response, so beneficial to learning and problem solving, is accompanied by high amplitude, low

frequency alpha and theta rhythms. (46, 47) When we use sound technologies to induce these slower brain wave patterns, we also induce the relaxation response, another possible reason for the increases in learning ability noted by so many researchers.

The Effect on Hormones

A recent study performed by Dr. Vincent Giampapa, M.D., former president of the American Board of Anti-Aging Medicine, revealed that placing a listener in the alpha, theta, and delta brain wave patterns using Holosync audio technology dramatically affects production of three important hormones related to both increased longevity and well-being: cortisol, DHEA, and melatonin.

Cortisol is a hormone produced by the adrenal glands. According to Dr. Giampapa, cortisol is the major age-accelerating hormone within the brain. It also interferes with learning and memory and has, in general, negative effects on health and well being.

DHEA is also produced by the adrenal glands. It is a precursor, or source ingredient, to virtually every hormone the body needs. DHEA levels are a key determinant of physiological age and resistance to disease. When DHEA levels are low, we are more susceptible to aging and disease; when they are high, the body is at its peak—vibrant, healthy, and able to effectively combat disease. DHEA acts as a buffer against stress-related hormones (such as cortisol), which is why as you get older and make less DHEA you are more susceptible to stress and disease.

A study published in the *New England Journal of Medicine* (December 11, 1986) found that a 100 microgram per deciliter increase in DHEA blood levels corresponded with a 48% reduction in mortality due to cardiovascular disease—and a 36% reduction in mortality for any reason.

Melatonin is a hormone associated with the creation of restful sleep. We make less of it as we age, and since during sleep many important rejuvenating substances are created in the brain, the inability to sleep soundly can dramatically decrease the quality of your life and greatly accelerate aging.

Dr. Giampapa found the following changes in levels of melatonin, DHEA, and cortisol in 19 users of Holosync audio technology listening four hours a day over a three-day period:

- Over 68% had increases in DHEA levels, with an average increase of 43.77%. Several participants had increases of 50, 60, even 90%.
- Cortisol was down an average of 46.47%, with positive changes in 68% of the people, and with several participants having decreases of 70 or 80%.
- Melatonin levels increased an average of 97.77%, with positive changes happening in over 73% of the participants. Many had improvements of 100, 200, even 300%.

Pushing the Brain to Change

In addition to the effects described above, there is an even more remarkable generalized effect when brainwave patterns are slowed into the alpha, theta, and delta ranges. Slowing of brain wave patterns increases electrical fluctuations in the brain, changing the neural structure and pushing the brain to reorganize itself at higher, more complex levels of functioning. This reorganization process is predicted by the work of scientist Ilya Prigogine, 1977 Nobel Prize-winner in chemistry.

Prigogine's work has been applied to all changes in all kinds of open systems—everything from a seed germinating, to a corporation expanding, a highway system growing, a cell dividing, or a human being experiencing behavioral or emotional changes.

The human brain is the ultimate open system, constantly exchanging energy with its environment. Up to a point, the system can handle all kinds of fluctuations. But if the input becomes too much, the system is pushed past its limits and the system reorganizes itself at a higher order. A runner, for instance, gives more physical input to his body than it can handle, and it responds by reorganizing itself at a higher level that can handle this increased input—which we call "getting in shape."

Using binaural beat technology to change brain wave patterns causes a similar effect in the brain. The alpha, theta, and delta brain wave patterns are states of great fluctuation in the brain. A graphic representation of these brain wave patterns shows that the amplitude (the height of the waveform) increases as we move from alpha to theta to delta. In other words, the amount of fluctuation increases. These increased fluctuations are more than the nervous system can handle with its current structure, and the brain responds by reorganizing itself at a higher, more complex level of functioning. It does this by creating new neural pathways within itself, creating increased communication between parts of the brain that previously were not communicating. This is the balance, or synchrony, between the two hemispheres of the brain discussed at the beginning of this appendix. This synchrony brings with it many remarkable changes. As noted earlier, Lester Fehmi, of the Princeton Biofeedback Research Institute, has stated that "synchrony represents the maximum efficiency of information transport through the whole brain." (49)

As demonstrated earlier in this paper, there are two main effects of reorganization and increased synchrony in the brain. One is an increase in various mental capabilities: increased learning ability, creativity, mental clarity, intelligence, intuition, and so on. Second, each time the neural structure changes, positive changes in mental and emotional health occur. As the brain reorganizes at the next level of functioning, the subject's model of the world changes with it. With the creation of new neural pathways, connections are perceived between bits of information that previously seemed unrelated, and more choices are available. Herein lies the theoretical explanation for the amazing personality changes that researchers have reported in subjects using sound technology similar to Holosync to change brain wave patterns.

Clearly we are on the frontier of a marvelous new field with untold possibilities. The ability to map and entrain brain waves, and the states they represent, gives us a powerful new tool to effect human change and growth. It has been shown that induced brain wave states can cause superlearning, increased creativity, induce sleep, control pain, modify behavior, focus attention, relieve stress, increase memory, and dramatically improve mental and emotional health. Centerpointe Research Institute is proud to be at the forefront of this new and exciting field. We invite you to join us as we leap into the 21st century.

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