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A Brief Overview of the Chemistry of Respiration and the Breathing Heart Wave

Peter Litchfield, Ph.D

Respiration: Chemistry and Mechanics

Respiration is behavioral-physiologic homeostasis, a form of self-regulatory behavior, which constitutes a transport system for delivery of atmospheric oxygen to each and every tissue based on their specific metabolic requirements, including the transport of metabolic carbon dioxide from the cells to outside air. The mechanics of respiration constitute breathing the use of the lungs for moving oxygen, carbon dioxide, and other gases to and/or from the blood. The chemistry of respiration constitutes the physiology of moving oxygen from the lungs to the cells, and carbon dioxide from the cells to the lungs. Optimizing respiration means good chemistry through good mechanics.

In this paper, breathing mechanics have reference to:

1) breathing rhythmicity (holding, gasping, sighing)
2) breathing rate
3) breathing depth (volume)
4) locus of breathing (chest and diaphragm)
5) breathing resistance (nose and mouth), and
6) collateral muscle activity for breathing regulation (muscles other than the diaphragm). Breathing chemistry has reference to the ventilation of carbon dioxide through these breathing mechanics in the service of establishing adaptive respiratory chemistry. Respiratory chemistry can be monitored by measuring changes in exhaled carbon dioxide, to be discussed later, so as to ensure that the learning of breathing mechanics is truly in the service of respiration.

Good breathing mechanics rather than good respiratory physiology, has unfortunately become almost the exclusive focus of breathing training and learning, often along with insistence on tying it to relaxation training regimens in the context of specific philosophical and/or professional agenda. As a result, it is not surprising then, that at least 50 percent of therapists and trainers who teach breathing actually deregulate respiratory chemistry by inducing over-breathing with their instructions to trainees, not realizing that they are inducing system-wide physiological crisis through the establishment of hypocapnia, i.e., carbon dioxide deficit. Unfortunately, based on this kind of thinking, myths and misunderstandings about good breathing often constitute the working knowledge of professionals and lay audiences alike. Here are some of them:

Good breathing means relaxation.
No. Good breathing is important in all circumstances, whether relaxed or not.

Learning good breathing requires relaxation.
No. This would mean that during most life circumstances, breathing is maladaptive.

Diaphragmatic breathing is synonymous with good breathing.
No. In many instances one may begin to over breathe as a result of switching from chest to diaphragm.

Good respiration is all about the mechanics of breathing.
No. Good breathing means ven-

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From the Editor

Douglas W. Matheson, Ph.D.

This time around we feature articles by Michael and Lynda Thompson from the ADD Centre in Mississauga, ON, Canada [Neurofeedback for Asperger's Syndrome: Theoretical Rationale and Clinical Results] and Peter Litchfield of Boulder, Colorado [A Brief Overview of the Chemistry of Respiration and the Breathing Heart Wave]. These papers offer cutting edge information about biofeedback and its application. I have also reprinted an article written last summer for Biofeedback, the Journal of the AAPB, concerning research methods in psychophysiology [Research methodology, validity, and evaluating studies: what's OK for research in psychophysiology?]. Additionally, we are including pictures from our annual meeting in Asilomar, California last November. Our new President, Yair Lurie invites members to participate more actively in the group and asks each of you to do what you can to make biofeedback more recognizable in your community. Yair would also like to welcome our new BSC board members, Dr. Ruby Ng, Dr. Dave Davis and Dr. James Jarnette. Our group is growing and you can help that progress by referring others interested in biofeedback.

Members interested in submitting manuscripts to the Newsletter for future

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From the President

Members Have a Voice at BSC

Yair Lurie, M.S.

Biofeedback Society of California members have a voice. The Society is listening and responding. All members now have three ways to voice their concerns and expectations. One way is by sending an email to bsc@biofeedbackcalifornia.org. Another way is by filling out a form on our Web site at www.biofeedbackcalifornia.org. Yet another way is by participating in our BSC member's only list serve at bsc@psych2.uop.edu/.

The society is making changes as a result of a recent survey. Specifically, we are using that data from the Matheson Survey of 2002 (published in the summer 2002 newsletter [Vol. 18, No 2]). The following opinions were expressed by N=42/180 members:

1. The majority of members expressed an interest in networking and attending biofeedback functions. As a result, the BSC will continue to provide two regional conferences (one in north and one in south, in addition to our annual conference in southern California). We also now have a listserv available. To join the list, send and email to requests@psych2.uop.edu and in subject live type subscribe BSC.
2. 67% of respondents want more cooperation with AAPB and 45% want more cooperation with other state societies and 67% want cooperation with SNR. As

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Research Methodology, Validity, and Evaluating Studies: What's OK for Research in Psychophysiology?

Douglas W. Matheson, Ph.D.

Reprinted from Biofeedback, Summer 2002

Students taking their first course in Research Methods are asked to learn the basic tenets including determinism, true experiments, quasi-experiments, threats to internal and external validity, control of extraneous factors, the logic of statistical decision theory (hypothesis testing), and type I and type II error, power and sample size, a priori vs. a posteriori testing, and the gospel according folks named Student, Fisher, Pearson, and Campbell and Stanley. Why should clinicians be concerned about these issues?

Generally speaking, clinical practice relies to some extent on the literature and research findings of the discipline. Research and its design provide the engine that drives most quality clinical procedures. Research design is the plan of an experiment.

True Experiments

True experiments involve the manipulation of independent variables in experimental designs utilizing two or more groups called between groups designs, or counter-balancing treatment effects in within subjects designs by given all possible sequences of events in order to control order effects. An independent variable is defined as a factor, under the control of the experimenter that has at least two levels, one level called the experimental treatment and the other, and the control treatment.

Between subjects designs utilize an experimental group who gets the active level of the independent variable and a control group who gets the null or no effect level of the independent variable. If the experiment shows differences after the treatment is given, the difference is attributed to the experimental treatment level of the independent variable, assuming that the participants are randomly assigned to groups and the treatments are randomly assigned to groups. Randomization provides that, on the average, groups are equivalent at the outset of the experiment. True experiments use random sampling of participants to groups and or random assignment of participants to groups in order to control for sources of variation such as individual differences, history and maturation effects, and reactive effects in participants (due to participation in the experiment). True experiments constitute the model for what scientists would like to do regarding finding cause and affect relationships in nature.

A counter-balanced design controls for order effects and is one where many if not all possible sequences of independent variable are used. The design assumes that any sequence effects are eliminated. Counterbalanced designs are not without problems that make them more subject to error than between groups designs.

In sum, the major ingredients in a true experiment are random sampling and assignment, and manipulation of an independent variable. True experiments are not easy to achieve. First a large population of participants from which to sample is often not available. The available pool might be small, and more importantly, may not represent the real world. Secondly, in an effort to do the right thing regarding sampling, scientists often set up a sampling strategy that does not reflect the actual nature of the population. Lets take a look at a couple of examples.

Leibovici (2001) conducted a randomized controlled outcome study (between subjects experiment) using 3393 participants who had bloodstream infections and were admitted to a hospital between 1990-96. He referenced two previous studies that claimed that remote intercessory prayer had had a positive effect on person's admitted to coronary care units.

The participants in the Leibovici study were randomly assigned to two groups, an experimental group and a control group with the hypothesis being: remote, *retroactive* intercessory prayer reduces the mortality and shortens the length of stay in the hospital and the duration of fever for the intervention group. Remote intercessory prayer is defined as praying for persons unknown. Retroactive means that the "experimental group" received prayer for their well-being and recovery some five to ten years <u>after</u> they had been discharged from the hospital. For the experimental group, a list of first names was given to a person who offered a short prayer for the well being and full recovery of all those in the experimental group. No mention was made of equal attention given to the control group.

The results showed that there was no significant difference in mortality rates, but did show statistically significant differences in length of stay in the hospital and durations of fever in favor of the intervention (experimental) group. In his discussion, Leibovici claimed that retroactive incessionary prayer was associated with shorter stays and lower fever in patients with bloodstream infection. His claim fell short of a cause and effect statement, but it certainly claims association.

The author further stated there is "no known mechanism" to explain the effects of retroactive prayer on blood infection related variables. No known mechanism may be translated into "no known effect". The effect size is the amount of influence the indepen-

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tilating in accordance with metabolic requirements.

Diaphragmatic, deep, slow breathing means better distribution of oxygen.
No. Mechanics may look letter perfect, but oxygen distribution may be poor.

Under breathing, with the result of oxygen deficit is common.
No. To the contrary, over breathing is common.

Good breathing translates into optimizing respiratory physiology, and contrary to popular thinking, learning to breathe well does not simply mean deep, slow, diaphragmatic breathing in the context of learning how to relax. Adaptive breathing means regulating blood chemistry, through proper ventilation of carbon dioxide, in accordance with metabolic and other physiologic requirements associated with all life activities and circumstances: relaxation or stress, rest or challenge, fatigue or excitement, attention or open-focus, playing or working. Deregulated breathing chemistry, i.e., hypocapnia (CO_2 deficiency) as a result of over-breathing, means serious physiological crisis involving system-wide compromises that involve physical and mental consequences of all kinds, to be examined later in this overview. Evaluating, establishing, maintaining, and promoting good respiratory chemistry are fundamental to virtually any professional practice involving breathing training. Good breathing chemistry establishes a system-wide context conducive to optimizing health and maximizing performance.

Breathing training is invariably included as an important component of relaxation training, but surely does not in and of itself constitute relaxation. Breathing may be fully optimized, and hopefully is, during times of stress and challenge where relaxation is neither possible nor adaptive. Once good breathing chemistry and breathing mechanics are in place, relaxation training may then also include the establishment of stable high-amplitude breathing heart waves, i.e., parasympathetic (nervous system) tone, otherwise known as the respiratory sinus arrhythmia (RSA) and as one of the frequency ranges (HF) of what is known as heart rate variability (HRV).

Respiratory Chemistry: The Role of Carbon Dioxide in Oxygen Distribution

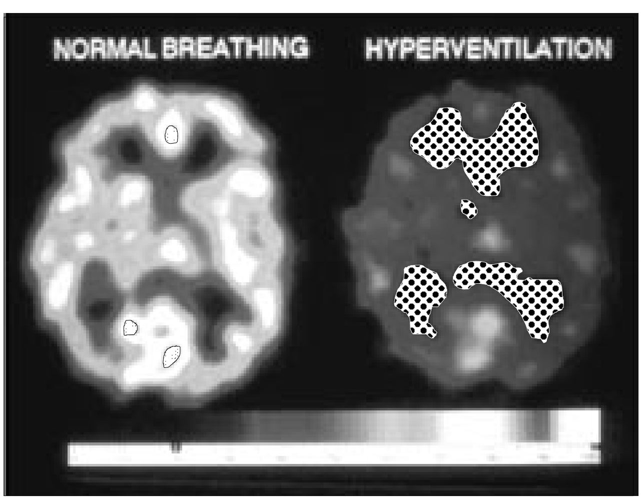
Blood is circulated with great precision to specific body sites based on their local and immediate metabolic requirements. Higher metabolism in more active tissues and cells generates higher levels of CO_2 resulting in immediate local vasodilatation (relaxation of smooth muscles with the result of increasing the diameter of the vessels), thus setting the stage for supplying the required oxygen and glucose to the associated tissues, such as to specific regions of the brain while thinking.

Higher levels of CO_2 also lead to an immediate drop in blood and extra cellular fluid pH levels through the formation of carbonic acid, thus obliging the hemoglobin to more readily distribute its oxygen to meet local metabolic requirements. Lower levels of CO_2 , as a result of lower metabolism, lead to blood vessel constriction (e.g., reduction in the diameter of the coronaries) and to higher levels of blood and extra cellular fluid pH (less carbonic acid), thus permitting oxygen and glucose to go elsewhere where metabolic requirements are greater. In the simplest of terms, this is the biochemistry of healthy respiration.

Deregulated Respiration: Effects of Carbon Dioxide Deficit on Physiology

The most serious form of breathing deregulation is overbreathing, an all too common and serious state of behavioral-physiologic affairs. Overbreathing is undoubtedly one of the most insidious and dangerous behaviors/responses to environmental, task, emotional, cognitive, and relationship challenges in our daily lives. Overbreathing can be a dangerous behavior immediately triggering and/or exacerbating a wide variety of serious physical and mental symptoms, complaints, and deficits in health and human performance.

Overbreathing* means bringing about carbon dioxide (CO_2) deficit in the blood (i.e., hypocapnia) through excessive ventilation (increased minute volume) during rapid, deep, and dysrhythmic breathing, a condition that may result in debilitating short-term and long-term physical and psy-



Effects of Overbreathing on Cerebral O_2: Vasoconstrictive effects
Reduction of O_2 Availability by 40 Percent
(░ = most O_2, ▩ = least O_2)

In this image, oxygen availability in the brain is reduced by 40% as a result of about a minute of overbreathing (hyperventilation). Not only is oxygen availability reduced, but glucose critical to brain functioning is also markedly reduced as a result of cerebral vasoconstriction.

**Note: Overbreathing is a behavior leading to the physiological condition known as hypocapnia, i.e., carbon dioxide deficit. Hyperventilation, although nomenclature synonymous with hypocapnia in physiological terms, is often used as a clinical term to describe a controversial psychophysiologic syndrome implicated in panic disorder and other clinical complaints.*

chological complaints and symptoms. The slight shifts in CO_2 chemistry associated with overbreathing may cause physiological changes such as hypoxia (oxygen deficit), cerebral vasoconstriction (brain), coronary constriction (heart), blood and extra cellular alkalosis (increased pH), cerebral glucose deficit, ischemia (localized anemia), buffer depletion (bicarbonates), bronchial constriction, gut constriction, calcium imbalance, magnesium deficiency, and muscle fatigue, spasm (tetany), and pain.

Blood is distributed based on metabolic requirement. Overbreathing is excessive ventilation of carbon dioxide, excessive because CO_2 levels in the blood no longer accurately reflect metabolic level; the ratio of metabolic CO_2 to expired CO_2 has shifted in favor of exhaled CO_2 . The consequence is a miscalculation of local metabolic requirements that leads to less than the required amount of vasodilation, or to vasoconstriction, and thus to potentially serious deficits of oxygen (hypoxia) and glucose (hypoglycemia) as well as of other required nutrients for the optimal functioning of a wide variety of tissues and physiological systems (e.g., brain, heart, and lungs). This misinformation about metabolism also triggers constriction of other smooth muscles, e.g., in the bronchioles and the gut, thus potentially exacerbating both asthma and irritable bowel syndrome.

Carbon dioxide deficit means a reduction in carbonic acid and a corresponding shift of blood and extracellular fluid pH in the alkaline direction, i.e., above the normal range of 7.38 ñ 7.40; alkalosis is an immediate consequence of hypocapnia. Paradoxically, this results in an increase in oxygen saturation in the blood, because hemoglobin does not encounter pH levels that accurately reflect current metabolic requirements and is thus less inclined than it would otherwise be to release its oxygen; the pH level does not properly reflect metabolic requirements. Thus, although oxygen saturation is maximized, oxygen distribution is withheld where in fact metabolic needs significantly exceed those reflected by the reduced CO_2 levels resulting from overbreathing.

The coupling of vasoconstriction and "disinclined" hemoglobin (because of higher pH levels) means significant compounding of oxygen distribution problems where oxygen deficits (hypoxia) are considerably greater than those brought about by vasoconstriction alone, e.g., deficits, in effect, that may exceed 50 percent in the brain. Combining these effects with glucose deficit in the brain, in the heart, and in other physiological systems can precipitate, exacerbate, and even originate serious consequences, including physiological and psychological com-

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plaints, symptoms, and syndromes of numerous kinds (see below).

Alkalosis, i.e., increased pH due to reduced levels of CO_2, leads to yet further compromises. Extracellular fluid alkalosis increases cellular excitability and contractility (e.g., neuronal excitability in the brain) and thus actually increases oxygen demand, anaerobic metabolism, and antioxidant depletion (caused by excitatory amino acids). And, in fact, yet further worsening matters, alkalosis inhibits the negative feedback normally associated with lower pH levels that limit the production of metabolic acids themselves (e.g., lactate), and hence yet further compromises performance. Blood alkalosis leads to migration of calcium ions into muscle tissue, including both smooth (e.g., coronary, vasocerebral, bronchial, gut) and skeletal tissue, resulting in increased likelihood of muscle spasm (tetany), fatigue, and pain. And, platelet aggregation is increased, thus elevating the likelihood of blood clotting.

Overbreathing is an insidious and unconscious habit, one that is not readily detectable. Overbreathing may be precipitated at stressful times of the day, during times of defensiveness and emotionality, during information overload, or upon the commencement of ordinary tasks through self-initiation or instructions from authority. Some individuals over breathe with little provocation and may do so chronically, all day without knowing it. And, unfortunately overbreathing is even induced (often) and reinforced by professionals who teach breathing mechanics (e.g., diaphragmatic training) in the name of relaxation, improved health, and better performance. Good chemistry is fundamental to optimal behavioral-physiologic homeostasis, basic to optimizing health and performance.

Chronic Deregulation: Compensatory Behavioral-Physiologic Activity and Its Price

Bicarbonates are required for controlling acidosis (when blood becomes less alkaline than normal, less than 7.38), i.e., neutralizing acids, brought about through physical activity (e.g., lactic acid) as well as through other physiologic activities (e.g., ketoacidosis as a result of diabetes). Chronic hypocapnia resulting from overbreathing ultimately leads to compensatory renal unloading of bicarbonates (inhibition of bicarbonate reabsorption in the kidneys), which lowers blood and intracellular pH toward normal levels, but in the end neither completely renormalizing nor stabilizing pH levels. Unfortunately, chronic compensatory behavior may ultimately seriously compromise buffering capabilities, resulting in reduced physical endurance and greater susceptibility to fatigue.

In addition to the loss of bicarbonates, there is also significant loss of magnesium (and phosphates) a deficiency that may ultimately lead to an imbalanced magnesium-calcium ratio critical to muscle functioning, resulting in increased likelihood of muscle fatigue, weakness, and spasm.

Although the blood pH, i.e. alkalosis, is reduced as a result of this compensatory behavior, and hemoglobin distributes its oxygen more consistently with metabolic requirements, smooth muscle constriction and its consequences remain a chronic condition (e.g., cerebral vasoconstriction, coronary constriction, bronchial constriction, and gut constriction).

Note: Individuals suffering with diabetes may overbreathe as a means to controlling ketoacidosis, i.e., reducing levels of carbonic acid. This is why biofeedback for relaxation training for example, was contraindicated for such individuals. Normalizing CO_2levels implicit in relaxation training, without proper attention to matter of chemistry, might well result in acidosis. The price for compensatory overbreathing behavior, however, is high and nevertheless needs to be seriously addressed.

Overbreathing: Effects on Health

Overbreathing, based on the chemistry of breathing described above, can trigger or exacerbate physical and psychological complaints such as: shortness of breath, breathlessness, chest tightness and pressure, chest pain, feelings of suffocation, sweaty palms, cold hands, tingling of the skin, numbness, heart palpitations, irregular heart beat, anxiety, apprehension, emotional outbursts, stress, tenseness, fatigue, weakness, exhaustion, dry mouth, nausea, lightheadedness, dizziness, fainting, black-out, blurred vision, confusion, disorientation, attention deficit, poor thinking, poor memory, poor concentration, impaired judgment, problem solving deficit, reduced pain threshold, headache, trembling, twitching, shivering, muscle tension, muscle spasms, stiffness, abdominal cramps and bloatedness. It is little wonder, then, why surveys have found that up to 60 percent of all ambulance calls in major US cities are the result of overbreathing!

The significance of the effects of this little known but thoroughly documented physiology can be put into perspective knowing that surveys suggest that 10 to 25 percent of the US population suffers from chronic overbreathing, and that over half of us overbreathe on frequent occasion! The following is a quotation from a book chapter written by Dr. Herbert Fensterheim (Chapter 9, Behavioral and Psychological Approaches to Breathing Disorders, 1994), a highly respected and internationally prominent author and psychotherapist, and it points to the fundamental importance of evaluating respiratory chemistry, i.e., overbreathing, in the mental health professions, regardless of a practitioner's school of thought or treatment paradigm:

> Given the high frequency of incorrect breathing patterns in the adult population, attention to the symptoms of hyperventilation [overbreathing] should be a routine part of every psychological evaluation, regardless of the specific presenting complaints. Faulty breathing patterns affect patients differently. They may be the central problem, directly bringing on the pathological symptoms; they may magnify, exacerbate, or maintain symptoms brought on by other causes; or they may be involved in peripheral problems that must be ameliorated before psychotherapeutic access is gained to the core treatment targets. Their manifestations may be direct and obvious, as when overbreathing leads to a panic attack, or they

> may initiate or maintain subtle symptoms that perpetuate an entire personality disorder. Diagnosis of hyperventilatory [overbreathing] conditions is crucial

Chronic vasoconstriction, magnesium-calcium imbalance, buffer depletion, and alkalosis (higher levels of blood and extracellular pH levels) as a result of overbreathing may in predisposed individuals trigger or exacerbate: phobias, migraine phenomena, hypertension, attention disorder, asthma attacks, angina attacks, heart attacks, cardiac arrhythmias, thrombosis (blood clotting) panic attacks, hypoglycemia, epileptic seizures, altitude sickness, muscle weakness and spasm, sexual dysfunction, sleep disturbances (apnea), allergy, irritable bowel syndrome (IBS), repetitive strain injury (RSI), and chronic fatigue.

In an important recent review article on the subject of hypocapnia (CO_2 deficit) in the New England Journal of Medicine (J. Laffey and B. Kavanagh, 4 July 2002), the authors say:

> Coextensive data from a spectrum of physiological systems indicate that hypocapnia has the potential to propagate or initiate pathological processes. As a common aspect of many acute disorders, hypocapnia may have a pathogenic role in the development of systemic diseases (pages 44 and 46). And, they go on to say; increasing evidence suggests that hypocapnia appears to induce substantial adverse physiological and medical effects (page 51).

Long-term vasoconstriction may also lead to ischemia in the brain and the heart (anemia in cells not adequately supplied with oxygen), result in reduced neurotransmitter synthesis that contributes to the onset of depression and other psychological syndromes, and chronically lower the threshold for most of the complaints listed above, e.g., chronic vasoconstriction and increased systemic vascular resistance may reduce the threshold for elevated blood pressure or precipitate angina attack in predisposed individuals.

It is estimated that the primary complaint of one third of all patients in general medical practice is fatigue, a condition that may actually be brought on and/or exacerbated by buffer depletion resulting from overbreathing, and a condition (fatigue) in and of itself that can be assessed through CO_2 measurement (capnometry) to be described later in this overview. On this basis alone, some prominent physicians in both Europe and America assert that capnometers, like blood pressure devices, should be on the desktop of every general and family practitioner.

It is estimated that more than a third of all those who suffer with asthma overbreathe, a condition potentially leading to immediate bronchial constriction and asthma attack. The struggle to breathe and fear of not getting enough air can easily lead to panicky breathing where vicious circle overbreathing may result in a progressive worsening of hypocapnia-induced bronchial constriction and increased airway resistance. Teaching good breathing mechanics to people with asthma through diaphragmatic breathing can very significantly improve breathing efficiency by increasing volume, reducing rate, establishing rhythmicity, and eliminating collateral muscle movement not required for good breathing. In effect, it reduces the struggle to breathe by introducing an effortlessness form of breathing that also provides for a sense of mastery over the debilitating effects of the condition. This training, however, can itself easily result in overbreathing through a combination of the success of the method itself (increased efficiency, volume) and the continued motivation to get enough air and where neither the therapist nor the patient are familiar with overbreathing and its effects.

Documented medical savings of 45 percent over a five year period in heart attack patients following only six breathing training sessions, led to legislation in Holland that all cardiac rehabilitation centers offer breathing training to patients. Unfortunately, this little known research and its highly practical implications remain relatively unknown to most professionals working in American cardiac rehabilitation centers, where the importance of behavioral respiratory physiology has simply not been introduced. The importance of breathing training in cardiovascular health is yet further supported by the article in the New England Journal of Medicine (page 50), where the authors point out that hypocapnia has been clearly linked to the development of arrhythmias, both in critically ill patients and in patients with panic disorder

It is estimated that the primary complaint of one third of all patients in general medical practice is fatigue, a condition that may actually be brought on and/or exacerbated by buffer depletion resulting from overbreathing, and a condition (fatigue) in and of itself that can be assessed through CO_2 measurement (capnometry)...

How can simple breathing training significantly influence the outcome of cardiovascular rehabilitation in patients who overbreathe? Consider the following: A survey of studies on overbreathing and coronary constriction show a reduction of blood volume by about 50 percent (a 23 percent reduction in coronary diameter), a significant reduction in compromised individuals; and, extreme coronary constriction as a result of overbreathing has also been identified in a subpopulation of patients. Increased platelet aggregation brought about by hypocapnia may precipitate blood clotting, i.e., thrombosis. Buffer depletion resulting from long-term overbreathing, as described earlier, may also significantly

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contribute to the onset of arrhythmias and other cardiovascular abnormalities. Increased vascular resistance as a result of vasoconstriction and alkalosis brought about through chronic overbreathing may trigger hypertension in predisposed individuals. Hypocapnia leads to cellular excitability and to increased contractility of the heart, increasing oxygen demand while oxygen availability is sharply decreased. And, the upward pH shift brings on calcium migration into muscle tissue, increasing the likelihood of arterial (coronary) spasm. Normalizing breathing chemistry reverses these effects.

The New England Journal of Medicine article goes on to point out that clinically significant overbreathing in pregnant women is commonplace, and that during childbirth, further lowering of the partial pressure of arterial CO_2 - even for a short duration - such as during anesthesia for cesarean section - may have serious adverse effects on the fetus The implications of this statement are staggering when considering that some child-birthing techniques used by many thousands of women (western) worldwide actually engaged women in the practice of extreme forms of overbreathing during childbirth.

Overbreathing during wakefulness is seriously implicated as an important variable in the origin and in the onset of sleep apnea. Hypocapnia is a common finding in patients with sleep apnea and may be pathogenic according to the same article in New England Journal of Medicine.

The seriousness of the effects of hypocapnia are made absolutely clear in the New England Journal of Medicine review article, written for the express purpose of warning physicians about their use of hypocapnia as a means to controlling symptoms and conditions resulting from injury and disease, as well as its widespread use in general anesthesia. In fact, the impact of hypocapnia on cerebral blood flow and blood volume is so dramatic, according the article, that almost 50 percent of emergency physicians and 36 percent of neurosurgeons actually induce hypocapnia to control of life-threatening intracranial swelling resulting from head trauma or brain injury.

**Overbreathing:
Effects on Cognition**

Cognitive and perceptual deficits are perhaps most clearly understood by newcomers to this physiology by examining the effects of hypoxia on the behavior of pilots. Every pilot knows about the cognitive and perceptual deficits resulting from the effects of hypoxia in high altitude chambers, including impaired decision-making, perceptual motor skills, information processing, problem solving, task completion, memory, thinking, and communication effectiveness. Serious cerebral hypoxia means that even the easiest of tasks become significant mental challenges, e.g., simple navigational calculations during an engine-out procedure. In fact, overbreathing is routinely monitored in fighter pilots while in flight. Particularly noteworthy, as is often emphasized by on-looking observers, is the fact that these performance decrements go completely undetected by those actually suffering from the hypoxia. Overbreathing at sea level and the resulting hypoxia produce precisely these same effects!

The potent impact of overbreathing on cerebral functioning is made clear in the recent article in the New England Journal of Medicine in the description of the use of hypocapnia for controlling intracranial swelling in otherwise life-threatening brain trauma circumstances: Hypocapnic alkalosis decreases cerebral blood flow by means of potent cerebral vasoconstriction, thereby lowering intracranial pressure. The dramatic impact of overbreathing on cognitive function is put into further perspective, when the authors describe the widespread and deliberate induction of hypocapnia during general anesthesia (e.g., for reducing the need for sedatives), as follows:

The causative role of hypocapnia in postoperative cognitive dysfunction is underscored by the finding that exposure to an elevated partial pressure of arterial carbon dioxide [i.e., normalizing CO_2 levels] during anesthesia appears to enhance postoperative neuropsychologic performance

Cognitive, perceptual, and motor skill deficits, brought about by hypoxia (oxygen deficit) are yet further exacerbated by cerebral hypoglycemia (glucose deficit, as a result of vasoconstriction) that may compromise brain functioning to a yet greater degree. The potentially debilitating combination of cerebral oxygen and glucose deficits resulting directly from overbreathing may seriously compromise and/or disrupt ability to attend, focus, concentrate, imagine, rehearse the details of an action (e.g., golf swing), initiate performance, play a musical instrument, sing, engage in public speaking, and perform all kinds of other complex tasks.

The implications of overbreathing and its regulation for working with children and adults suffering with attention deficits are significant.

There is a fine line between vigilance and stress. In the transition from vigilance to stress, i.e., from positive attentiveness to guarded defensiveness (fight-flight behavioral patterns), overbreathing may be immediately instated with its debilitating effects occurring within less than a minute. This same kind of transition may occur when task-demand exceeds a certain level of complexity or when relationship challenge exceeds a certain level of emotionality: overbreathing as a component of defensive posturing takes over. Task-induced overbreathing for example can insidiously and unsuspectingly contribute to the degradation of human performance, insidious because the performer is neither likely to be aware that overbreathing is taking place, nor have any idea whatsoever as to its effects. Performers who are task-induced ìoverbreathers are good candidates for breathing chemistry training.

The implications of overbreathing and its regulation for working with children and adults suffering with attention deficits are significant. Low cerebral CO_2 as a result of overbreathing shifts the EEG power spectrum downwards and elevates the presence of theta EEG activity, the frequency domain of principal interest to neurofeedback practitioners who seek to reduce theta activity in clients who suffer attention deficit disorder. Before beginning such work it truly behooves practitioners to normalize the chemistry of breathing, a fundamental system-wide physiological consideration, before beginning neurofeedback or other forms of behavioral-physiologic training.

Overbreathing: Its Effects on Emotion

Cerebral hypoxia and cerebral hypoglycemia not only have profound effects on cognition and perception but also on emotionality: apprehension, anxiety, anger, frustration, fear, panic, stress, vulnerability, and feelings of low self-esteem. Cerebral (brain) oxygen and glucose deficits may trigger disinheriting of emotional states, i.e., release of emotions otherwise held in check Loss of emotional control, intensification of emotional states, and exacerbation of debilitating stressful states of consciousness may result from overbreathing in challenging and adverse circumstances, e.g., flying phobias and debilitating public speaking anxiety. Emotional discharge in challenging environments itself may, of course, further exacerbate cognitive and other performance deficits.

Failure to understand the source of physical sensations resulting from overbreathing, e.g., light-headedness, tingling of the skin, tightness of the chest, sweaty hands, and breathlessness, typically leads to a false interpretation of their meaning. The incorrect, and usually negative, self assessment that may result, e.g., I am losing control is likely to elicit secondary emotional responses (e.g., fear) and further exacerbate the ones directly resulting from cerebral oxygen and glucose deficits. And indeed, practitioners and trainers themselves, not familiar with the effects of overbreathing, may unfortunately also misinterpret these secondary effects, taking them as evidence supporting their own biases about the significance of the kinds of complaints reported by the client, e.g., relaxation moves you closer to yourself, and this makes you uncomfortable. Overworking is your way of protecting yourself.

Sometimes overbreathing is deliberately induced for the very reason that it can trigger emotional memories and states, e.g., rebirthing. Stanislav Grofís Holotropic Breathwork, widely known for its use in triggering emotional and memory release, is an excellent example of how overbreathing lowers the threshold for emotional expression. Some breathing inductions used in natural child birth, for example, involve extreme forms of overbreathing, based on the premise that disorientation reduces capacity to focus on pain; from a respiratory chemistry perspective, however, this amounts to induction of system-wide crisis with potentially adverse effects on the infant.

Failure to understand the source of physical sensations resulting from overbreathing, e.g., light-headedness, tingling of the skin, tightness of the chest, sweaty hands, and breathlessness, typically leads to a false interpretation of their meaning.

Overbreathing: Effects on Performance

Compromising the blood buffering system (i.e., reduced capacity to regulate acidosis) means reduced physical capacity and endurance, ranging from limiting athletes in their pursuit of achieving peak levels of physical performance, to contributing to the incapacitation of individuals with fatigue and unable to perform the simplest of tasks without exhausting their supply of buffers.

Incrementally increasing the workload on an exercise bike or treadmill increases metabolism, and hence the output of carbon dioxide. Normal ventilation means that the CO_2 exhaled is consistent with level of metabolism; there is no overbreathing. Eventually, however, when buffers become depleted and can no longer neutralize lactic and other acid byproducts, overbreathing becomes a short-term solution to the resulting acidosis, i.e., carbonic acid is reduced, thus offsetting the build up of other acids. Monitoring CO_2 levels during exercise on an exercise bike or treadmill permits an observer to take note of this critical point, the point at which overbreathing is itself a compensatory response to buffer depletion, the point at which physical exhaustion can be identified. And, as described previously, chronic overbreathing itself may lead to buffer depletion, thus ultimately reducing physical capacity and endurance to a point where simple exercise becomes equivalent to the maximum endurance effort of an athlete.

Buffer depletion physiology has very significant implications for performance and health. Running out of buffers with exercise equivalent to walking to work, crossing a few streets to lunch, or preparing dinner for the family means physical exhaustion doing the simple physical chores that define the daily routine of life. Overbreathing may not only lead to buffer depletion but may then also become its own short-term solution to the resulting acidosis, i.e., a vicious circle syndrome. This state of affairs can be observed by exercising on an exercise bike or treadmill and noting the point at which there is a drop in carbon dioxide level, the point at which overbreathing is engaged.

Professional and lay audiences both ponder the ways in which stress ultimately has its effects on health and performance. What are the mediating

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BSC 28th Annual Convention — November

BIOFEEDBACK FI

Keynote speaker Liz Strobel and new board member, Dave Davis

Dr. K.K. Deeapak came all the way from India

Margin Woon on Music Therapy and biofeedback

Jeff Cram and Mari

Hershel Toomim's session on HEG

J and J's Jan Hoover demonstrates his new capnometer

More of Toomim's talk

r 8-10, 2002 — Asilomar Conference Center

ROM THE HEART

Jeff Cram, our fearless conference chief

Dr. Naras Bhat's daughter, Joy Bhat, demonstrates native Indian dancing

Asilomar grounds

Nara's Presidential address

Dave Jacob's listening intently

Deer in the Asilomar grounds

Board member Rick Harvey

Keynote Speaker Elizabeth Strobel sorting slides

Bob Whitehouse talks about capnomitry

Members enjoying a break from the rain

Attentive audience

Julian Issacs pontificates

Chemistry of Respiration and the Breathing Heart Wave

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variables that lead to behavior-physiologic deregulation? One important contributing factor may be the way in which one encounters challenge: bracing or embracing, defensive-posturing or life-engaging? The defensive or bracing mode often includes overbreathing (part of the fight-flight behavioral configuration) that may lead to the fatigue symptoms and complaints associated with the effects of buffer depletion and magnesium deficiency, along with the wide range of physical and psychological effects previously described.

The fatigue associated with overbreathing may be misidentified as depression. Exercise may be prescribed when rest is in order, where exercise will actually exacerbate the problem and is contraindicated. Buffer depletion, resulting from exercise and associated compensatory overbreathing, may in fact precipitate cardiac arrhythmias even in otherwise healthy individuals. Rest will permit build-up of the buffers, but upon returning to a challenging environment without breathing and other forms of self-management training, overbreathing is likely to be reinstated, once again resulting in buffer depletion and a relapse of fatigue and associated effects of stress Deregulated respiratory chemistry constitutes a behavioral-physiologic mechanism that may directly account for some of the effects of stress on homeostasis and self-regulation.

Respiratory Training: General Considerations

Fritjof Capra, famed physicist and systems theorist, states his position on the mindbody dichotomy so well when he says, the organizing activity of living systems, at all levels of life, is mental activity (The Web of Life, 1996). In other words, there simply is no dichotomy, that all of life is itself inherently mindful Thus, in this thesis there is no distinction between physiological or psychological crisis; defensive posturing or bracing and life-engaging or embracing are mindful frames of physiological reference, comprising what might be described as life postures.

These life postures are fundamental operating-definition culture-based concepts as can be seen in Western psychology where there is emphasis on defensiveness, and in Eastern philosophy and practice (e.g., meditation), where there is emphasis on embracement of chi, i.e., life or breath. Both of these postures are profoundly reflected in the chemistry and in the mechanics of respiration.

Breathing evaluation and training bring together differing western schools of thought and tradition, including physiology, psychology, healthcare, and human performance with the promise of weaving them together with Eastern thinking, traditions, and practice into an active, personal, and mindful participation in behavioral-physiologic self-regulation for health and performance.

Seeing physiology as mindful carries with it an important implication: it is the ego part of the mind that identifies itself as separate from the body giving rise to the mind-body dichotomy through its indignant claim on ownership of all of the mind, wherein the mind necessarily came to be viewed as our unconscious, rather than as a property of the fundamental essence of life itself and in all of its forms. Accessing the body, then, for the mindful physiology oriented practitioner, means accessing the mind: intuitions, images, feelings, archetypes, and meaning itself. Accessing the mind through body sensitivity training is fundamental to what has come to be known as biofeedback and is the basis for breathing evaluation and training. It is little wonder that breathing is a point of physio-spiritual connection in Eastern philosophical thinking.

As Capra points out in his book, The Web of Life, the whole is not simply greater than its parts but actually provides for the definition, the very identity, of the parts themselves. Overbreathing sets the stage for crisis, even for trauma, and for a consciousness of defensive posturing and bracing. It engages state-dependent behaviors, even state-dependent personalities, which are protective in nature offering the prospect of safety in a threatening world; overbreathing becomes a doorway into a different consciousness where one may disconnect, isolate, or flee, but pay the price of behavioral physiologic deregulation. Changing consciousness, means changing the definition of constituent physiological dynamics: rapid heart rate is a sign of stress in the context of defensiveness, whereas it is a sign of joy in the context of embracement. Good respiratory chemistry and mechanics set the stage for embracement, rather than defensiveness, as a life posture. Wellness is ultimately about embracing, about the heart, about bringing together the mindfulness of physiology with the personal consciousness. Health is about seeking, presence, and availability, not about ego and defensiveness. When naked, don't overbreathe, be there.

Learning about the behavioral physiology of respiration offers the prospect of bringing easy to under-

Breathing evaluation and training bring together differing western schools of thought and tradition, including physiology, psychology, healthcare, and human performance with the promise of weaving them together with Eastern thinking, traditions, and practice into an active, personal, and mindful participation in behavioral-physiologic self-regulation for health and performance.

stand, highly practical, and easy to implement educational applications of mindful-physiology to healthcare and human performance practitioners everywhere. Everyone acknowledges some measure or responsibility for breathing, as is evidenced by everyone's use of the pronoun I. Breathing training is an ideal context in which to teach people about the mindful nature of physiology, where self-regulation training for health and performance can make a powerful impact on the practical thinking of large audiences within a short time. The theme is: the whole body is the organ of the mind, not just the brain. Our minds are the music that our bodies play to the universe

Respiratory Training: Specific Considerations

Breathing chemistry training does NOT replace breathing mechanics training; the two together comprise true respiratory training (i.e., getting O_2 to the cells and CO_2 back to the lungs). There is NO specific breathing protocol, technique, or program that constitutes the right one however, keeping respiratory chemistry in the adaptive window is a critical consideration in most any kind of breathing training. There are numerous approaches to teaching the mechanics of adaptive breathing that permit practitioners to integrate breathing evaluation and training into their work based on professional background, expertise, experience. Unfortunately, however, in very few cases is the chemistry of breathing included as a component of the training.

Breathing is a complex behavior. It is voluntary and involuntary. It is greatly influenced by emotion. It is synchronized with complex speech behavior. Basic neurophysiological control of breathing originates in the respiratory centers located in the brain stem, the pons and medulla, where breathing rate and volume are regulated based on CO_2 levels. While in a coma, breathing mechanics (rate and volume) track CO_2 levels precisely. There are other breathing centers throughout the brain including the limbic system (emotion), the speech areas of the brain, and the frontal cortex (voluntary control). These other regulatory centers may interfere with adaptive breathing, resulting in deregulated breathing, overbreathing that is often associated with breath holding, gasping, sighing, chest breathing, rapid breathing, reverse breathing (contracting the diaphragm while breathing out), and so on. Training for adaptive breathing chemistry, in most instances, means restoring regulated breathing through reinstatement of the basic brain stem breathing reflex.

How is overbreathing identified? Without monitoring CO_2 levels, there is simply no way of knowing. Use of the capnometer is the only practical and technically reliable method for detecting it with certainty. Arterial carbon dioxide ($PaCO_2$) can be measured directly through invasive monitoring, or indirectly by means of measurement of CO_2 content in exhaled air. Measurement of CO_2 at the end of exhalation, or at the end of the tide of the air breathed out, is known as end-tidal carbon dioxide or $ETCO_2$, and is under normal circumstances highly correlated with invasive arterial measurement. Capnometry is used in virtually every surgery room and critical care unit in America, and is based on textbook physiology and highly reliable technology. *

The objective of breathing training while at rest is to restore proper breathing chemistry (CO_2 levels), establish breathing rhythmicity (reduction of holding, gasping, sighing), lower breathing rate, increase breathing depth, shift the locus of breathing from chest to diaphragm, encourage nasal breathing, relax musculature during exhalation, reduce collateral muscle activity, and establish a stable presence of high amplitude breathing heart wave activity (parasympathetic tone, RSA). Training for good breathing chemistry involves learning how to:

1) Evaluate breathing both at rest and in the context of multiple kinds of challenge;
2) Teach the physiology and psychology of respiration;
3) Identify the sensations of overbreathing, and reinstate the basic brain stem breathing reflex;
4) Interpret physiological experience, e.g., deregulated vs. regulated breathing;
5) Train breathing mechanics: rhythmicity, volume, rate, resistance, and locus of control;
6) Instate prophylactic (deliberate) techniques for consciously disengaging or preventing overbreathing;
7) Configure new patterns of behavioral-physiologic defensive posturing, without overbreathing;
8) Establish embracement physiology where overbreathing is not a mindful component; and
9) Generalize new patterns of breathing that normalize chemistry in diverse life circumstances.

In summary, training involves:

1) education
2) learning prophylactic techniques
3) reinstating the basic respiratory reflex mechanism
4) learning new patterns of defensive posturing, and;
5) learning to engage embracement physiology by establishing new chemistry and its associated physiologic mindfulness'

Breathing evaluation and training may be useful for behavioral physiologic applications by healthcare providers and patients, performance trainers and athletes/artists, corporate trainers and trainees, behavioral health professionals and clients, human service providers and clients, consultants and self-improvement trainees, educators and students, and academicians and researchers. Examples of performance training applications include: improving memory, enhancing thinking and problem solving skills, improving concentration (playing an instrument), attention training (e.g., attention deficit), reducing anxiety (e.g., public speaking, test taking), managing stress, managing anger, decreasing fatigue, increasing alertness and readiness, reducing muscle tension, diminishing physical pain, facilitating relaxation, facilitating disciplines of inner directedness (e.g., meditation), maximizing performance training (e.g., flight training), natural child birth preparation, peak performance training (e.g., athletes and coaches), and evaluating and improving physical condition.

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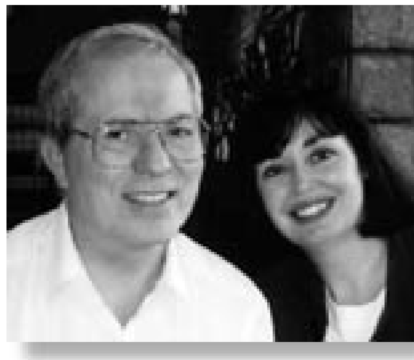
Neurofeedback for Asperger's Syndrome: Theoretical Rationale and Clinical Results

Michael Thompson, M.D. and Lynda Thompson, Ph.D.

Patterns Seen in Asperger's Syndrome:

People with Asperger's Syndrome (AS) often are initially diagnosed as having Attention-Deficit/Hyperactivity disorder; thus, they are often seen by neurofeedback practitioners who work with clients who have ADHD. A British study found that, on average, a child with AS has been seen by three different professionals before being correctly diagnosed (Wing, 2001) so it is important to understand the symptom picture in order to do an appropriate differential diagnosis and hopefully get it right the first time. The rationale for doing neurofeedback training is that those with AS appear to have characteristic EEG signatures which, at the central location (CZ), are similar to those found in ADHD but more extreme (Thompson, 2002). In our clinical experience, they show a favourable response to neurofeedback intervention (Thompson, 1995, 1998, 2002), albeit taking more sessions than the 40 to 60 that are usually sufficient when working to improve attention. Incidence is on the rise and some people feel there are particularly high numbers of AS individuals in certain parts of California where the computer industry is a big part of the economy.

Asperger's Syndrome is along the continuum of autistic spectrum disorders. These disorders have core symptoms "characterized by the triad of impairments of social interaction, communication, and imagination associated with a narrow range of repetitive activities" (Wing, 2001, p. xiv, Attwood, 1999). AS came into the DSM-IV diagnostic codes for the first time in 1994 so American psychologists and psychiatrists are not all that familiar with the picture, although it was first described by a Viennese pediatrician in 1944. Lorna Wing brought AS into awareness in the English literature in 1981. Those clients who



are diagnosed as autistic have severe deficiencies and delays in language development and these are not found in clients with Asperger's Syndrome. Indeed, Those with AS typically have shown no language delays (Rourke, 2000) and will often have exceedingly high verbal IQ scores (Thompson, 2002). There is, however, something different about the emotional aspects of their language, things like prosody and modulation of loudness that are more right hemisphere functions. Both the autistic and the Asperger's syndrome clients demonstrate primary deficits in their ability to interpret non-verbal social communications (innuendo, abstract meaning), appropriately initiate and maintain social interactions, handle anxiety, shift mental set, and sustain external attention span and response control. Their symptoms overlap with those of Attention Deficit Disorder in terms of inattention (more in their own world) and impulsivity. The impulsive behavior in the person with AS is usually associated with being anxious in a social situation where they are not sure what to do. They may demonstrate "islands of very high intelligence" that correspond to a singular (obsessive) area of interest (Thompson & Havelkova, 1983). One five-year-old seen at our clinic was interested in weather. He could not only tell you what a barometer was, he could tell you how to build one. He did not watch cartoons on television. He preferred the weather channel. They often present like little professors with extensive knowledge in this one area.

AS clients want to have social interactions but lack the innate ability to understand social innuendo and appropriately communicate emotions. They may seem bossy with other children because they are not very flexible and they like everyone to follow the rules. In this regard, they may sometimes be regarded as tattletales and not understand why other children dislike them when they were just telling the truth. Certainly they are not good at social lies and may embarrass a parent by making an honest but impolite observation. They usually are a bit awkward in their motor skills (the way they run or throw a ball, for example) and they will eschew team sports since they have trouble getting a sense of the game. In adolescence they are prone to becoming depressed, perhaps because the social scene becomes both more important and more complex during those years. They do best in situations where people are kind and accept the person with AS as being bright and a bit eccentric.

In terms of brain function, different activation of the fusiform gyrus for facial recognition is found in those with AS (Pierce, 2001). The part of the brain that the normal person uses for figuring out a puzzle lights up on the brain scan of someone with AS asked to say what emotion is shown by a person in a photograph. The amygdala, orbital and medial prefrontal cortex, medial temporal areas and the thalamus are all involved in the process of attaching emotional significance to stimuli and are most likely of central importance in understanding the autistic spectrum disorders, including AS (Schulz, 2000).

EEG brain maps show less activation in the areas of the right hemisphere that process emotional information (unpublished data from Gunkleman and from our own clients). There is also more slow wave activity seen in central locations. The peak is sometimes in the theta range, somewhere between 4 and 8 Hz. and sometimes, especially in adolescents and adults, it may be in the alpha range even though the recording is done eyes open. This dominant slow wave activity is similar to patterns seen in ADHD but the peaks are usually higher. Results on computerized continuous performance tests vary. Sometimes they will have difficulties, especially if they get upset after making too many mistakes. More often, however, the person with AS will do quite well on the TOVA or IVA because their anxiety component and desire to follow the rules leads to good effort and they do not become too anxious because there is no social interaction. Parent questionnaires usually are in the clinically significant range for ADHD symptoms. It is helpful to also use an Asperger's questionnaire such as the one found in Tony Attwood's book. It is the clinical history of problems in social interactions that will usually clinch the diagnosis.

Neurofeedback Interventions:

Over the past decade we have worked with more than 50 clients with AS, age five to fifty-one. Training parameters were based on client's symptom picture, EEG pattern, and knowledge of cortical functions. The most frequent intervention was to decrease the client's dominant slow wave frequencies while enhancing 12-15 Hz activity with placement at Cz or C4 referenced to the right or the left ear respectively. When full cap assessments showed excessive slow wave activity at other locations (PZ, P4, T6, F4, FZ, F3, Fp1) these sites were also used. We have most often worked without 19 lead assessments in order to keep costs down for the client, though it is obviously desirable to have that information. Coaching in metacognitive strategies was done as appropriate for academic levels. Often people with AS have quite messy handwriting and their written work does not match their verbal skills. Use of a computer for word processing is certainly a boon to them and many of them have a keen interest in computers.

One 21-year-old we worked with had barely finished high school despite a gifted range IQ. He had gone to a private school (a Waldorf school) where they nurtured him and made allowances for his eccentricities. After graduation he had had great difficulty trying to live on his own after his parents moved to another city but he refused to leave the neighborhood he knew. He had been unable to find steady employment and had attempted suicide. Thought by others to be ADD and depressed, he was first diagnosed as having AS when seen at our clinic. The first clue that he was different was the aloof manner in which he walked around the office and touched things as the history was being taken. When he proceeded to clean his ears and then examine the earwax (after being told he would be dong a test that involved watching and listening for targets) the socially inappropriate, in his own world style was clearly demonstrated. The early history included the fact that he had been an early talker and his first word had been "back-hoe" as he liked to watch construction machines even before he could walk. After training he found employment with a small company doing Web design and was able to live on his own in an apartment. When we did an 18-month follow-up by telephone, we learned that he had maintained his job for over a year and even had a girlfriend. She reportedly complained that she put more into the relationship than he did but he just told her that, after all he had been through, it was not surprising that he kept a little more to himself.

Asperger's Syndrome is along the continuum of autistic spectrum disorders. These disorders have core symptoms "characterized by the triad of impairments of social interaction, communication, and imagination associated with a narrow range of repetitive activities"

Sufficient training with those who have AS (sometimes more than 100 sessions) has consistently produced a decrease in the theta/beta power ratio (4 – 8/13 –21) with the clearest change being an increase in SMR. In those clients where pretesting of the IQ was possible, increases of about 10 points were found. TOVA data were inconsistent since those with Asperger's syndrome often scored well even prior to training. Parents noted remarkable improvement in social interactions: children went from having no friends to initiating and maintaining some peer friendships. The largest improvements were in those who received > 80 sessions. AS were sometimes initially hard to evaluate because they were nervous in a new situation and did not like the feeling of having their scalp and ear lobes prepped but they usually became easy to work with once they knew the routines.

Conclusions:

We hope that sharing our results will encourage others to work with people with AS. They are an interesting group and refreshingly honest. (The first adult client we had with AS was very matter-of-fact in pointing out all the syntax errors he found in *The A.D.D. Book,* which he had been given so he could read the chapter on Neurofeedback.) EEG biofeedback for AS is based on the differences found in the EEG and these patterns do make sense in terms of the symptoms seen. Excess slow wave activity corresponds to being more in their own internal world; low SMR is consistent with fidgety and impulsive behavior, anxiety and also with the tactile sensitivity exhibited by many; high left prefrontal and frontal slow wave activity is consistent with lack of appropriate inhibition; high slow wave activity in right parietal-temporal areas is consistent with the inability to easily interpret social

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Neurofeedback for Asperger's

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cues and emotions; high slow wave activity at or near F4 may correspond to difficulties with appropriate social communication. Improved social interaction found in conjunction with EEG shifts toward more activation in these areas is a logical outcome. More activation also means more alert to the outside world and thus better able to benefit from socialization efforts taking place outside of the neurofeedback training. The positive results support neurofeedback as an intervention that helps the person with AS both in terms of their own self-regulation skills and in terms of being able to benefit more from the other social interventions that should also be in place. Children with AS should not be exposed to settings where children with behavior problems predominate such as some special education classes and social skills groups. Neurofeedback needs to be coupled with practicing appropriate behaviors in school, home and other social environments where people are kind and where social behavior is consistently modelled.

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Research Methodology

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dent variable has on the dependent variable. In the prayer study, the effect size can be loosely defined as the difference between the mean hospital time and the mean fever duration in the two groups. Since remote retroactive prayer was predicted to have an effect, we must assume that the author intends to make a statement about effect size even though he fails to define a mechanism for the effect.

Cohen (1994) outlined how small, medium, and large effect sizes can interact with factors such as sample size, error, and both statistical and practical significance. Essentially, the larger the sample size, the easier it is to get statistical significance. From a statistical perspective, the larger the sample size the better the sample mean point estimates the population mean, and the narrower the sampling distribution. It follows that the narrower the sample distribution, the less the distributions overlap and the more likely we get statistically significant differences. In the large N prayer study, it is easy to see why there were statistical differences, even with a tiny effect size. In other words, given a large enough sample size, it is easy to show statistically significant differences. Does it have any clinical significance? Apparently it doesn't.

True experiments, like this one, are said to have higher external validity than small sample or N=1 studies. That is, they can be generalized more easily to the real world.

Let's look more closely at two important concepts that affect the ability of researchers to control for factors in an experiment, internal and external validity. These concepts were made famous by Campbell and Stanley (1963). Essentially internal validity is the degree to which an experimental scheme is methodologically sound and free of the influence of extraneous variables. An experiment is internally valid if it shows a cause-effect relationship between the independent and dependent variable.

Leibovici came up short of claiming internal validity in his experiment, but did hint that prayer is associated with reduction of hospital time and fever. The problem here is the changes could also be associated with phases of the moon, the tides, and changes in the Dow Jones average. Why? Because these other variables were not taken into account. In fact, it could be safely said, the perfect experiment on human behavior has yet to be done. If we look long enough and hard enough, we can always find both fault and virtue with a true experiment.

Social Psychologist Donald Campbell, late of Lehigh and Northwestern Universities, led psychology in an effort to clean up its research nest. Campbell, who proposed what he called "evolutionary epistemology" as a unifying theory of knowledge, had as a major focus throughout his career the study of false knowledge -- the biases and prejudices that poison everything from race relations to academic disciplines where erroneous theories are perpetuated by those with vested interests in them. " (Northwestern University, 1999)

Let's review some of the basics: External validity is the degree to which experimental results may be generalized to other situations and populations, i.e. the real world. Typically, group research employing random sampling and random assignment to groups will initially possess higher external validity than will studies that do not use random selection/assignment such as case studies and single-subject experimental research that do not use random selection/assignment. Traditionally, single subject designs and case studies, using subjects as their own controls, have high internal validity and low external validity while completely randomized group outcome true experiments are the reverse, lower in internal validity and higher in external validity Matheson, Beauchamp and Bruce (1978). There are thousands of controlled outcome studies that claim to have yielded significant treatment effects but may in fact not have (Matheson, D., 2002).

Quasi-Experiments

"For generations, virtually no respectable researcher this side of the orbiting space lab has designed or carried out a reputable scientific study without an understanding in what Campbell called quasi-experimentation, the highly sophisticated statistics-based approach he invented to replicate the effects of the truly randomized scientific studies that are all but impossible in the complex world of human behavior" (Northwestern University, December, 1999. Quasi-experimentation literally means "almost" experimental implying that the procedure tries to emulate a true experiment without the support of random sampling or has incomplete control over fundamental variables.

After the smoke clears and the dust settles, the prayer study then was not a "true experiment," but rather a quasi-experimental design because extraneous variables were not controlled.

So, random sampling may not be the panacea previously thought. What happens if the sampling procedure is so restrictive that it prevents a study from adequately representing a population? Zimmerman, Mattia and Posternak (2002) observed that methods used to evaluate the efficacy of antidepressant medication differ from treatment for depression in routine clinical practice. (Zimmerman et. al. 2002)

The Inclusion/exclusion criteria narrow the demographics of the sample in order to limit the effects of extraneous variables. Used primarily in drug trials, the set of inclusion/exclusion criteria specified in these clinical trials applies primarily to efficacy trials evaluating the potential of a treatment (drug) when taken as prescribed. Zimmerman et. Al. (2002) found that the inclusion/exclusion method seriously restricts the size of the usable sample. Of the 803 participants in their clinical sample of depressed individuals, 86% would have been excluded from clinical trials because they had co-morbid symptoms including bipolar or psychotic disorders, suicidal tendencies, were not depressed enough, or had other symptoms leading to exclusion. How representative of the "real world" patient populations are such clinical trials?

The authors concluded that the remaining patients (N=252) were not representative of real world clinical practice and in fact represent a minority of patients treated in clinical practice. If clinical research is reduced to not being applicable to clinical practice, what good is it?

The inclusion/exclusion method

runs the serious risk of reducing the external validity of a study to make it of questionable value to the clinical practitioner. If we can't generalize to our situation, where is the utility?

What to do:

So, what do we do as clinicians and researchers to glean some truth out of the literature? Obviously the answer is complex, unclear, and may sound vague. We do the best we can to evaluate the literature realistically. We must keep in mind that fact that most of the literature of psychology is based on sophomores in college taking Introductory Psychology classes and participating in experiments for extra credit or class requirement or rats kept in galvanized cages in some dark laboratory colony. The concepts of internal and external validity are guidelines that help readers evaluate the utility of studies (proposed or published).

One solution is to keep the internal validity high by doing N=1 studies. There is no problem with individual differences because there are none. To evaluate these studies Gottman and Leiblum (1974) offer a solution. They suggested using a Shewart Chart (used in quality control in manufacturing) to evaluate behavior change in N=1 studies. Essentially, it involves using a confidence interval approach about the mean of ongoing behavior over at least 40 or more trials. To visualize, draw an X and Y axis. Plot the data for a baseline period before intervening. One must be careful here to insure that the baseline shows random variation and independence. If the baseline is not independent, the concept of autocorrelation is introduced (Gottman and Leiblum, 1974, pg. 144) and steps must be taken to transform the data to alleviate autocorrelation.

Autocorrelation exists if knowing about one thing reduces the uncertainty about the other. With autocorrelation, we can predict the future by knowing the past and obviously the data are not independent. Once we know that the baseline is independent, we calculate the mean and standard deviation of the data over this period. Extend a horizontal line from left to right representing the mean. Similarly extend two other horizontal lines representing two standard deviations above and below the mean. Plot the behavior. Whenever the behavior drifts beyond the two standard deviation interval, we might say the behavior has changed significantly.

The other approach is to actually do a randomized controlled outcome study using a sample that does not include college sophomore or a restricted inclusion/exclusion method. This approach is difficult, if not impossible. How do I find a large sample of participants suffering from spasmodic torticollis or OCD while controlling for age, gender, and length of time in diagnosis?

The answer lies somewhere in between. Our government (FDA) has taken serious strides to improve the interpretation of drug effects, claims about biofeedback instruments, and clinical research, in general to protect the citizenry from harm, and that's good. However, some think it's overkill. Sampson (1978) complained that the FDA often drags its feet because efficacy studies, double blind studies, and huge inclusive/exclusive studies are not available to support the use of some drugs. The case in point is the drug Chymopapain, an enzyme injected into damaged spinal lumbar spinal disks to reduce pain and suffering by relieving the pressure from the nerve roots. The drug is widely used in Europe and Canada, but at the time, not available in the US because of the control issue listed above.

Meanwhile, back at the ranch, people were suffering. Sampson (1978) clearly felt that political issues were involved and the lack of big studies that yield questionable results might be problematic.

Wittenberg R, Oppel S, Rubenthaler F, & Steffen R.(2001) found, in a randomized study, done in Germany, that after 5 years, good and excellent results were observed in 72% of the chymopapain group. That is, nearly 3/4 of the patients in the trial benefited from the enzyme.

An issue with our body of knowledge is that only significant results are usually published. What about all the studies that don't make the cut? Driving up a one-way street the wrong way (assuming you don't crash) can be a learning experience. We learn what not to do the next time. The only way for biofeedback clinicians to improve their clinical services is to be aware of the pitfalls of bad research and try not to make the mistakes of others. There is no substitute for knowledge of and about research methods. I remember a quote from one of my statistics professors who related, "If you don't believe in something, you will fall for anything." Most of us believe in the scientific method, but we must use it judiciously and correctly if we are going to flourish as a discipline. We have to have more than Dr. Dean Edell reviewing the literature, telling us what is good and bad, and understanding the issues involved in research.

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Chemistry of Respiration and the Breathing Heart Wave

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Heart Rate Variability: The Breathing Heart Wave

Wellness is ultimately about embracing, about the heart, about bringing together the mindfulness of physiology with the personal consciousness. Health is about seeking, presence, and availability, not about ego and defensiveness the breathing heart wave speaks to the physiology of this thinking.

Heart rate changes in cycles. These cycles comprise what is known as heart rate variability or HRV as it is known in the literature. One of these cycles tracks the breathing pattern: breathing in increases heart rate, and breathing out decreases heart rate (also known as the respiratory sinus arrhythmia, or RSA). This pattern of heart rate change (variability) increases in amplitude as one relaxes, decreases in amplitude as one becomes tense, and disappears altogether when one becomes highly anxious, stressed, or fearful.* Monitoring this heart rate cycle, the *breathing heart wave,* provides for direct observation of parasympathetic nervous system activity, and is hence known as the *parasympathetic HRV frequency*.

Heart rate VARIABILITY, where rate tracks breathing as described above, is a significant physiological marker to good relaxation training, *and should not to be confused with heart RATE itself*. Variability is measured by looking at heart rate changes from beat to beat. That is to say, heart rate is recalculated with every beat, and is not averaged with preceding beats as is usually done in monitoring heart rate by healthcare professionals and performance trainers. Monitoring relaxation based on average heart rate, rather than variability, is an insensitive and unreliable measurement tool. In fact, relaxation often does not result in reduced heart rate (averaged value), nor does anxiety necessarily result in elevated heart rate.

Breathing training for relaxation includes good breathing mechanics (e.g., diaphragmatic), good breathing chemistry, and the establishment of a reliable high amplitude breathing heart wave.

Heart Rate Variability: Other Frequencies

When changes in heart rate are analyzed formally, as in a Differential Fourier Transform (DFT) by frequency, the predominant frequency ranges of heart rate variability can identified by their higher amplitudes. Three such relatively high amplitude frequency ranges have been proven to be sensitive indicators of autonomic nervous system regulation and associated changes in emotion, alertness, attention, and stress. These are the Very Low Frequency (VLF, 0.0033 to 0.04 Hz), Low Frequency (LF, 0.04 to 0.15 Hz), and High frequency (HF, 0.15 to 0.4 Hz, RSA, or breathing heart wave) ranges. Monitoring and recording HRV in these frequency bands has proven useful in tracking and evaluating autonomic nervous system function.

†† The HF frequency band is widely known as the parasympathetic HRV frequency band whereas the LF frequency band is sometimes referred to as the sympathetic HRV frequency band. The parasympathetic (HF) and sympathetic (LF) ranges of heart rate variability are only two regions of the HRV spectrum that are of interest to practitioners reviewing the practical implications of an extensive HRV research literature. A third frequency band is VLF, which has recently been associated with ruminative thinking and is now of serious interest as well. These three frequency domains along with the ultra low frequency domain (ULF) are also of interest to researchers who study HRV behavior and its relationship to the presence of cardiovascular disease.

A note of caution: Conventionally, the range of HRV frequencies associated with parasympathetic tone (the RSA) is often restricted to the High Frequency (HF) band of 9 to 24 cycles per minute. Although this assumption may be misleading, the HF band is nevertheless often taken to be a realistic frequency range for breathing rate and therefore for parasympathetic tone (the RSA).

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**Important note: Greater breath size resulting from the slowing of breathing and/or diaphragmatic breathing may have a significant impact on the amplitude of the breathing heart wave (RSA), and should not be confused with an increase in parasympathetic activity.*

*Measurement of Ed-Tidal CO_2 :

The presence of a gas is measured in terms of its pressure, and more specifically in terms of its relative pressure contribution to total atmospheric pressure, i.e., its partial pressure. Total atmospheric pressure on a standard day at sea level is 760 millimeters of mercury (mmHg), and is comprised of the partial pressures of all of the gases present in the air, e.g., partial pressure oxygen is 19 percent of the total pressure, or 144 mmHg. Carbon dioxide in atmospheric air is so low that capnometer readings during inhalation are nil. At rest, exhaled $ETCO_2$ should be approximately 5 percent of the total pressure, or 38 mmHg (also known as units of torr). Individual metabolism varies; normal range is 35 to 45 mmHg, increasing with exercise.

From the Editor

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issues, please do so via email to me at dmatheson@uop.edu.

From time to time people ask what the Biofeedback Society of California is about. Searching our web page I found an undated statement and have taken the liberty to revise the document. While this revision is not official, I would like suggestions, yea or nay, about the revision. Please email your comments to and we will make your responses known in the next issue.

Mission Statement: Biofeedback Society of California

Based on well-documented principles of human learning, Biofeedback is a non-invasive form of treatment and training. The therapist attaches sensors or electrodes to the body and these sensors provide information—feedback—which is displayed visually or by sound for the patient to see and/or hear. The signals typically measure muscle tension, brainwave function, heart and respiration information, and/or skin temperature. With this information, patients can learn to make changes so subtle that at first they cannot be consciously perceived. With practice, however, the new responses and behaviors can help improve quality of life and to bring relief from a variety of disorders, including headache, stress, anxiety and depression problems, attention problems (ADHD), cardiovascular and respiration disorders, to name a few. Biofeedback is also used to improve performance in school, in sports and in business.

Founded in 1975, the Biofeedback Society of California is the oldest and largest state biofeedback society and the first biofeedback organization to offer professional certification. It is an open forum for the exchange of ideas, methods, clinical experience, and results of biofeedback and applied psychophysiology and related disciplines.

The emphasis of the Society is on clinical application and scientific research and the society provides local networking, educational meetings and referral services. Specifically the main objectives are to:

1) Advance biofeedback and applied psychophysiology in educational, scientific, clinical and personal growth areas of development,
2) Educate professionals and the public,
3) Develop practice standards and ethics,
4) Provide criteria concerning who may apply biofeedback and under what circumstances,
5) Provide peer review, and
6) Provide standards for the evaluation of biofeedback and insure certification of individuals practicing biofeedback.
7) To provide information and mentoring to those wanting to learn about biofeedback practice.

From the President

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a result, BSC has invited AAPB to participate in our annual conference by co-sponsoring workshop and general session speakers. We will start to explore involvement with our neighboring state societies.

3. 36% want conference topics to include RSA. As a result, BSC will hold a workshop, several short courses, and a panel on RSA this next year.
4. 48% want conference topics to include equipment and software. As a result, the BSC will support several vendor demonstration and training opportunities. Hardware and software vendors will have how-to-do articles in the newsletter.
5. 71% want national biofeedback leaders to speak at our annual conference. AAPB has agreed to sponsor two well-recognized speakers at our joint conference next November. As a result, BSC has invited Dr. Paul Lehrer and Dr. Ted La Vaque to participate in next year's BSC annual conference. Stay tuned for more details. Other national leaders will be announced soon.

The Biofeedback Society of California would like to remind all members that they have a voice and that the society will continue to rededicate our mission to meeting the needs of our members.

Please let us know how we can help you today.

BSC'S PHONE NUMBER IS (800) BSC-6966 [(800) 272-6966]
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