Polygraph

VOLUME 38 2009 NUMBER 2

Contents

Published Quarterly

P.O. Box 8037, Chattanooga, Tennessee 37414-0037

A Respiration Primer for Polygraph Examiners

Mark Handler, Joel Reicherter, Raymond Nelson, and Chris Fausett

"Divide each difficulty into as many parts as is feasible and necessary to resolve it."
- Rene Descartes

Introduction

The analysis of Psychophysiological Detection of Deception (PDD) data relies on the mathematical combination of scores assigned to a fixed set of physiological parameters. These parameters can be recorded and measured for their differential response to various stimulus questions describing past behavioral acts, and then inferentially and empirically correlated with attempts to deceive (ASTM International, 2002; Bell, Raskin, Honts & Kircher, 1999; Handler, 2006; Kircher & Raskin, 1988, 1999, 2002; Krapohl & McManus, 1999).

One of the required physiological signals in PDD testing is that of movement associated with pulmonary ventilation (breathing) (ASTM, 2002; Bell, Raskin, Honts & Kircher 1999; Department of Defense Polygraph Institute [DoDPI], 2006). Respiratory data are generally obtained via a pneumograph transducer placed around the thorax and abdomen of the test subject. Breathing movement is graphically displayed for evaluation by computer algorithms or traditional hand-scoring methods. When recorded electronically, the data are digitized and stored in numerical form.

PDD examiners have historically evaluated breathing movement data through a subjective approach that relies on the presence or absence of various signature patterns indicative of deception (DoDPI, 2006). Timm (1982a; 1982b) introduced the concept of the Respiration Line Length (RLL) as an objective, though general, measure of increases or decreases in respiration activity. RLL is obtained by measuring the length of the graphical respiratory wave form for a specified period of time and is evaluated by comparing one line length to another. Empirical studies have shown that greater decreases in breathing movement as measured by RLL are correlated with increased salience of stimuli during PDD testing (Harris, Horner & McQuarrie, 2000; Kircher, Kristjansson, Gardner, & Webb, 2005). Empirically-based hand-scoring methods emphasize only those patterns that have been reliably correlated with deception and most of those patterns result in decreased RLL (ASTM International 2002; Bell, Raskin, Honts & Kircher, 1999; Handler, 2006; Kircher & Raskin, 1988, 1999, 2002; Krapohl & McManus, 1999).

This paper is offered as a primer for the prospective and practicing polygraph examiner with respect to the "respiration channel" in PDD testing. It will provide descriptions of the physical organs and the mechanical properties involved in pulmonary ventilation. The paper will discuss some of the putative neural substrates that contribute to rhythmic breathing and those involved in

Authors' Note

The authors are grateful to Chuck Slupski, Toby McSwain, Pam Shaw, Don Krapohl, Dr. Tim Weber, Dr. Charles Honts and Dr. Stuart Senter for their thoughtful reviews and comments to drafts of this paper. The views expressed in this article are solely those of the authors, and do not necessarily represent those of the Lafayette Instrument Company, the American Association of Police Polygraphists or the American Polygraph Association. The authors are grateful to the Lafayette Instrument Company, Lafayette, Indiana for their generous contribution which allowed the purchase of the software used to create the diagrams in this article. Questions and comments are welcome at polygraphmark@gmail.com.

altering that rhythm. It will offer evidence contrary to the historically taught "fight or flight" concept as the underlying cause of arousal and suggest the Orienting Response as an alternative hypothesis. Finally, the paper offers suggestions as to how it may be possible to extract more diagnostic information from the respiration channel and calls for further research.

Brief description of respiratory system and the mechanics of breathing

The primary function of the respiratory system is to supply the cells of the body with oxygen and to vacate the body of carbon dioxide. Pulmonary ventilation or breathing describes the collective actions that move air into and out of the lungs. External respiration describes the exchange of oxygen for carbon dioxide in the alveoli. Internal respiration describes the exchange of oxygen for carbon dioxide between the tissues and blood. Cellular respiration describes the cellular metabolic reactions that consume oxygen and produce carbon dioxide. PDD testing relating to this phenomena focuses on the first aspect, pulmonary ventilation (breathing), or the moving of air into and out of the lungs (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993).

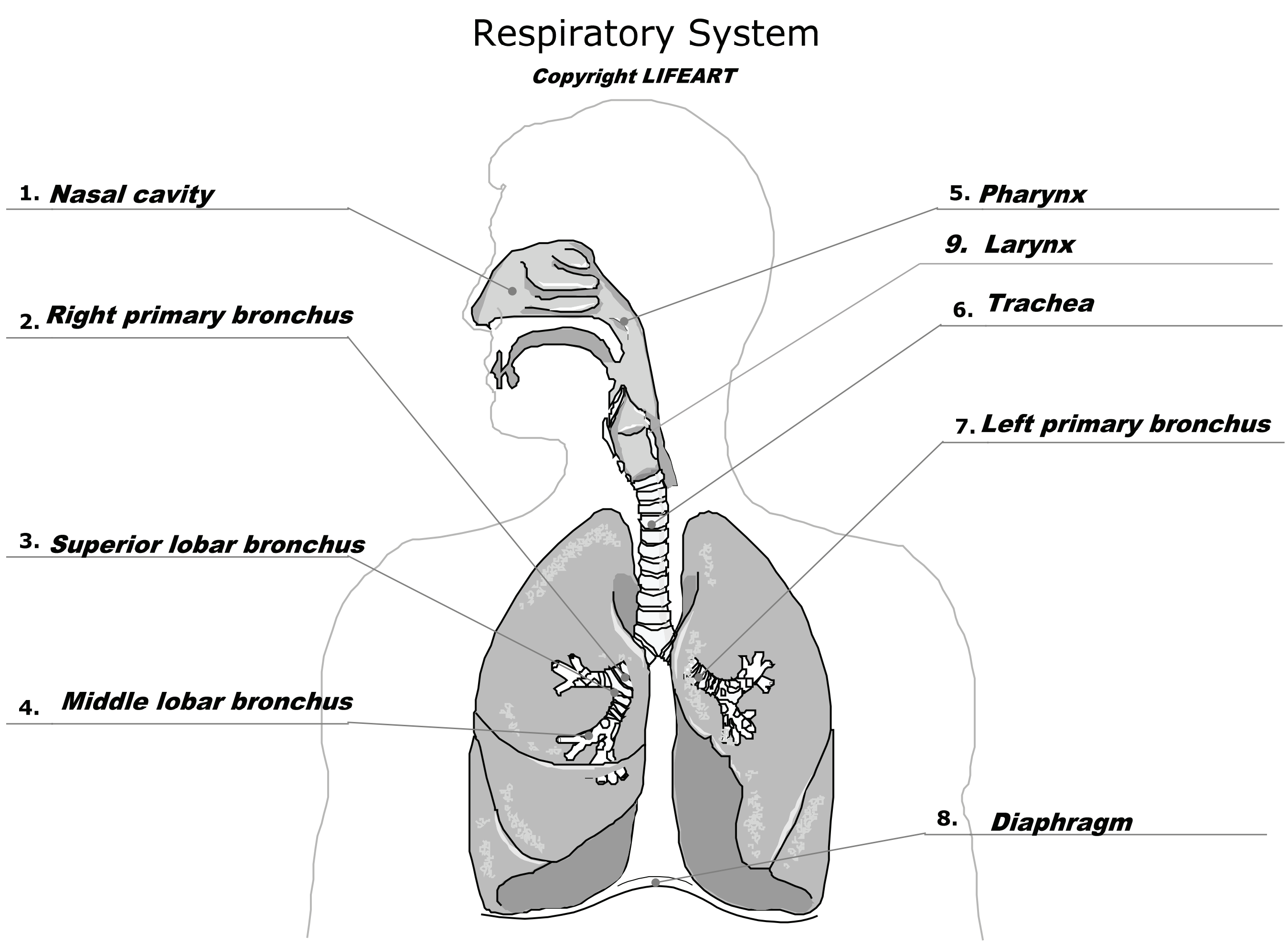

Figure 1 - A basic diagram of the airway path. Copyright LIFEART and reprinted with permission of LIFEART and SmartDraw, Inc.

Breathing involves moving air through the airway (dead air space) composed of the nasal cavity, pharynx, larynx, trachea, bronchi bronchial tree then into the lungs. The airway, through which the air travels, warms, humidifies and cleans the air before directing it to the lungs. The nasal passageway contains olfactory receptors which are unusual in that their input bypasses the thalamus and is sent directly to cortical and limbic system areas of the brain that stimulate memory. The pharynx connects the nasal cavity and mouth to the larynx. The larynx is composed primarily of cartilage, vocal cords and other connective tissue, and connects the pharynx to the trachea. The trachea, composed of C shaped cartilaginous rings, is a flexible tube that connects the larynx to the bronchi. The bronchi enter the lungs and branch out to form secondary and tertiary bronchi leading to terminal bronchioles and finally into alveoli air sacs. Pulmonary capillaries surround the alveoli sacs providing the pathway for blood flow to and away from them. It is at this junction the exchange of oxygen for carbon dioxide takes place (Harver & Lorig, 2000; Marieb, 1999; Tortora & Grabowski, 1993). (See Figure 1.)

Smooth muscle of the airway from the trachea through the bronchioles is under control of the autonomic nervous system. Stimulation of adrenergic sympathetic fibers causes dilation of the bronchial muscle and decrease in mucous secretion. Evolutionary adaptations have apparently resulted in the bronchial smooth muscles being normally under greater parasympathetic control. This results in a tendency towards constriction of and increased secretion of mucous.

Ventilation Dynamics

The mechanics of breathing generates a pressure differential between the inside and outside of the lungs, causing air to move one direction or the other. Air, as with fluids, moves from areas of higher pressure to lower pressure regions. Just before inspiration, the differential pressure between the inside and outside of the lungs (intrapulmonary pressure) is zero and there is no air movement. The act of breathing causes the pressure inside of the lungs to be lower than that outside and thus air flows inward (Boyle's Law), similar to the concept of drawing a fluid up into a syringe. This negative intrapulmonary pressure is made possible by the expansion of the lungs resulting from the ventilation dynamics of the diaphragmatic and intercostal muscles (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993).

The muscles of normal, quiet inspiration (eupnea) include the diaphragm and the external intercostals. The diaphragm is a large, domed shaped muscle that separates the abdominal cavity from the thoracic cavity. The diaphragm is attached to the sternum and is the muscle most responsible for eupneic breathing. During normal quiet breathing the diaphragm contracts, causing it to descend about one half inch into the abdominal cavity. This results in stretching the thoracic cavity downward, increasing its volume. The diaphragm is innervated by the bilateral phrenic nerves which leave the spinal cord at the third, fourth and fifth cervical segments (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993).

Simultaneously, contractions of the intercostal muscles lift the rib cage and pull the sternum outward, like a handle on a bucket. The external intercostal muscles are innervated by nerves leaving the first through the eleventh thoracic segments of the spinal column.

Since the lungs are passive, they have no capacity to expand or contract on their own but rather are subject to external forces; much like a sponge absorbs and releases water. Each lung is encased by one continuous serous tissue folded over itself called the pleural membrane. The parietal pleura portion is attached to the outer wall of the thoracic cavity with the visceral pleura bonding directly to the lungs. This creates a small space between the two pleurae which is called the interpleural space or pleural cavity. Both pleurae secrete a fluid into the cavity which reduces friction between them. Just prior to inspiration, the pressure within the pleural cavity is about 4mmHg below atmospheric pressure. This negative pressure between the pleura membranes keeps the lungs sucked to the chest wall thus preventing them from collapsing inward. As the thoracic cavity expands, the lungs are pulled into an expanded mode, reducing the pressure in the alveoli (intrapulmonic pressure), resulting in air pulled into the lungs (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993). (See Figure 2.)

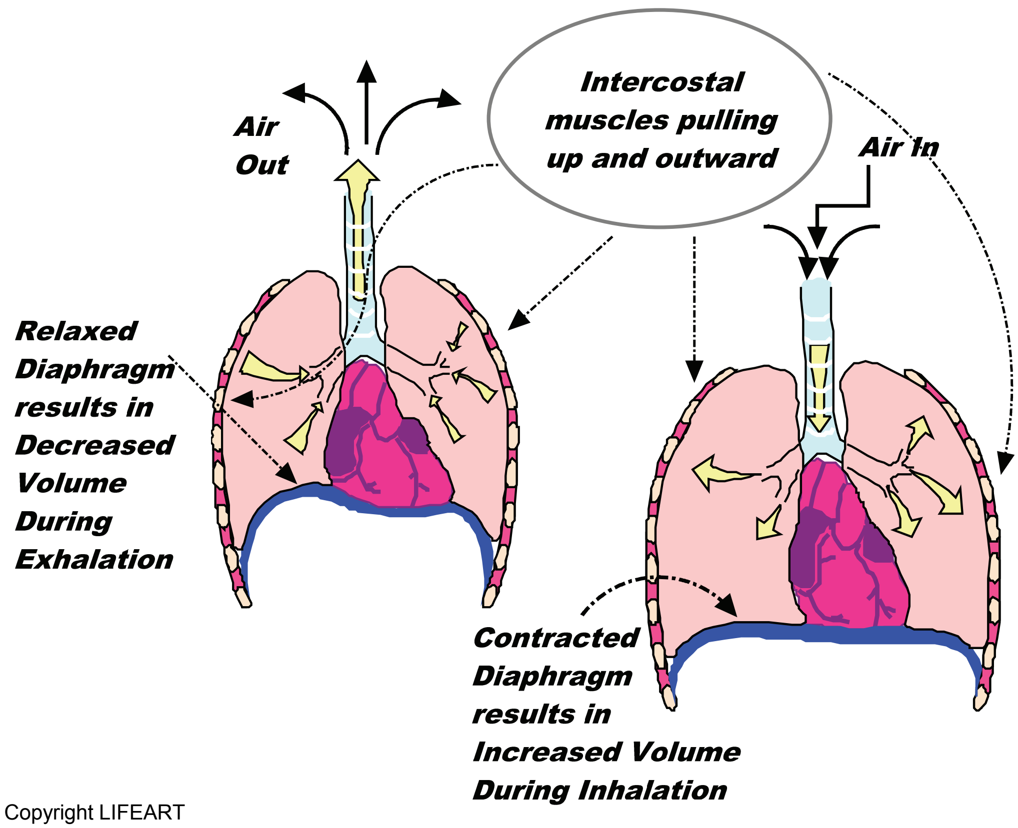

Figure 2 - Diagram showing how thoracic volumetric changes move air into and out of the lungs. During inhalation, the increase in the volume of the thoracic cavity results in air being drawn into the lungs. Copyright LIFEART and reprinted with permission of LIFEART and SmartDraw, Inc.

The combination of the contractions of the diaphragmatic and intercostal muscles results in an action that increases the thoracic cavity by approximately 500 milliliters. This increase causes a drop of intrapulmonary pressure of about 1-2 mmHg and air rushes into the lungs.

Expiration during eupnic breathing is passive and is accomplished through the elastic nature of the lungs and relaxation of the inspiratory muscles. As the muscles relax and the lungs recoil, the volume of the thoracic cavity decreases and there is no longer a difference in pressure between the inside and outside of the lungs. Additionally, alveoli ducts and bronchioles have elastic fibers that recoil inward, expelling air. Finally, inward pull resulting from the surface tension of water vapor in the alveoli also contributes to lung volume decrease. The intrapulmonary pressure rises to about 1 mmHg above atmospheric pressure to force air out of the lungs (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993).

Regulatory Control of Breathing

Vegetative regulations of visceral body organs, including breathing dynamics, are controlled in part by nuclei and centers in the brain stem. The respiratory rhythmicity centers are located in the lower brain stem, medulla oblongata, with refining regulatory centers in the pons (see Figure 3). In the medulla, the rhythmic respiratory center is comprised of two distinct respiratory areas known as the dorsal respiratory group (DRG) and the ventral respiratory group (VRG). The DRG neurons are the primary innervators of the phrenic nerve and thus the diaphragm muscle (Harver & Lorig, 2000; Heimer, 1995; Janig, 2006).

The VRG, a column of individual nuclei stacked upon one another, contains mostly expiratory neurons and receives drive input from the DRG. The VRG is also involved in innervating the larynx and pharynx via vagal motoneurons which assists in maintaining airway patency. During inhalation, the VRG innervates the external intercostal muscles and has some connection to the phrenic nerve. Expiratory neurons originating in the VRG project to the internal intercostal muscles and abdominal muscles but these function mostly during intense and rapid exhalation such as during exercise when passive exhalation would take too long.

Modulatory centers such as the pontine respiratory group (formerly called the pneumotaxic) and a putative "apneustic center" located in upper area of the pons (see Figure 3) appear to be associated with phase-related activity. If nuclei exist that form an apneustic center it seems they may function as a "cut off switch" terminating inspiration. While this center has not been positively identified, it is presumed to be located at about the same level as the pontine respiratory group. Investigators who have experimentally transected the brain stem at this level have been able to produce apneusis (inspiratory spasms or cramps) but only if they also sever the vagus nerve. This suggests any "apneustic center" that exists receives input via the vagus nerves in order to prevent apneusis (Hlastala & Berger, 1996; Levitzky, 1999). While not well defined, the function of the respiratory related neurons in the pons seems to be to "fine tune" the action of eupneic respiration helping to provide a smooth transition between inspiration and expiration. The ponto-medullary respiratory rhythmicity center, however, can be influenced by the emotional limbic system centers as well as the cognitive cerebral cortical areas (Hlastala & Berger, 1996; Levitzky, 1999).

Reflexes in the breathing cycle

Stretch receptors within the airways have the potential to influences the respiretory cycle. One such stretch receptor reflex, known as the Hering-Breuer inflation reflex, can result in decreased respiration drive. As the lungs expand through pulmonary inflation, it activates the sensors of these stretch receptors which project via the vagus nerve to the DRG and the pontine respiratory group. The end result is bronchial dilation and increased expiration time resulting in a decrease in respiration rate.

This seems to be a protective reflex which has developed to prevent the lungs from over-expanding (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993).

Irritant receptors are located throughout the airway and can be activated by such things as certain chemicals, gasses, smoke, dust and very cold air. Activation by these vectors is transmitted primarily by the vagus nerve and can result in bronchial constriction which functions to protect the airways from the noxious agent (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993).

Chemoreceptors are located centrally in the medulla and peripherally in the great vessels of the neck. The central chemoreptors are exquisitely sensitive to carbon dioxide, which is the most tightly controlled chemical factor. Carbon dioxide diffuses into the cerebral spinal fluid and forms carbonic acid which liberates hydrogen ions resulting in a drop in the pH of the cerebral spinal fluid. It is these hydrogen ions that actually excite the central chemoreceptors in the medulla which in turn stimulates ventilation. The peripheral chemoreceptors, however, are more responsive to oxygen levels in the blood. Chemoreceptors sensitive to oxygen are located in the aortic and the carotid bodies. If the circulating level of oxygen drops substantially, these act to stimulate respiration rate and depth. Under normal conditions, oxygen levels in the blood affects breathing only indirectly by enhancing the sensitivity of the central carbon dioxide sensors (Harver & Lorig, 2000; Hlastala & Berger, 1996; Levitzky, 1999; Marieb, 1999; Tortora & Grabowski, 1993).

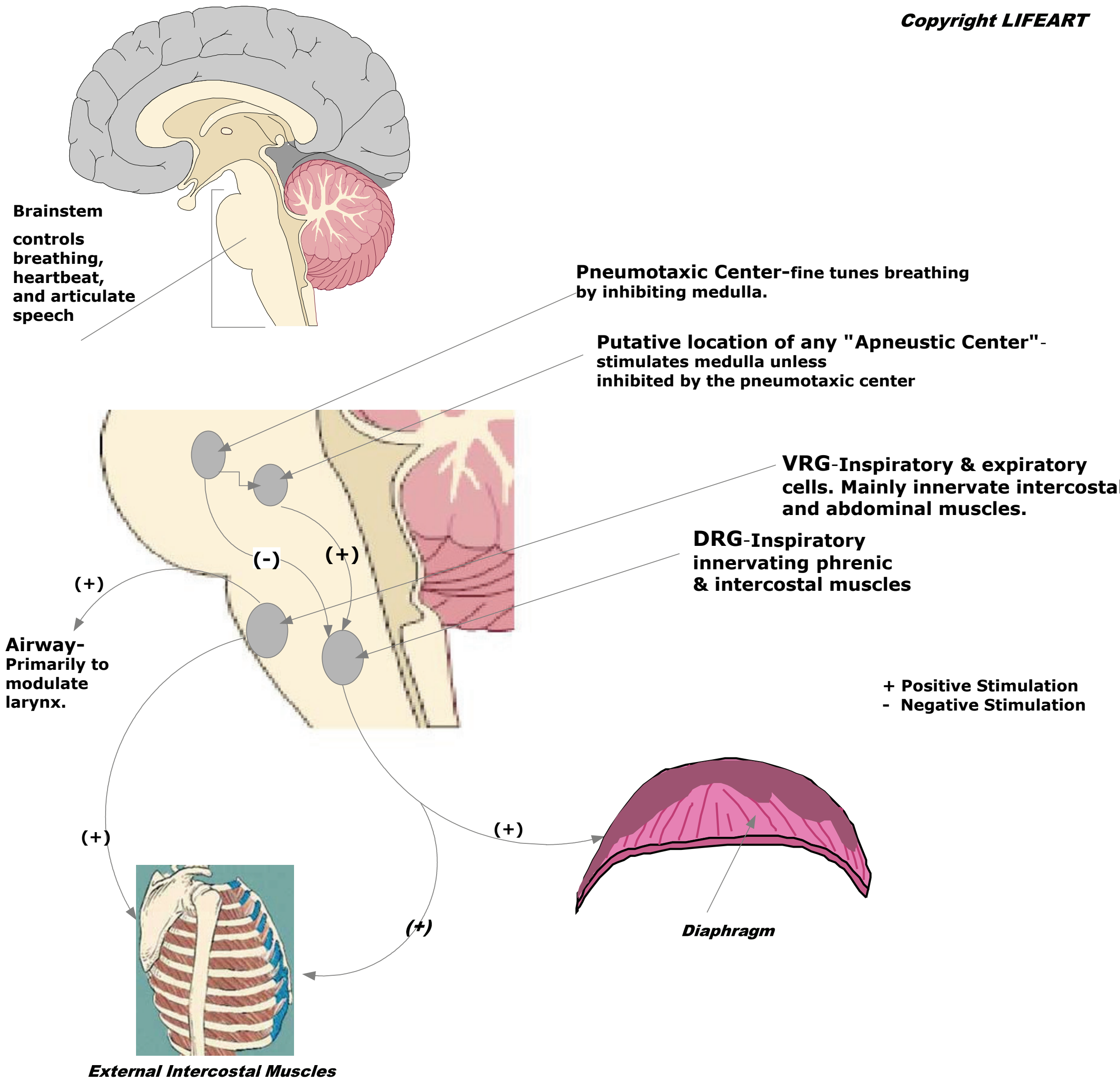

Figure 3 – General locations of central nervous system nuclei responsible for rhythmic regulatory control of breathing. DRG and VRG generalized location and effects on the diaphragm and intercostal muscles during eupneic breathing.
Copyright LIFEART and reprinted with permission of LIFEART and SmartDraw, Inc.

Hypothalamic Integration

The hypothalamus is a collection of small nuclei located at the base of the forebrain in the ventral portion of the diencephalons (below the thalamus). The hypothalamus may be physically small, about 1% of the brain, but is metaphorically a grand maestro in the orchestration of bodily functions. The hypothalamus regulates a wide range of physiologic and behavioral functions and is the key controlling and integrating agent for homeostatic functions via the autonomic nervous system. The behavior control column of the hypothalamus is important to aspects of breathing control as it projects to somatomotor and autonomic control centers in the brain stem and spinal cord that determine respiratory behavior. Emotional, motor control and cognitive states generated in the telencephelon direct the hypothalamic activity, often via the behavior control column (Janig, 2006) (see Figure 4).

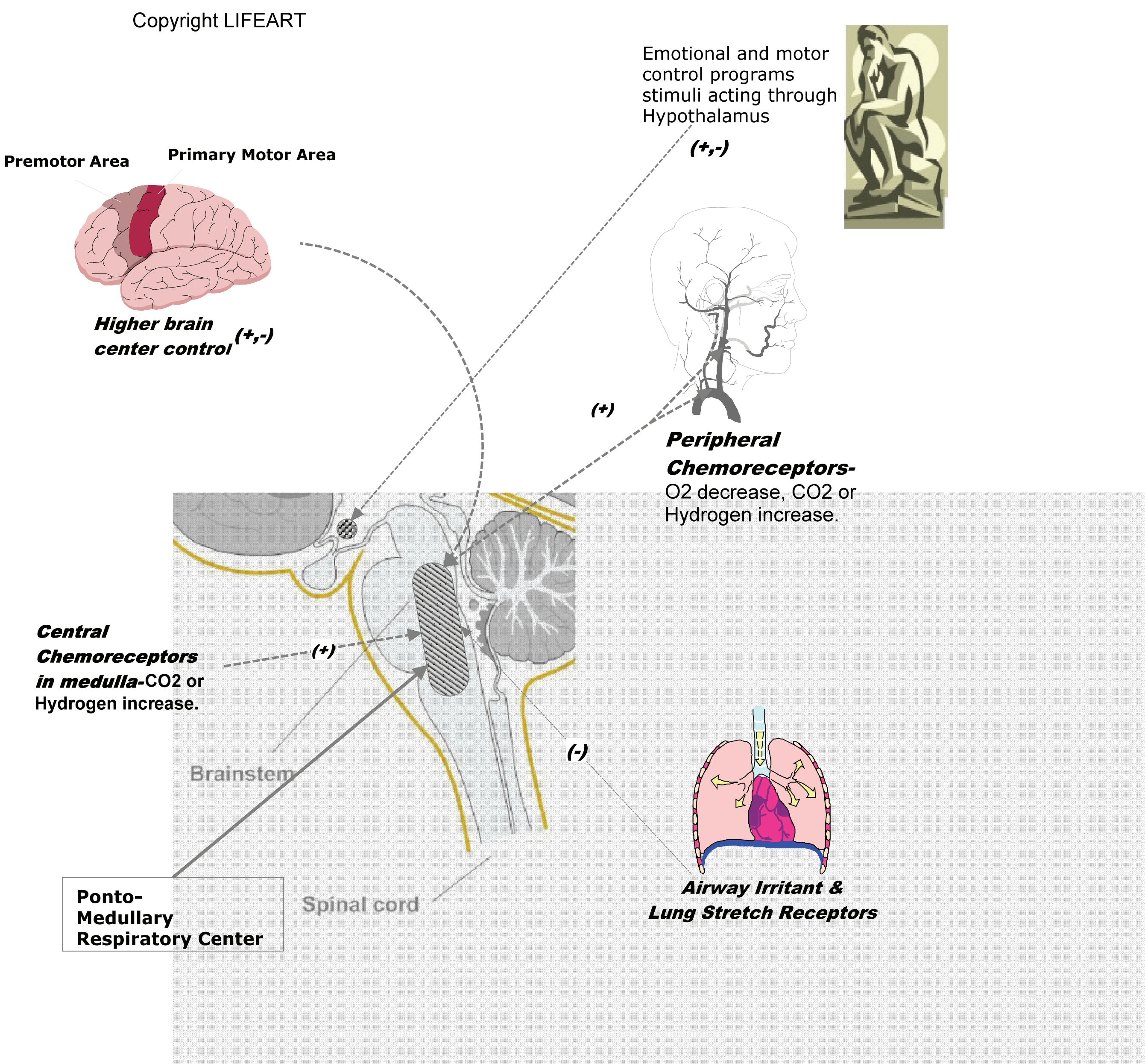

Figure 4 - Chemical and higher order regulation of breathing. Inhibitory influences are denoted with a (-) and excitatory influences by (+).
Copyright LIFEART and reprinted with permission of LIFEART and SmartDraw, Inc.

Inhibition of breathing and a review of the Orienting Response

Breathing inhibition has been found to be a reliable indicator of arousal during polygraph testing (Harris et al., 200l; Kircher et al., 2005; Nelson et al., 2008). A number of theories have been proposed to explain the underlying cause of arousal during PDD testing (Handler & Honts, 2008, Handler & Honts, 2009; Kleiner, 2002; Lykken, 1974; Steller, 1987) and many of these incorporate some reference to the Orienting Response (OR).

The orienting response, first described by Pavlov (1927) as the "orienting reflex" was said to bring an immediate response in both human and animal to changes in their surroundings. Pavlov sometimes called it the "what is it" reaction, and noted it was of great significance for survival. Some of the stimuli that are known to cause an OR include: novelty, intensity, color, surprise, a conditioned stimulus, complexity, uncertainty or conflict (Pavlov, 1927).

The orienting response increased the probability of survival. Pavlov wrote "The biological significance of this reflex is obvious. If the animal were not provided with such a reflex, its life would hang at any moment by a thread" (Pavlov, 1927, p. 12). Pavlov's early description of the reaction discussed the postural changes and skeletal responses that seemed to be aimed at an investigatory and assessing response. These postural changes include: momentary cessation of motor activity (freezing), an orientation of the head towards the stimulus and an adjustment in receptors (pricking up the ears or a cocking of the head) towards the source of the stimulus. Pavlov believed the purpose of the OR was to prepare for better reception and response to a possibly threatening stimulus (Barham & Boersma, 1975) and he constructed the first known sound-proof room, "the silence tower", to study the OR.

Stimuli may be categorized as either signal or non-signal in nature. Signal stimuli are those that convey important information to the organism and may be regarded as significant (Sokolov, Spinks, Naatanen & Lyytinen, 2002). One example of a signal stimulus would be the sudden appearance of a deadly predator in the local area. Signal stimuli need not be physical in nature to solicit an OR. For example, verbal stimulus that captures the subject's attention can also invoke an OR. Non-signal stimuli, on the other hand, are those the organism considers neutral, and tend to convey no important information, such as different pure tones (Cacioppo, Tassinary & Berntson, 2000). Novel stimuli are initially signal stimuli as they convey to the organism that something new has happened and they reliably elicit an OR. If a novel stimulus is repeated but not paired with any meaningful consequence, the OR associated with it will decrease and eventually become extinct through a well-known process called habituation (Ohman, Hamm & Hugdahl, 2000). Habituated stimuli, though once novel, do not elicit ORs.

Significant stimuli are said to possess signal value, and can evoke an enhanced or greater OR (Gati & Ben-Shakhar, 1990). Sokolov (1963) determined that the significance or salience of a stimulus can affect the magnitude of an OR. He described signal stimuli as stimuli that are not novel but rather familiar and important. From a survival standpoint, it may be more beneficial to an organism to respond to a stimulus of known importance than one which is novel (Cacioppo, Tassinary & Bernston, 2000).
Sokolov found that an organism could self-assign salience to the particular stimulus and this salience may result from a previous experience or reflect an innate biologically programmed autonomic or behavioral response. While the OR can be an affectively neutral response, it may just as well be one that occurs concomitantly with an emotional stimulus (Ohman, Hamm & Hugdahl, 2000).

Signal value stimuli are thought to be associated with consequences which may be tied to memory (Ohman, 1979). An organism evaluates a stimulus and compares it to information stored in long-term or short-term memory. The current input is compared to active memory to determine if the stimulus is new and mismatched against previously encoded information, or if the stimulus matches an element of memory that has been primed to be significant (Cacioppo, Tassinary & Bernston, 2000). In either case, an assignment of novelty or significance can result in an OR. Both signal and non-signal

ORs may have the initial cognitive function of information intake and processing of the stimulus. In the case of non-signal stimuli, a mismatch results in the OR occurring. The organism may compare the stimulus to information stored in memory and assign signal value, based on recognition and possible consequences, resulting in a signal value OR.

Data have shown stimuli with signal value will elicit larger and more slowly habituating ORs than non-signal ORs (Siddle, Stephenson & Spinks, 1983). While the response patterns for signal and non-signal ORs were similar, the underlying purpose may differ. Non-signal stimuli, novel stimuli, can evoke responses that may signal the organism that a potentially harmful or dangerous situation exists and prepare the organism to deal with that situation. Signal stimuli are those that can be elicited by recognized or familiar stimuli that have some degree of known significance (Sokolov, 1963).

Descriptions of the physiological responses associated with the OR in humans are well documented (Darrow 1936; Lynn 1966; Sokolov, 1963). These include; increased skin conductance, decreased heart rate, vasoconstriction in the limbs, an initial *delay in respiration rate and decrease in frequency*, and an increase in general muscle tonus. Possible benefits of the physiological response of OR are: Increased palmar perspiration allows for better tactile differentiation (Darrow, 1933), better hand grip (Boucsein, 1992; Darrow, 1933), and protection against injury (Adams & Hunter, 1969). Increased plantar perspiration allows for better footing; (Boucsein, 1992) an obvious benefit to bare foot runners and tree climbing primates. Vasoconstriction mobilizes reserve blood flow in preparation for fight or flight and may make the animal less likely to bleed as well as raise systemic blood pressure. Reduction in respiration results in quieting, making the animal less likely to be seen due to reduced movement and may result in increased olfactory intake. Dilation of the bronchioles reduces resistance which allows for a sustained level of oxygen intake with minimized movement associated with pulmonary ventilation.

Ideas surrounding breathing suppression relating to OR versus traditional discussions surrounding fight or flight

As early as the 19th Century, Darwin (1872, p.283) noted perception increased if body movement and breathing was quieted. Recent investigators (Stekelenburg & van Boxtel, 2001, 2002) have reported findings of suppression of breathing during tasks that require attention which they relate to the OR. Recall that the OR is not limited to novel stimuli, but also occurs to stimuli the organism has determined to be important. An important consideration is the magnitude of reactions found to be commensurate with the salience or intensity of the stimulus (Gati & Ben-Shakhar, 1990; Siddle, Stephenson & Spinks, 1983; Stekelenburg & van Boxtel, 2001).

Stekelenburg and van Boxtel (2001) propose a centrally controlled prepotent motor control pattern that engages to enhance the body's sensitivity to stimuli. They concluded this pattern includes both inhibition of pericranial (facial) electromyographic (EMG) activity, and changes in respiration and heart rate when attending to external stimuli. Drawing a parallel with Sokolov's description of the OR (Sokolov, 1963), Stekelenburg & van Boxtel (2001) suggest the organism engages in a complex autonomic and somatomotor pattern of response that may have evolved to increase the chance for survival. One finding was that as attention increased, so did inhibition of breathing. Earlier studies also reported findings of breathing suppression and body movements during voluntary attention or involuntary orienting, particularly to low and moderate intensity stimuli (see, e.g. Graham, 1979; Sokolov, 1963; Turpin, Schaeffer & Bouscein, 1999).

The comparator theory proposed by Sokolov (1963) discussed the OR within a cognitive context. Sokolov proposed that repeated processing of sensory information gradually builds a "mental model" of the organism's surrounding world. Sokolov believed the organism assesses a stimulus and then compares that assessment to information already stored in memory. Sokolov stated that if a mismatch of information occurs between the incoming stimulus and the neuronal model, an OR will occur because of novelty, and thus is referred to as "novelty stimuli." If the organism detects no discrepancy between the stored and current input, an OR will not occur. For example, a rabbit eating grass in a field hears a rustling. It detects a difference or mismatch in local noises and it experiences an OR. This mismatch results in a non-signal OR that is nature's way of stopping the rabbit from eating to warn it there may be a threat nearby. If the rabbit were to keep eating the grass while a coyote was approaching, it may not survive the encounter. If the rabbit finds all is well it may well continue grazing.

Responses commonly associated with fight-or-flight reactions include increased heart rate, increased blood pressure, increased muscle tension, increased contractile force in the heart, vasoconstriction in the blood vessels supplying the skin and viscera (except the heart and lungs), vasodilatation in the blood vessels supplying the skeletal muscles and brain, transformation of glycogen into glucose which is released into the bloodstream for energy, sympathetic impulses to the adrenal medulla to cause the release of epinephrine and norepinephrine into the bloodstream, reduction in digestive actions, increase in respiratory passageways and an *increase in the rate of respiration* (Cannon 1929; Rathus, 2001; Tortora & Grabowski 1993).

The increase in respiration rate is incongruent with what has been empirically found to be diagnostic during polygraph testing. Deeper, faster breathing would result in an increase in RLL which is untenable given the results of recent studies of the respiration channel during polygraph testing.

The OR, RLL and Polygraph Testing

In the context of a polygraph test "significant stimuli" can be in the form of polygraph test questions to which the examinee assigns the greatest importance. A match between the stimulus and a mental representation can elicit a "significance-OR" (Verschuere, Crombez, De Clercq, & Koster, 2004). Lykken (1974), while discussing the Guilty Knowledge Test, stated "…for the guilty subject only, the 'correct' alternative will have a special significance, an added 'signal value' which will tend to produce a stronger orienting reflex than a subject will show to other alternatives" (p. 728). The measured strength of the OR has been correlated with stimulus intensity and can be produced at both low and high intensities (Lynn, 1966). Since perceived stimulus salience might well be linked to the memory that is associated with the event, it is reasonable to assume the crime related stimuli will produce significant ORs in a deceptive examinee. A person who is truthful to the relevant issue has no memory of the crime; however, they are likely to assign greater salience to the comparison questions.

There is an abundance of empirical data from polygraph testing supporting the idea that reduction of RLL infers salience and contributes to decisions of truthfulness or deception (Harris, Horner & McQuarrie, 2000; Kircher, Kristjansson, Gardner, & Webb, 2005). RLL has become the primary metric by which the respiration channel is evaluated and arguably, the OR contributes to some degree to this reduction in RLL.

RLL encompasses several breathing waveform patterns affecting depth and rate into a single metric. Overall when the subject perceives the question with greater jeopardy, the behavior pathway is to conserve energy until needed. Thus when greater jeopardy is perceived cognitively along with the emotional mix generated out of the limbic system, an increase in sympathetic arousal is launched. The receptor mix in the airway receives norepinephrine resulting in dilation with a consequent reduction in airflow resistance. Because air flow is increased through a dilated airway, diaphragmatic and intercostal muscle contraction can be reduced which is reflected in lower respiratory waveform amplitude. As a consequence not only is the ventilation amplitude decreased but the respiratory cycles are reduced. In sum, the RLL is shortened as question jeopardy perception is increased.

Attempts to separate OR from emotion

Recent attempts have been made to separate deception from the OR using a Concealed Information Testing paradigm. Ambach, Stark, Peper, and Vaitl (2008) reported results from attempts to uncouple deception from orienting. Ambach et al. (2008) concluded decreases in RLL measurements were a result of deception or preparation to deceive, as opposed to OR processes. We are not entirely convinced that deception and ORs are mutually exclusive.

Perhaps an alternative explanation is the act of deception, including preparation and execution, will raise the salience of a stimulus. Such increases in salience have been shown to result in larger ORs (Gati & Ben-Shakhar, 1990; Siddle, Stephenson & Spinks, 1983; Stekelenburg & van Boxtel, 2001). It may well be that deception and salience are inextricably intertwined and may not be separable. In the Amach et al. experiment, the increase in signal value from deception clearly made a difference in the RLL measurements which they inferred resulted from different mental processes. This suggests there is a difference when deception is introduced but does not definitively prove why deception decreased RLL. A more parsimonious suggestion is that “deception” increased salience of those targets thereby enhancing the OR. An additional consideration is that the RLL measurement is less sensitive to differences in salience. This has important implications in the weighting of RLL data in automated polygraph scoring systems. Published weighting of components in such algorithms consistently favors EDA over RLL (Nelson et al. 2008).

It is possible that similarly designed follow-up experiments using within-subject trials may shed light on whether dual mental processes are involved. By assigning test subjects to both truthful and deceptive conditions, it may be possible to determine if there are differences in how individuals’ self-assign salience to objects when they are truthful compared to when they are deceptive. Greater individual arousal during the deceptive versus truthful condition would tend to confirm an increase in salience attributable to deception. Finally, increasing the sample size of the truthful group may increase the power to detect statistical significance with smaller effect sizes.

Conclusions and Recommendations

The purpose of this paper is to provide the practicing polygraph examiner with a primer of breathing mechanics and the OR as they may relate to polygraph. The article is part of a series directed to provide a more economical, defensible and satisfactory description of what we measure during polygraph testing. We discussed the current understandings of regulatory versus voluntary control of breathing as a foundation for understanding how the OR may contribute to breathing inhibition during polygraph. We suggest in an ideal polygraph testing setting changes to breathing occur unconsciously as a result of attending to the stimuli. We provided past and current research to support the notion of the OR contributing to breathing inhibition during polygraph testing. We provided some discussion surrounding why fight-flight-freeze behavior as described in the literature is difficult to reconcile with existing empirical data from polygraph studies. We suggest the idea of degrees of salience as a possible contributor to differences in breathing inhibition during deceptive response activity. To the extent that existing research in scoring feature development has demonstrated the contribution of the breathing inhibition to the detection of deception, we suggest that the OR provides a more satisfactory explanation for observable and measurable changes in respiratory activity during periods of deception, than does traditional fight-or-flight explanations. We hope continued research will attempt to further evaluate the role of orienting as a basis for response in the comparison question testing paradigm.

Based on current research surrounding the OR we offer several suggestions for improving respiration data quality which could ultimately lead to extracting more useful data from the respiration channel. These include; use of a Silent Answer Test (SAT) as described by Horvath Reid (1972) and Matte (1996), developing a signaling device to be activated by the examinee to indicate they have attended to the test question, and developing a method of evaluating differences between pre-stimulus and post-stimulus data.

In a SAT paradigm, the examinee is not required to voice an answer, but is instructed to simply listen to the question. By not requiring the examinee to answer, we would remove any artifact related to answering and/or preparing to answer. Some of the experiments we reviewed that found breathing inhibition associated with the OR did not involve vocalization of answers. Reactions are assumed to be a direct representation of the amount of salience the examinee attributes to each individual stimulus as it is presented serially. This is consistent with the notion that the polygraph is clearly not a lie detector, but rather an instrument that measures physiological reaction to a stimulus. Differential salience is inferred from differential reactivity. Truthfulness and deception (or significant responses or no significant responses) are then opined from differential salience.

Some may express concerns of an examinee dissociating during a silent answer polygraph examination. Field remedies for this concern include having the examinee nod or shake their head slightly in answer to the test question. There may be a concern that motor related activity or mental preparatoration associated with head movements causes confounding reactions. To obviate this concern, we suggest providing the examinee with a signaling device used to inform the examiner they have attended to the test question. Optimally it would be something like an electronic touch device integrated into the polygraph that the examinee could activate with a finger. We would suggest having the examinee only activate the device to test questions answered in the affirmative. Most polygraph techniques call for test relevant and comparison test questions to be answered "No" and thus this procedure would potentially only minimally affect responses to non-scoring questions. Arguably the respiration channel would be more stable using this approach, possibly providing more diagnostic value because there is less noise in the signal. Another alternative might be using an eye-blink signal to alert the examiner that the examinee has attended to the test question.

Finally we suggest manufacturers develop data evaluating algorithms capable of comparing pre-stimulus and post-stimulus data. Several of the recent experiments we reviewed that support breathing inhibition being related to attention or OR use similar measurement approaches. One example might be to compare ten seconds of the post-stimulus line length with four seconds of the pre-stimulus line length. Considerations for comparison might include; percent differences, line length differences, peak amplitude differences or differences in respiratory period. Instrument software designers could use existing platforms and data measuring tools to develop software that may allow us to extract more useful data from the respiration channel.

References

Adams, T., & Hunter, W.S. (1969). Modifications of skin mechanical properties by eccrine sweat gland activity. *Journal of Applied Physiology*, 26, 417-419.

Ambach, W., Stark, R., Peper, M., Vaitl, D. (2008). Separating deceptive and orienting components in a Concealed Information Test. *International Journal of Psychophysiology*, 2008 Nov; 70(2):95-104.

ASTM International (2002). *Standard Practices for Interpretation of Psychophysiological Detection of Deception (Polygraph) Data* (E 2229-02). West Conshohocken, PA: ASTM International.

Barham, R.M. & Boersma, F.J. (1975). *Orienting Response in a Selection of Cognitive Tasks*. Netherlands, Rotterdam: University Press.

Bell, B. G., Raskin, D. C., Honts, C. R. & Kircher, J.C. (1999). The Utah numerical scoring system. *Polygraph*, 28(1), 1-9.

Boucsein, W. (1992). *Electrodermal Activity*. New York, NY, Plenum Press.

Cacioppo, J. T., Tassinary, L. G., & Berntson, G. G. (2000). *Handbook of Psychophysiology*, 2nd edition. New York, New York: Cambridge.

Cannon, W.B. (1929). *Bodily Changes in Pain, Hunger, Fear and Rage,* 2nd edition. New York: Harper & Row.

Darrow, C. W. (1936). The galvanic skin reflex (sweating) and blood pressure as a preparatory and facilitative function. *Psychology Bulletin*, 33, 73-94.

Darrow, C.W. (1933). The functional significance of the galvanic skin reflex and perspiration on the backs and palms of the hands. *Psychological Bulletin*, 30, 712.

Darwin, C. (1872) *The expressions of the emotions in man and animals*. London: Murray.

Department of Defense Polygraph Institute (2006). *Test data analysis: DoDPI Numerical Evaluation Scoring System*. Ft. Jackson, South Carolina.

Gati, I. & Ben-Shakhar, G. (1990). Novelty and significance in orientation and habituation: A feature-matching approach. *Journal of Experimental Psychology: General*, 119, 251-263.

Graham, F. K. (1979). Distinguishing among orienting, defense and startle reflex. In H. D. Kimmel, E. H. van Olst, & J. H. Orlebeke (Eds.). *The orienting reflex in humans* (pp. 137-167). Hillsdale, NJ: Erlbaum.

Handler, M.D. (2006) The Utah PLC. *Polygraph*, 35(3), 139-148.

Handler, M.D. & Honts C.R. (2008). Psychophysiological mechanisms in deception detection: a theoretical overview, *Polygraph*, 36(4) 221-236.

Handler, M.D. & Honts C.R. (2009). You Can't Run, But You Can Hide: A Critical Look at the Fight or Flight Response in Psychophysiological Detection of Deception, *European Polygraph*, in press.

Harris, J.C., Horner, A., & McQuarrie, D.R. (2000). An Evaluation of the Criteria Taught by the Department of Defense Polygraph Institute for Interpreting Polygraph Examinations. Johns Hopkins University, Applied Physics Laboratory. SSD-POR-POR-00-7272.

Harver, A. & Lorig, T.S. (2000). Respiration. In Cacioppo, J.T., Tassinary, L.G. and Berntson, G.G. (Eds.), *Handbook of Psychophysiology.* (p. 265-293). Cambridge: Cambridge University Press.

Heimer, L. (1995). *The Human Brain and Spinal Cord*, 2nd edition, New York, NY, Springer-Verlag.

Hlastala, M.P. & Berger, A.J. (1996). *Physiology of Respiration*, New York, NY, Oxford University Press.

Horvath, F.S, and Reid, J.E. (1972). The polygraph silent answer test. *Journal of Criminal Law and Criminology and Police Science*, 63(2), 285-293.

Janig, W (2006). *The Integrative Action of the Autonomic Nervous System: Neurobiology of Homeostasis*. New York: Cambridge University Press.

Kircher, J. C. & Raskin, D.C. (1988). Human versus computerized evaluations of polygraph data in a laboratory setting. *Journal of Applied Psychology*, 73, 291-302.

Kircher, J. C. & Raskin, D.R. (2002). Computer methods for the psychophysiological detection of deception. In Murray Kleiner (Ed.) *Handbook of Polygraph Testing.* :Academic Press: San Diego.

Kircher, J. C., Kristjansson, S. D., Gardner, M. K. & Webb, A. (2005). *Human and computer decision-making in the psychophysiological detection of deception*. University of Utah. Salt Lake City: Utah.

Kircher, J.C., & Raskin, D.C. (1999). *The Computerized Polygraph System (Version 3.0) Manual.* Salt Lake City, UT: Scientific Assessment Technologies.

Kleiner, M. (2002). Physiological detection of deception in psychological perspectives: a theoretical proposal. In M. Kleiner. (Eds.) *Handbook of Polygraph Testing*; San Diego, CA. Academic Press.

Krapohl, D. & McManus, B. (1999). An objective method for manually scoring polygraph data. *Polygraph*, 28, 209-222.

Levitzky, M.G. (1999). *Pulmonary Physiology*, 5th edition, New York, NY, Mc Graw Hill.

Lykken, D.T. (1974). Psychology and the lie detection industry. *American Psychologist*, 29, 725-739.

Lynn, R. (1966). *Attention, Arousal and the Orienting Reaction.* Oxford, UK, Pergamon Press.

Marieb, E.N. (1999). *Human Anatomy & Physiology.* Old Tappan, NJ: Benjamin.

Matte, J. A. (1996). *Forensic psychophysiology using the polygraph.* J.A.M. Publications: Williamsville, NY.

Nelson, R., Handler, M.D. & Krapohl, D.J. (2008). Brute-force comparison: A Monte Carlo study of the Objective Scoring System version 3 (OSS-3) and human polygraph scorers. *Polygraph*, 37(3), p. 185-215.

Ohman, A. (1979). The orienting response, attention, and learning: An information processing prospective. In H. D. Kimmel, E. H. van Olst & J. F. Orlebeke (Eds.), *The orienting reflex in humans* (pp. 443–471). Hillsdale, NJ: Erlbaum.

Ohman, A., Hamm, A., & Hugdahl, K. (2000). Cognition and the Autonomic Nervous System; Orienting, Anticipation & Conditioning. In Cacioppo, J. T., Tassinary, L. G., & Berntson, G. G. (Eds.). *Handbook of Psychophysiology, 2nd edition*. New York, NY: Cambridge.

Pavlov, I. P. (1927). *Conditioned Reflexes.* Oxford, Clarendon Press.

Rathus, S.A. (2001). *Essentials of Psychology, 6th Edition*. Fort Worth, Texas: Harcourt.

Siddle, D. A. T., Stephenson, D., & Spinks, J. A. (1983). *Elicitation and habituation of the orienting response*. In Siddle, pp. 109-82 (1983).

Sokolov, E. N., Spinks, J. A., Naatanen, R. & Lyytinen, H. (2002). *The Orienting Response in Information Processing*. Mahwah, New Jersey, Lawrence Erlbaum Publishers.

Sokolov. E. N. (1963). *Perception and the Conditioned Reflex*. New York, New York, MacMillan.

Stekelenburg, J.J. & Van Boxtel, A. (2001). Inhibition of pericranial muscle activity, respiration, and heart rate enhances auditory sensitivity. *Psychophysiology*, 38(2001), 629-641.

Stekelenburg, J.J. & Van Boxtel, A. (2002). Pericranial muscular, respiratory, and heart rate components of the orienting response. *Psychophysiology*, 39 (2002) 707–722.

Steller, M. (1987). Psychophysiologische Aussagebeurteilung - Wissenschaftliche Grundlagen und Anwendungsmöglichkeiten der "Lügendetektion". Göttingen: Hogrefe.

Timm, H. W. (1982a). Analyzing deception from respiration patterns. *Journal of Police Science & Administration*, 10, 47-51.

Timm, H. W. (1982b). Effect of altered outcome expectancies stemming from placebo and feedback treatments on the validity of the guilty knowledge technique. *Journal of Applied Psychology*, 67, 391-400.

Tortora G.J. & Grabowski, S.R. (1993). *Principles of Anatomy and Physiology*, 7th edition. New York, NY Harper Collins.

Turpin, G., Schaefer, F., & Boucsein, W. (1999). Effects of stimulus intensity, risetime, and duration on autonomic and behavioral responding: Implications for the differentiation of orienting, startle, and defense responses. *Psychophysiology*, 36, 453–463.

Verschuere, B., Crombez, G., De Clercq, A., & Koster, E. (2004). Autonomic and behavioural responding to concealed information: differentiating defensive and orienting responses. *Psychophysiology*, 41, 461-466.