Commentary Regarding Living Architecture Project

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Context

The human sensory system is a filtering system. Physical phenomena are perceived by the senses and are translated into modulated streams of ionic current. These currents are moved though the body, via the nervous system, to the brain. Specialized brain regions receive and decipher these modulated current signals to process them for interpretation by other functionalities operating within the body.

There are volitional and non-volitional (autonomic) aspects to our physiology. We can consciously and intentionally stimulate motor neurons, which innervate muscle fibers, to move our bodies. Other processes, like heart rate, digestion and perspiration are primarily subconsciously mediated. Some actions, like breathing, are subject to both subconscious and conscious control. Our conscious thought rests upon an emotional sea and our emotions are linked to autonomic processes in our bodies. If aroused, we can experience increased heart rate and perspiration. If we are happy, delicate muscles in our face contract to create a smile. Our mood, which stimulates our conscious thought, will influence our perception because our emotional substrate acts as a neurological filter.

Marshall McLuhan describes a communications medium as an environmentally-conditioned transport system for sensed data. This transport system is a perceptual filter that includes our own nervous system. As a filter becomes more effective, the filter becomes a better descriptor of the incoming data. By example, in contemporary speech recognition algorithms, the human vocal tract is estimated and modeled. The vocal tract is defined by the position and movement of the neck, teeth, tongue, cheeks, mouth and lips. The coefficients that describe the vocal tract filter become the descriptor of the speech. The medium of the vocal tract acts to filter the buzzing of the vocal cords to produce intelligible speech. Speech recognition algorithms operate by reducing words to the filter description which produces those words. This technology exploits, as operating principle, the idea that the medium filter (vocal tract) is exactly the message.

If the medium is a perceptual filter, it seems the medium must encompass the entire, environmentally-conditioned, data transport system from external source to internal conscious awareness. Judgment of artistic effort, as with ones ability to discern beauty, rests upon the presumption of consciousness and that depends upon ones physiological state The effect of physiological state, upon people's ability to appreciate art, has historically been noted. In "Of the Standard of Taste" – 1757, Hume writes, "But though all the general rules of art are founded only on experience and on the observation of the common sentiments of human nature, we must not imagine, that, on every occasion the feelings of men will be conformable to these rules. Those finer emotions of the mind are of a very tender and delicate nature, and require the concurrence of many favorable circumstances to make them play with facility and exactness, according to their general and established principles. The least exterior hindrance to such small springs, or the least internal disorder, disturbs their motion, and confounds the operation of the whole machine." In this statement, Hume muses that the ability to appreciate art is subject to ones emotional state.

The medium established by our physiological state is pivotally important. We absorb data that has been environmentally and neural-sensorially conditioned. The manner in which we generate conscious thought, regarding this absorbed, conditioned data is dependent upon our emotional state. Emotional state is reflected in autonomic processes, within the body, that are related to our physiological state. Furthermore, when considering human perception as a recursive system, cause and effect can conspire to create other behavior. Ones ability to consciously interpret the environment, within the confines of an emotional framework, will affect ones influence within that environment and the affected environment may act to influence physiological state and subsequently emotional state.

There is no clear separation between the sensory mediums from outside to inside the body. Human perception encompasses a continuum of medium filters, whether they are rooted internal or external to the body. Also, the relationship between body and environment is richer than these connected medium filters. There is a resonance established, between body and environment, which is subject to the cause and effect relationship between physiological and emotional state. We are stimulated by the environmental medium, and in turn, we manipulate that medium.

The sensed environment can be considered an extension of one's body by virtue of the idea that information is not aware of any boundary between animate and inanimate. People seek out beautiful environments to inhabit because they feel a matched connection to those surroundings. However, even though our surroundings may be intimate, our direct (real-time) influence on those environments is restricted to that which is close to us and practically manipulated. We can adjust our clothing to be warmer or cooler. We can eat eggs for breakfast and salad for lunch. We can place a pillow in the car seat to give a height boost for better driving visibility.

We can't spontaneously change the character of our fixed buildings and cities. As a result, we are less connected to the world at large, as it seems beyond and away from our scope and influence. Instead, if seemingly faraway aspects of our environment were more directly influenced by us, then it seems our sphere of caring would branch outward. A "Living Architecture", that has a bidirectional dialog with its inhabitants and can be influenced by them in a human-time scale, has the potential to create an increasingly robust and vital connection between people and the spaces they inhabit.

Assuming that dialog is mediated, in part by a bidirectional autonomic and conscious connection between architecture and inhabitant, then the formally distant can become as meaningful as the feeling of a favorite jacket or the smell of basil plants in the windowsill. Presently our feelings, which are coupled to our autonomic responses, can encourage us to make intimate and conscious changes to our environment. Our influence on the larger environment is much more subject to our ability to marshal resources of time, labor, energy and materials, so intimacy and empowerment are both precluded. The possibility of developing intimate pathways between our small selves and the much larger world seems a relevant task, if we are focused on extending the reach of human caring.

A Starting Point

Architecture presently leads to the establishment of an environmental permanence, compared to human time scales. The feelings and conscious thoughts of people, living in an unchanging architecture, would seem to be vitally important. An ability to clarify potential occupants' feelings and thoughts about a space, prior to its physical implementation, could be helpful in the design process. Presently, workstation tools exist to marry the tasks of design and realization with the capacities of feeling and immersion. Psychophysiology researchers have become acutely aware of the power of this juxtaposition. A common tool in psychophysiology laboratories worldwide is the Virtual Reality (VR) workstation. This tool can be readily combined with technology that permits the measurement of human affect. Affect is the observable (measurable) expression of emotion.

With this combined configuration, in service of architectural design, participants can be treated to sequences of virtual realizations. Simultaneously, the sensory influence of the design effort will express as an autonomic state in the participant. The participant would be empowered to walk around the virtual structure, peer around corners and even hear the interior echoes of the building. Autonomic and cognitive feedback, would be synchronously coupled to the subject's walk-through of the virtuality.

Autonomic feedback could be expressed in terms of the Circumplex Model of Affect. James Russell first described the Circumplex Model of Affect in 1980. Affective states arise from the behavior of two independent neurophysiologic systems, the arousal and valence systems. Affective states are a function of these two systems. The circumplex model is two-dimensional, with arousal and valence defined as orthogonal (perpendicular) axes. The arousal axis, plotted vertically, ranges from zero to high arousal.The valence axis, plotted horizontally, ranges from negative to positive affect. Objective physiological indexes of affect or emotion are available. As valence examples, increasing zygomaticus activity indicates positive affect and increasing corrugator activity indicates negative affect. Physiological example indices for arousal include heart rate and electrodermal activity. Employing the Circumplex Model of Affect, emotional states are classified and reported as a two-dimensional vector with displeasure/pleasure as one dimension and non-arousal/arousal as the orthogonal dimension.

Cognitive feedback could be expressed as a verbal commentary of one's thoughts as they traversed the virtual space. Alternatively, subject-controlled indicators could be employed to reflect concurrent thoughts regarding the usability or potential of any particular space, as paired to specific locations in the virtuality.

In principle, autonomic and cognitive feedback data could be used to make guided or automatic adjustments to the virtual model. A hallway could be made longer or shorter, colors in a room could change, window sizes could be adjusted to allow more or less sunlight. Because changes to the virtual environment would impact participant autonomic function, and if the measured changes could be employed to directly mediate the design, then a so-named "emotional state – design resonance loop" might be created. In this situation, a virtual design could possibly be modulated in real-time by autonomic state feedback. The loop could be automatically exited when a particular autonomic state was reached.

Future Steps

Resources exist that would permit measures of participants' physiology as they might experience a real architecture. Autonomic recording systems would allow the logging of participant data during a walk-through. As a practical matter, this possibility is best suited for research investigations. The invasive quality of recording autonomic data, given present technology, would preclude large-scale practical deployment. However, it would be useful to record participant autonomic data and pair it with data from a host of non-invasive sensors, such as thermal imagers, carbon dioxide monitors and occupancy detectors. Perhaps meaningful relationships could be established between collective participant autonomic states and other non-invasive sensors. A defining example might involve the opening of a sunroof, when enclosed carbon dioxide levels have reached a specific level. The autonomic responses of individuals could be measured during such an activity. In this manner, building control functionality could be validated by participant autonomic (emotional state) testing.

Reference Information

Human Nervous System

The central nervous system (CNS) includes the brain and spinal cord. The peripheral nervous system (PNS) connects between the CNS and the body. The PNS consists of two parts, the autonomic nervous system (ANS) and the somatic nervous system (SoNS). The ANS regulates fundamental physiological states that are typically involuntary, such as heart rate, digestion and perspiration. The SoNS mediates voluntary control of body movements via skeletal muscle.

The autonomic nervous system (ANS) is largely responsible for maintaining the equilibrium of the body's systems. The ANS is connected to smooth muscles, cardiac muscle tissue and secretion glands of organs. The ANS is composed of three components, the sympathetic nervous system (SNS), parasympathetic nervous system (PsNS) and enteric nervous system (ENS). The SNS and PsNS work in an opposing manner to maintain the internal equilibrium of the body.

Affective stimuli can have a significant effect on the ANS and many physiological signals reflect the activity of the ANS. The SNS functions in circumstances that require quick responses. The PsNS functions in circumstances that do not require immediate responses. As SNS activation increases, then PsNS activation decreases and vice-versa.

Affect and Emotion

Affect is the observable (measurable) expression of emotion.

Theories of Emotion

The James-Lange Theory of Emotion
Emotions occur as a result of physiological reactions to stimuli. The experience of the body's physiological response generates the emotion. Emotional state depends on how the subject interprets their own reaction to any specific event. The subject's perception of their own physiological reaction is the emotion.

The Cannon-Bard Theory of Emotion
Emotions occur when the thalamus activates the CNS in response to stimuli, which results in physiological reaction. Physiological reaction and cognitive interpretation of emotional state occur simultaneously and are largely independent. The perception of a stimulus leads to both the emotion and physiological reaction. Furthermore, different emotions can share similar physiological responses.

Schachter-Singer Theory of Emotion
In response to stimuli, a physiological reaction occurs. A cognitive label accompanies the reaction. The reaction and the label act to generate an emotion. The subject's history provides the framework to experience their reaction and categorize it as a specific emotion. Subject's perceive their own physiological responses and then emotionally interpret them by considering the context of their circumstances.

Circumplex Model of Affect

The Circumplex Model of Affect was first described in 1980 by James Russell. Affective states arise from the behavior of two independent neurophysiological systems, the arousal and valence systems. Affective states are a function of these two systems. The Circumplex model is two-dimensional, with arousal and valence defined as orthogonal (perpendicular) axes. The arousal axis, plotted vertically, ranges from zero arousal to high arousal. The valence axis, plotted horizontally, ranges from negative to positive. Objective physiological indexes of affect or emotion are available. As valence examples, positive affect is indicated by increasing zygomaticus activity and negative affect is indicated by increasing corrugator activity. Physiological example indices for arousal include heart rate and electrodermal activity.

Motivational State

Perhaps even more fundamental to emotional state is the concept of motivational state. Motivational state is indexed by specific, bodily expressed, physiological states that can easily be measured. Motivational state is based on the concept of core relational themes, called "challenge" and "threat." During the course of living, humans relate to environmental stimulus as a combination of challenge and threat. A challenge response is similar to the aerobic physiological response, and involves an increase in heart rate and cardiac output and a decrease in vascular resistance. A threat response is characterized by an increase in heart rate, blood pressure and an increase or little change in vascular resistance and a decrease or no change in stroke volume. Motivational state information can be used to better reflect objective differences between similar Circumplex model defined emotions, such as anger and fear.

Interpersonal Connection

There is a vast amount of expression that falls outside the realm of what we can experience by looking, hearing, tasting, smelling and feeling. The unaided human sensory system can only perceive a small fraction of the physical phenomena surrounding us. The range of human hearing is 20Hz to 20,000Hz. The visual chromatic spectrum runs from red (780nm) to violet (390nm). We can taste five basic flavors: bitter, salty, sour, sweet and umami. For all human senses, there are limits to both sensitivity and range. There are sounds too soft to hear, colors we can't see and flavors too intense to identify.

Technology can extend the sensory range beyond what is normally perceivable by humans. For example, the small electrical signal, manifested by the heart, can't be directly perceived by people until the tiny signal is translated into a record which can be seen. The different modalities of human physiology express in a variety of ways. In the circumstance of body movement, the nervous system guides and propagates an electrical signal which originates the brain. When the signal reaches the targeted area, the muscle manifests an electrical signal during contraction. In the lungs, inspired oxygen is exchanged for expired carbon dioxide. Vascular beds in the fingertip fill and empty with blood during each heartbeat cycle and the pressure in the arteries changes during the course of each beat. The oxygen saturation level in the blood relates to respiratory activity. All of these different actions can be observed directly, once the changing variable of electricity, gas concentration, optical property or pressure is transformed into a human-perceptual quantity. Transformations of data, from the hidden to the perceivable, are possible in many different forms. For example, the skeletal muscle contraction's electrical signal, the electromyogram, can be converted directly to audible form.

Physiological data is highly complex and has rhythmic, chaotic and fractal qualities and it must first be well-perceived before it can be better understood. To better measure and interpret physiological data, one can use specific equipment to sense a subtle process and convert the signal into forms readily perceived by one or more of the human senses. Simultaneously, this data can be converted into forms amenable to computer-based processing. In this manner, complex data can be better conceptualized and then additional, software-based, interpretive tools can be evolved to assist in the process of further understanding.

There are volitional and non-volitional (autonomic) aspects to our bodies. We can consciously and intentionally stimulate motor neurons, which innervate muscle fibers, to move our bodies. Other processes, like heart rate, digestion and perspiration are primarily subconsciously mediated. Some actions, like breathing, are subject to both subconscious and conscious control. Conscious thought rests upon an emotional sea and our emotions are linked to autonomic processes in our bodies. If aroused, we can experience increased heart rate and perspiration. If we are happy, delicate muscles in our face contract to create a smile. Our mood, which stimulates our conscious thought, will influence our perception because our emotional substrate acts as a neurological filter.

Sensory expansion, directed in service of evaluating human expression, is of interest because an interpersonal dialog can be established at a deeper level. Assuming that dialog is mediated, in part by a bidirectional autonomic and conscious connection between one person and another, then the formally distant can become as meaningful as the feeling of a favorite jacket or the smell of basil plants in the windowsill. Presently our feelings, which are coupled to our autonomic responses, can encourage us to make intimate and conscious changes to our relationships with one another. The possibility of developing new communication pathways between ourselves, seems a relevant task, if we are focused on extending the reach of human caring.

Alan Macy is currently the Research and Development Director, past President and a founder of BIOPAC Systems, Inc. He designs data collection and analysis systems, used by researchers in the life sciences that help identify meaningful interpretations from signals produced by life processes. Trained in electrical engineering and physiology, with over 30 years of product development experience, he is currently focusing on psychophysiology, emotional and motivational state measurements, magnetic resonance imaging and augmented/virtual reality implementations. He presents in the areas of human-computer interfaces, electrophysiology, and telecommunications. His recent research and artistic efforts explore ideas of human nervous system extension and the associated impacts upon perception. As an applied science artist, he specializes in the creation of cybernated art, interactive sculpture and environments.