Information Movement and Parasympathetic Regulation of Sympathetic Arousal

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Introduction

Physics reached a high point when Einstein showed that quantities of energy can be understood as matter multiplied by a constant ($E=mc^2$). Since this famous equation was written, the difference between energy and matter has become something of a muddle. Apparently, light may go slower or faster than *c* (e.g., Giovannini et al, 2015; Aspect et al, 1982). As far as I can tell, it is assumed that photons or other particles go slower when they are carrying information, and faster when they are not.

Physicists may be on the verge of agreeing that information, not matter or waves or particles, is the centrally important aspect of their science. I think neuroscientists too should assume that their work involves most centrally the movement and processing of information.

This does not mean that energy or motives to approach pleasures and avoid pains do not drive information processing (e.g., Bernstein, 1995). Perhaps most importantly, the conscious processing of valid concepts rather than invalid ones can itself be the greatest pleasure (See Deci, 1975 on intrinsic vs. extrinsic motivation; and Bion, 1962 on thinking)).

To study brain laterality is to study sequences of information processing operations. Compared to the Right Hemisphere of the brain (RH), the Left Hemisphere (LH) is more involved with words (semantic concepts), numbers

(arithmetic concepts), details, and logic. And, compared to the LH, the RH is more centrally concerned with generating global impressions, images, and intuitive responses to reality.

The RH operates to summarize quickly sensory data from the body and the external physical and social environments. *Now* is apparently the province of the RH (e.g., Tweedy, 2012, p. 6; McGilchrist, 2010, p. 362). Though anatomically the LH sits 'next to' the RH, functionally it is 'on top of' or 'after" the LH in the information processing sequence. Schore (2011) makes clear that the Left Hemisphere is at the end of the human information processing sequence. And, that extensive communication of information takes place between the LH and the RH. This iterative, information exchange may illustrate something fundamental about human cognition.

Apparently it takes about 0.5 seconds for sensory information registered by the parts of the nervous system below the LH to become reflected upon consciously (Libet, 1993). And, rather than focusing on intuition or some *big picture gestalt* of *the latest now*, the LH pays focal attention to words, numbers, and logic (more or less competently) to infer the meaning of the parts, the little pictures, that comprise an organized, conscious experience of *the big picture*.

The LH is central in the performance of *executive functions*. From an evolutionary perspective, the utility of sophisticated, scientific thinking is to increase decision making competence over and above that possible by means of the raw instincts controlled by the subcortical parts of the brain. For almost all right handed people, and 60% of left handers, executive

functions depend on operations in the neocortex of the LH. Off course, most decisions made in the body (and in social organizations) never reach the level of the executive's focal attention. Instead, they are made outside of focal attention on the basis of instincts and habits learned under the influence of the two parts of the Autonomic Nervous system: the sympathetic system which stimulates physiological arousal; and, the parasympathetic system which brakes and regulates arousal.

This paper attempts to extend ideas presented before about mind and body interactions (Bernstein, 2011; 2014a; 2014b; 2016). Results are reported from a pilot study that measured heart rate variability (HRV) while subjects were in states of relaxation, psychological defense, and sexual arousal. Relationships between information processing operations in specific anatomical regions of the heart, lungs and brain and subjective states are considered. It is hypothesized that the nature of information transmitted by afferent and efferent myelinated neurons between the heart, lungs, brainstem, and Left and Right neocortical hemispheres mediates thinking and feeling reactions to stimuli originating in the body and the external world.

Heart Rate Variability Study

The ability to regulate somatic and psychic operations depends to a large extent on Parasympathetic Tone which can be measured by assessing Respiratory Sinus Arrhythmia (RSA) or its correlated measure---Heart Rate Variability (HRV).

> RSA is a naturally occurring rhythm in the heart rate pattern that oscillates at approximately the frequency of spontaneous breathing…By quantifying RSA

> and…its relation to HRV during various challenges…it is possible to measure the dynamic regulation of the myelinated vagal brake to study the responses of [an individual] to objects. (Porges, 2011, p. 122)

HRV is simply the interval between heart beats. Typically, pulse rate is reported in terms of beats per minute, (e.g., 60 bpm). In actuality a person with a pulse of 60 bpm is experiencing small to large changes in heart rate within every second. Various studies have shown that compared to a small range of RSA or HRV, large ranges (High Parasympathetic Tone) can increase somatic and mental health (Porges, 2011). And, that anxiety reduction can be achieved when HRV or RSA data are feedback to patients who are asked to time their breathing to the RSA or HRV fluctuations provided to them via biofeedback devices (e.g., Zucker et al 2009).

Porges had identified two discrete brainstem nuclei in human infants: the *nucleus ambiguous* (NA) and the *nucleus tractus solitaries* (NTS). The NA receives and sends impulses via myelinated neurons innervating the heart, lungs and brain. The NTS in contrast only has non-myelinated tracts. Human infants are born without completely myelinated NA neurons. This is why premature infants must remain in very controlled environments or "incubators". They are unable to process information about and respond effectively to stressors including hypoxia, thermal changes, dehydration and hypoglycemia.

A small pilot study was done in which adult subjects wore a pulse monitor on the left forearm which sent a signal wirelessly to a cell phone that displayed any change in HR every 0.8 seconds. [1] The phone displayed HR changes above or below a baseline measure of HRV taken for 20

seconds while the subject sat quietly in a chair before different tasks were undertaken. It also displayed HR in terms of beats per minute,

The subjects included 5 patients with moderately severe anxiety disorders in my clinical practice (3 males, 2 females); and 5 non-patients (3 males, 2 females). Subjects were between 27 and 60 years of age. All subjects had consented to participate after given assurances of anonymity and being told that the noninvasive procedure was very unlikely to cause any harm.

Over fifty 20 second resting, baseline periods (about 5 per subject) were used to determine that the median HRV measured with our device in this sample of n=10 was 8. This is an absolute value since deviations could be either above (+) or below (-) 8. And, the distribution of HRV of 68% of subjects changed by 8 beats or less within 0.8 seconds. In other words, a typical person with a resting HR of 60 beats per minute experiences an effective change in HR in 0.8 seconds from between 52 bpm to 68 bpm.

Two sorts of situations were used to assess changes over individualized baseline HRV. In the clinical setting I would just observe the cell phone monitor as the session progressed. Non-clinical subjects were asked to monitor the HRV reading themselves while alone and masturbating to orgasm.

Turning first to the clinical context, I observed what one would expect given the results reported in the literature. That is, for the most part these anxious patients had low HRV range (relatively poor parasympathetic tone) through most of the 50 minute psychotherapy sessions. However

there were notable exceptions. One involved a 35 year old professional man who was best diagnosed as a having what Winnicott, (1960) called a "false self" organization.

The patient had been an outstanding student and was a conscientious worker, though he did not enjoy his work. He had a considerable interest in ideas. But he had no female friends and suffered chronically from dysthymia. He also had a severe phobia of spiders. He would be classified as a *Repressor* by Byrne (1961). That is, someone who is mostly unconscious of his anxiety, He also had rather intense, unresolved, unconscious Oedipal issues. He also had what is typically called "idiopathic hypertension".

In the course of one meeting he mentioned somethings about current world events, his HRV hovering about 4. After about 20 minutes I made the interpretation that he was angry at me because I represented an authority figure to him. His HRV jumped to 30, about 4 standard deviations above baseline! And, he reported a subjective experience of being hurt by my comment. He seemed to feel it was a rupture in an otherwise friendly chat. In contrast, when I had brought up the spider phobia he showed little change in HRV range. Perhaps because this was not an "experience near" threat to his fragile self.

I have seen many patients with so called idiopathic hypertension. To me there is no doubt about the cause of their vascular problems. They are simply suffering from dysautonomia due to unresolved, unconscious conflict. Which is an axiomatic psychoanalytic explanation for really all

psychosomatic pathology. Virtually all these patients have Low Parasympathetic Tone.

The results with the non-clinical sample also appear were in line with Freud's ideas about sex. All 5 subjects in the non-clinical sample reported similar results. As sexual excitement increased over the course of masturbation with accompanying sexual ideation, HRV increased and reached a maximum at the so called moment of "inevitability", i.e., , when orgasm is felt to be immanent. Near and during orgasm in both male and female subjects, HRV increased to 50 or above. In other words, orgasm was associated with increases in parasympathetic tone over 6 standard deviations above baseline. And, it fell afterwards in the course of normal parasympathetic rebound from high sympathetic arousal.

Sexual function is normal in those with good parasympathetic tone. Presumably because they are able to regulate sympathetic arousal without overly suppressing it. This is due to competent parasympathetic braking. Specifically, normal subjects were able to apply and then disengage the brake on sympathetic arousal at least once in under one second. .

Of course as sympathetic arousal increases to orgasm, heart rate in bpm terms rises. Otherwise, the large range of HRV would result in cardiac arrest. Typically subjects reported bpm reached 150 bpm or higher at orgasm. Hence, an HRV of 50 would effectively indicate a bpm range of 50 to 200, a range that would not be fatal for those with normal heart function.

Cognition, Feeling, and Information Movement

I assume that myelinated neurons from the brainstem NA travel through the limbic region to the cortical white matter of the RH. The information regarding HRV is communicated to the LH. Then the signal is passed back and forth between the hemispheres until orgasm is achieved. I think this iterative process is a correlate of thinking about the sexual sensations and concepts during sexual arousal.

Psychopathology including sexual dysfunction is due likely to an inability to let sympathetic arousal flow and then be down regulated due to conflicts about the meaning of sexual behavior. The HRV data and what we know about the LH and RH is consistent with this idea. And, it accords well with Freud's first sexual libido theory.

In effect, the scientific, logical LH asks the RH to use gestalt like standards to decide if its analysis of sexual thoughts. "Is this okay?" "Should I feel guilty about this sort of pleasure? "Or, is it okay to let go and climax?" "I won't die will I?" In other words, just the sorts of worries a person with sexual conflicts and guilt has along with restricted HRV, the sort seen in the consulting room.

That the RH is more innervated by myelinated nerves from previous brain regions, e.g., the brainstem NA is consistent with the idea that impulses travel to and from the heart, lungs, and brainstem to cortical areas, first RH, then LH, then iteratively back and forth until orgasm. To

be sexually competent is to be competent to sense, think, and feel during sex, and during any sympathetically arousing activity.

So, the movement of information from the body and subcortical areas of the brain, especially the NA in the brainstem, engender an iterative transfer of data between Left and Right brain cortical regions that is affected by competent regulation of arousal by means of parasympathetic braking.

Man and Machine

There seems to be a taboo against considering human thinking and behavior in terms of mechanisms. This implicit prohibition seems to run through discussions of what happens at the top of the human nervous system. The part which seems to most define the person. Many believe that "the devil (or god) is in the details". In any case, it is widely believed that human welfare is affected by ineffable things like gods and spirituality; as well as by scientific thinking, and social norms of behavior (e.g., the rapidly changing beliefs about sexuality, privacy, crime,, punishment, and the value of human life).

McGilchrist's (2009) believes that the most scientific part of the brain, the LH, is somehow responsible for the world's problems. Of course, scientists need brains. But I do not think it is going out on a limb to suggest that social variables such as normative values and behaviors are more meaningful determinants of the state of the world than the idea that the LH of the brain is some sort of evil contraption.

One plausible social cause of the increasingly wretched behavior of virtually all corporations, most governments, and many individuals is that since about 1975, undergraduate students decided in very large numbers to pursue master's degrees in business administration. MBAs are taught how to make money by pushing the boundaries of social customs promoting cooperation and individual development up to and beyond the law. This is done often under the thin cover of buzz words implying that management groups care about "empowerment" and "diversity" (Bernstein, 2003).

Since not every MBA can be a CEO, one finds them managing business functions once considered of low status such as servicing products, billing, and even the mail room. Hence, businesses around the world today have become very efficient and effective. They are managed "scientifically". This way of thinking is now part of medicine. Physicians, and hospital administrators consider patients "customers" or "clients". Measurements of patient satisfaction are done more routinely than measurement of medical outcomes. Employees and "end users" are part of a "mechanized system".

In contrast to McGilchrist, Tweedy (2012) has written that the LH performs the functions of god, a presumably positive force. This is consistent with the idea that scientific thinking can discover the laws of Nature. Learning the truth is, I think, is the greatest pleasure we can experience (e.g., Bion, 1962). But scientific knowledge is a destabilizing force. To correct norms of thinking and behavior that have arisen recently around the world, we need more valid scientific thinking, not less. This involves integrating biological, psychological, and social theories. But there is great resistance to integrating

ideas and almost everything else including races, genders, and social classes, (See, Bernstein, 2014, chapter 3).

E.O. Wilson's theory of Sociobiology (1975) which integrated social and biological ideas was met with tremendous resistance at first. Now, it is fashionable to accept Sociobiology. Wilson (1999) calls the connections between all valid ideas from all subfields *consilience* (Wilson, 1999). I think Wilson and Tweedy's examination of William Blake's ideas involve what the Greeks called *The Logos* or "The perfect wisdom of the word of god". And, we are pretty sure that word processing occurs in the LH.

Certain aspects of nature are today beyond our ability to describe, predict, or control. Scientists should like to get "ineffables" like god out of their theories and methods. Maybe in the future our science or that of nerds on some other planet will be able to make currently ambiguous causes of human behavior more explicit.

After all, Freud won the Goethe Prize for literature in 1930, not a Nobel Prize for science. In 2002, Daniel Kahneman became the first psychologist to win a Nobel Prize. Kahneman studied the very biases in inference processes that can make it appear, for example, that the world is a worse place than it was in 1945. Television and the internet make beheadings and mass murders salient instantaneously to us all. Kahneman showed how the mere availability and vividness of information biases people to exaggerate its importance as a cause of events (e.g., Kahneman and Tversky 1972).

In any scientific theory that purports to predict aspects of reality, important variables not accounted for explicitly are called "latent variables".

Such unspecified variables cause prediction errors. The errors can be quantified using multivariate, statistical modelling methods such as path analysis (e.g., Bernstein et al, 1979). Operationalizing and adding new, valid predictors reduces prediction errors. They belong for now in the quantifiable *error term* of statistical prediction models.

In the meantime we must contend with "fundamentalist thinkers", some in positions of power, who deny climate change, the utility of vaccinations, the interactions of the mind and body, the validity of many psychoanalytic concepts, and the rights of homosexuals, minority groups, and woman.

At some level of mind most, if not all people, consider things that happen without explicitly apparent explanations to be the result of ineffable factors such as luck (good or bad) or supernatural agents (e.g., gods or devils). The validity of latent variables, those that have yet to be described, operationalized, and quantified cannot be tested by objective scientific methods. But they can be imagined. We have and will continue to develop methods to operationalize previously vague concepts at biological, psychological, and social levels of analysis in order to test their validity.

Today, most formal scientists and regular citizens or n*aïve scientists* (Heider, 1958) can, at least, consider social causes of biological events. For example, if a child contracted polio before Salk's' vaccine, it might have been considered "an act of god" or just bad luck. After an effective medicine was available, the causal sequence resulting in disease might plausibly include the competence of the infant's caregivers (e.g., parents, government agencies) to get him or her vaccinated. That is, events once attributed to

supernatural, uncontrollable entities may come to be understood as caused, in part, by social psychological variables such as the competence of decisions made by individuals and groups.

Decisions based on valid concepts of nature are more effective regulators of thought, feeling, and overt behavior than decisions based on invalid concepts. Superstitions like knocking on wood, and throwing spilt salt over the left (not the right) shoulder to prevent misfortunes seem to be nonsense. If learning and using valid causal explanations were not more reinforcing than using invalid theories, we would still be living in caves and trees.

Very predictable behavior is characteristic of some better made machines. Humans may be more than machines---spiritual, infinite or some other ineffable thing. But human thought, feeling, and overt behavior, like the actions of machines, can be predicted and controlled to an important degree. Applications of cognitive science have depended on basic research in cognition. . Norman & Shallice (1976) lucidly described some assumptions underlying the study of thinking processes:

> [Our] analysis is centered around actions, primarily external actions, but the same principles apply to internal actions—actions that involve only the cognitive processing mechanisms. One major emphasis in the study of attentional processes is the distinction between *controlled* and *automatic* processing of perceptual inputs….However, the critical point is that the phenomenal distinction between willed and ideomotor acts (automatic, habitual actions) flows from the separation of the supervisory attentional mechanisms from the systems they oversee. The phenomenology of attention can be understood through a theory of mechanism (p. 16).

Adding concepts from evolution to cognitive theory makes clear that the basic function of the nervous system is to make decisions that best enhance survival and reproduction. Decisions are called for when deviations from standards of ideal functioning are detected in the body, mind, or the external physical and social worlds.

When all the agencies of the nervous system below the LH, including the sympathetic and parasympathetic parts of the Autonomic Nervous System, have registered sensory data and are flummoxed about how to respond to it, they will call for help from the boss.

Cybernetics and General Information Theories describe how a mechanism may attempt to stay in control by making decisions to manage what may be stressful problems. *TOTE* or *Test-Operate-Test-Exit* processes describes an elemental decision making operation. A thermostat illustrates *TOTE* operations: The device *Tests* the current temperature. If temperature deviates from the standard, a heating or cooling element is stimulated to *Operate*. Another *Test* is made to see if the operation was successful. If so, the system will *Exit* the control procedure (See Carver & Scheier, 1981).

We use different congenital biological standards, and learned social and logical standards for different situations. For example, blood pressure and heart rate should be higher when running than when sitting quietly. And, social norms indicate that one may scream loudly at a football match but should whisper in a library.

Discrepancies between a current condition and some ideal biological, psychological, or social state are measured throughout the nervous system.

Stress can be quantified in terms of the size of deviations above and below standards of ideal functioning. For example, mechanoreceptors in the vasculature respond to expansion or constriction of blood vessels by increasing or decreasing neuronal firing rates (cf. Northoff, 2011).

Pathologies of the body and mind are, in part, causes and effects of dysfunctional TOTE processing. Disordered mental functioning often involves futile repetition of control attempts. For example, obsessional thinking that one feels compelled to do, involves an inability to Exit TOTE processes. Similarly, compulsive pathology involves an inability to *Exit* overt behavioral routines (e.g., cleaning).

This is Freud's *repetition compulsion* in cybernetic terms. The impulse to repeat control attempts when prior decisions are less than ideal is a normal feature of the nervous system. Repetition becomes a pathology if it produces decisions that are no better previous decisions. All psychotherapies aim to promote alterations in the patient's habits of thinking so that they can make better decisions in life.

For example, if one expects that they are about to faint or lose consciousness upon standing up quickly, they may decide intentionally to sit down. Or, one can stimulate the gag reflex with a finger and cause vomiting to reduce time spent in a nauseated state. Masturbation may be the first intense pleasure that can be induced by will and executive functions.

Animals are busy responding or not responding to representations of objects and conditions in the external world, and to aspirations arising from the nervous system itself. I was impressed in grade school by a teacher who

told us that a thing could be considered alive if it were *irritable.* And, of course,, the exigencies of life are variously irritating. The mere passage of time operates to upset baseline levels of physical materials. For example, if you sit in a chair and do nothing else, you will have to urinate sooner or later.

Deciding when to relieve oneself is a function of relatively raw sense data from the bladder that indicates a standard for volume has been met or exceeded. , and more advanced cognitive elements such as thoughts of wetting your pants and feelings of shame. One sees more than a few patients who are chronically worried about urination and often feel an urge to empty the bladder when, for practical purposes, it is already empty.

We are motivated by sensations, thoughts, and feelings of displeasure to reduce stress. But sometimes stress is experienced as pleasurable. All change is not death exactly. So, for example, some participate in "thrill seeking" activities like motor car and motor bike racing, sky diving, rugby, and American football. What these all have in common is that they involve looming, potentially injurious objects or situations (e.g., that curb, that guy, the ground).

These include activities that cause activation of the almost universal instinct to avoid looming objects. Motor car and motor bike racing, sky diving, American football, rugby, sex sometimes, and even writing for a deadline can create this experience of looming trouble, and an urge to do something to, at least avoid injury, if not win the race!

This thrill seeking or more exactly looming avoidance type of experience This, in turn, motivates the person to think of creative decisions to refine

instinctive urges in order to avoid the looming thing.. This is a pleasure. Which is to say, stress causes decision making and I think the enjoyable or awful feelings we get throughout life stem from the validity of the decisions we make.

Ideally this neurological propensity promotes the development of a durable control system. Such a system of habits of thinking and moving the body are what neurologists call competent executive functions; and, the psychoanalyst would call a durable, competent ego. Executive functions seem to depend most on LH processing of words and numbers using logic.

Freud, of course, felt that sexual motives lay at the bottom of most if not all unconscious conflict. That is, people feel bad if they should imagine or actually feel good. Because sexual pleasure was once, and I think still is, imagine to be a sin. The nature of sin or non-ideal sensation, cognition, feeling and overt behavior is determined by the super-ego in psychoanalytic terms.

Where do the rules or standards for correct action reside in the nervous system? I think there are two types of 'rules' or 'standards' or 'ideals' used by the person to regulate psyche and soma. And, that they are coded in two different parts of the brain. Specifically, I think logical and numerical rules are used by the LH. And, that for most people 'gestalt-like' standards of "good form" are used in the RH. Further, I propose that feedforward and feedback occurs at high rates between the LH and RH. In effect, the pending decisions made via logic and scientific thinking in the LH are sent to the RH to check on their soundness from what might be called an aesthetic or gestalt sensibility of wholeness.

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NOTE

[1] MicroIT, LLC participated in the development of this device.