Understanding the Complexity of Communication: Neurocommunicology

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ABSTRACT

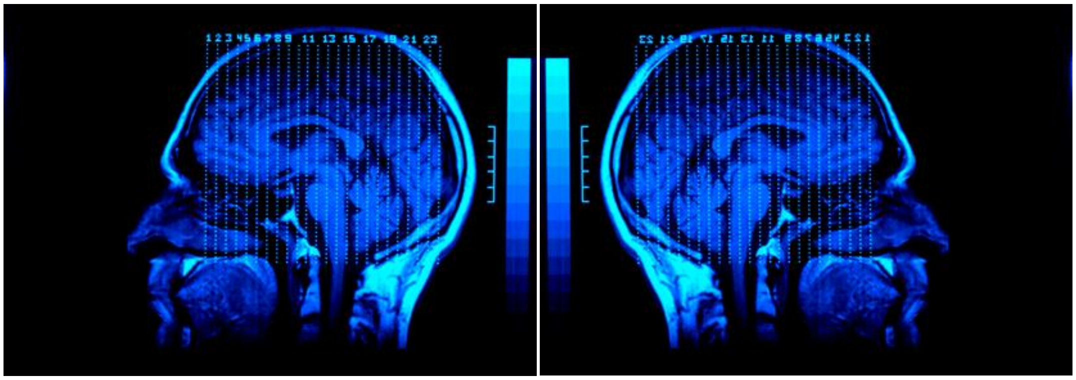
As professionals in a communication industry, we should look deeper to understand how simple acts, like agent-customer dialogue, are the product of complex neural networks. In the contact center industry we communicate all day long with customers and rarely give a thought to the staggering complexity through which we navigate during every attempt at interaction. This paper advances the premise that communication is the most complex human function. The study of how complex neurological processes shape communication behavior is referred to as neurocommunicology. This essay explores six key neurological links that constitute the theoretical foundation of neurocommunicology.

Warning: This article gets to the heart of the biological basis of communication and is not recommended for leisure reading. However, if you really want to know the internal workings of communication, *read this*. You will come to understand that communicative behavior is produced, shaped, and limited by functional, integrated, and adaptive neural systems.

UNDERSTANDING THE COMPLEXITY OF COMMUNICATION: NEUROCOMMUNICOLOGY

Neurocommunicology refers to the study of how complex neurological processes produce, shape and limit communication behavior in a social, linguistic and physical environment. The preponderance of evidence upon which the model is built comes from several innovative technologies used to map neurological activity: (1) computerized tomography (CT scan) a technique where several narrow beam x-rays are taken of the brain, recording differences in cell densities, (2) positron emission tomography (PET) where subjects ingest a glucose based radioisotope that allows instruments to measure blood concentrations in the brain, and, therefore, neural activity, (3) functional magnetic resonance imaging (fMRI) which imposes a magnetic field onto the brain to detect atomic density and changes in oxygenation, and (4) magneto encephalogram (MEG) measures the magnetic fields produced by the electrical currents of neurons. These four techniques (i.e., CT, PET, fMRI and MEG) are noninvasive technologies that provide detailed spatio-temporal maps of neural activity.

The model is also built upon neuropharmacological research, specifically the biochemical processes by which neurons communicate. Neurotransmitters (i.e., acetylcholine, serotonin, norepinephrine and dopamine) are one method by which neurons communicate, serving to link synapses that comprise functional systems of the brain. For example, acetylcholine ($C_7H_{17}NO_3$), the first discovered neurotransmitter, connects neurons thought to be involved in the process of learning and associative memory. Serotonin ($C_{10}H_{12}N_2O$), implicated in the systems that regulate mood, has been the subject of numerous psychiatric studies. Norepinephrine ($C_8H_{11}NO_3$), the neurotransmitter thought to be responsible for the “fight or flight response,” affects both mood and emotion. Dopamine ($C_8H_{11}NO_2$) regulates movement and, when overabundant in the limbic system, is linked to schizophrenia. Research has shown a consistent relationship between levels of neurotransmitters and personality characteristics such as novelty seeking, harm avoidance and reward dependence (Cloninger et al., 1991).



Although these four transmitters (e.g., acetylcholine, serotonin, norepinephrine and dopamine) represent a small minority of neurochemicals, they are the subject of numerous studies because of their involvement in learning, emotion and behavior. Although neurotransmitters play a role in linking functional neural systems, models that advance a one-to-one correspondence between a neurotransmitter and a behavioral predisposition (i.e., serotonin imbalance causes depression) may be oversimplifying the complex and dynamic processes that comprise neural activity.

The model of neurocommunicology places the vertical yet integrated structure of the human brain at the center of the communication process. The model is built upon six key links, each vital to our understanding of communicative behavior.

Link One: Genotype and Brain Development

Lewin (1985) defined genotype as “the genetic constitution of an organism” (p. 686). Rather than equating genotype to a “blueprint” for the construction of an individual, genotype refers to the potential for the development of an individual that is determined by a person's genetic constitution. The genotype consists of hereditary information that may be passed onto children even though the parent may not acquire his or her genetic potential. For example, an individual may possess the genetic potential to be six feet tall. Whether or not the individual achieves his or her genetic potential, however, is a function of the environment. The structure of the human brain, encoded in genotype, reflects a long history of evolution (Ratey, 2001). In fact, brain development in the fetus recapitulates the stages of human evolution. During initial development, we form a “reptilian” brain (subcortical region or brainstem), which controls functional systems such as sleep, respiration, body temperature and automatic movement. Built upon the reptilian brain is the mammalian brain or limbic system, which enhances movement, creates memory and produces emotion. The final layer, the cortex, is built upon the limbic system. The cortex refines the lower functions, promotes integration and facilitates language. The three levels (i.e., cortical, limbic, and subcortical) constitute the vertical phylogenetic organization of the brain. Although they are distinct in location and function, these three regions are linked inextricably by complex synaptic and neurochemical systems (Luu & Tucker, 1998; Pert, 1997).

Genotype does not, however, determine the outcome of development because the embryo is surrounded from the moment of conception by a unique biological environment. The characteristics of the environment, especially in the first six weeks after conception, affect the ability of fetal cells to carry out their instructions for development. Ratey (2001) explained the profound interaction between instructions (genotype) and environment during the later stages of fetal development:

> There is a drop from about 200 billion neurons to 100 billion. This widespread cell death is normal, for it eliminates the wrong and weak connections that could inhibit efficient and proper brain function…It also points to the fact that even at the very beginning of development the brain is a social organ: where there is no connection, there is no life.

(p. 26)

Neural pathways, either built by design or structured by environment influence, are reinforced through nutrition. Therefore, a newborn's brain already contains complex neural networks that reflect the dynamic interaction between genotype and environment.

After birth, the brain continues to grow, creating new synapses and eliminating others through atrophy. Critical periods of development arise "when the connections for a function are extremely receptive to input. Once the window closes, neural connections are pruned down to the most efficient, according to how much they are used" (Ratey, 2001, p. 40). Critical periods, for example, have been identified for the acquisition of phonemes and grammatical structures (Ratey, 2001).

Link Two: Genotype and Language

Human DNA contains instructions for building key areas involved in language. Other primates, such as monkeys, "lack this left lateral language area: their vocalizations…utilize a more primitive cortical speech area above the corpus callosum" (Calvin, 1996, p.79). Some theorists, most notably Noam Chomsky, argued further that our DNA contains instructions for developing a universal grammar (Chomsky, 1972, 1975, 1980). Similarly, Pinker (1994) asserted that we are born with a language instinct, making language different from other human abilities:

> Language is a complex, specialized skill, which develops in the child spontaneously, without conscious effort or formal instruction, is deployed without awareness of its underlying logic…" (p. 18).

Although the possibility of a universal grammar or a language instinct is intriguing, research data are inconclusive. Deacon (1997), for instance, refuted the idea of a language instinct suggesting instead that humans are biased toward learning language:

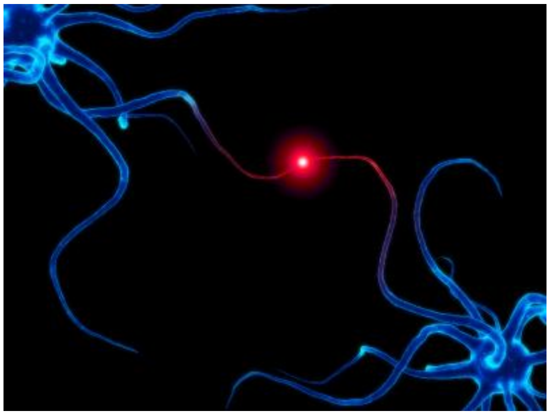
> Rather than a language organ or some instinctual grammatical knowledge, what sets human beings apart is an innate bias for learning in a way that minimizes the cognitive interference that other species encounter when attempted to discover the logic behind symbolic reference…(p. 141).

Lieberman (2000) proposed that although the neural circuitry necessary for language is innate, language acquisition (i.e., phonemes, words, and grammar) is a learned process. He rejects the existence of a language module, proposing, as an alternative, a functional language system (FLS) that integrates the vertical structures of the brain:

> The correct model for the functional organization of the human brain is not that offered by "modular theorists…a set of petty bureaucrats each of which controls a behavior and won't have anything to do with one another." The neural bases of human language are intertwined with other aspects of cognition, motor control and emotion (p. 2).

Data taken from CT, PET, fMRI and MEG scans suggest that language is not a localized brain function. Rather it is the product of complex neural networks that incorporate cortical, limbic and subcortical systems (Stemmer & Whitaker, 1999).

Link Three: Imagery, Language and Neurological Activity



Although genotype directs the composition of the brain, physical energy in our environment also creates and alters synaptic structure, especially when processed repeatedly. When we encode fragments of sensory information into neural networks, we develop sets of coherent and identifiable images. Although our neural networks of images allow us to perceive our environment as a whole, information gathered by the sensory organs is fragmented (Ratey, 2001). When we stand in front of an audience, for example, our neural networks regarding the event serve to create a coherent picture puzzle of the audience, room, etc. despite the fact that many pieces of the sensory puzzle are missing.

The richness of language as a source of information stems from neural networks that span both the vertical and lateral structures of the brain (for a review of tomographic research on language, such as CT, PET, fMRI and MEG scans, see Demonet, 1998; Dronkers & Ludy, 1998; Fields & Troster, 1998; Luu & Tucker, 1998; Papanicolaou, Simos, & Basile, 1998; Segalowitz & Chevalier, 1998a, 1998b; and Whitaker, 1998). Language systems are structured upon several important social agreements, such as segmentation and categorization of physical and social phenomena (semantics), guidelines concerning how to feel about these categories (prosody and frequently associated words), rules for organizing categories (syntax) and discourse telling us how and why things occur (Damasio & Damasio, 1999). The implicit social agreement reflected in language structures allows for vital human activities, such as the coordination of action, sharing of resources and development of identity and meaning (Baars, 1997; Deacon, 1997; Lieberman, 2000; Pearce & Cronen, 1980; Pinker, 1994; Shimanoff, 1980).

Recent research in neuroscience suggests that the architecture of the human brain promotes symbolic expressions. Demasio and Demasio (1999) explained three networks that produce linguistic devices, such as metaphor:

> First, a large collection of neural systems in both the right and left cerebral hemispheres represents nonlanguage interactions between the body and its environment, as mediated by varied sensory and motor systems…it also creates another level of representation for the results of its classification… Second, a smaller number of neural systems, generally located in the left cerebral hemisphere, represent phonemes, phoneme combinations, and syntactic rules for combining words…A third set of structures, also located largely in the left hemisphere, mediates between the two. (pp. 30-31)

Because neural networks connect images and actions with speech production, "symbolic representations such as metaphor can easily emerge from this architecture." (Damasio & Damasio, 1999, p. 34). In essence, sensorimotor images are married synaptically to linguistic constructions, generating linguistic devices, especially metaphor.
The combination of imagery and language allows for the creation of social context (see Baars, 1997, pp. 115-129). When we ground new information in a context, we activate language systems that guide perception, emotion and behavior. Language networks, therefore, serve to construct an ordered world of social contexts. For example, when we activate language networks that are connected to "fear", serving to categorize the sympathetic response of the autonomic nervous system, we also evoke all the accoutrements of language—vocal inflections hinting at limbic arousal (prosody), associated concepts (harm, threat, etc.), syntax telling us the object of the fear, and discourse that explains how and why fear occurs (e.g., "butterflies in my stomach"). LeDoux (1996) contended that language makes the human experience of emotion unique: "feelings will be different in a brain that can classify the world linguistically and categorize experience in words than in a brain that cannot" (p. 302).

Language systems are also adaptable, evolving continually to meet the demands of a structured yet unpredictable physical and social environment (Sankoff, 1980). Although our brains are shaped by language (Stemmer & Whitaker, 1999), our brains also shape language to satisfy physical, psychological, social and existential needs (Epstein, 1990). Once we learn how to interact with the world linguistically (i.e., semantics, syntax, discourse), we seek incoming information that conforms to those known patterns. When current categorizations are not found useful new language systems emerge, which, in turn, categorize future sensory information (Deacon, 1997).

Link Four: Brain and Behavior

Human behavior is the product of cortical, limbic and subcortical systems. At the most basic level, all behaviors are muscle movements produced by motor neurons. The basal ganglia and the cerebellum refine muscle movements by adjusting force, timing and execution. Integration with sensory systems in the cortex allows muscle movement to be skilled, adaptive and functional (Kolb & Wishaw, 1996). Because motor neurons connect, either directly or indirectly, to other functions, behavior can be viewed as the juxtaposition of muscle movement, physical energy in the environment, stored images, language systems, and limbic activation.

Face to face communication behavior reflects the multifunctional and vertical structure of brain systems. If we say, "Nice weather we are having", we produce a symphony of intricate muscle movements (controlling respiration, vocal tract movement, tongue and mouth movement), produce vocal inflections (pitch, rate, volume and quality), exhibit facial expressions that indicate limbic arousal, and employ language, revealing the structures that compartmentalize, categorize, and explain our social environment. Because these systems operate simultaneously, our behavior can be viewed as the manifestation of sensory, emotional and linguistic systems. To study behavior, language, imagery and emotion separately, therefore, is to ignore the nature of the neurological systems that generate these phenomena.

Link Five: Sensory Organs and the Brain

Perception, in neurological terms, can be defined as the "subjective experience of the physical energy in one's environment" (Kolb & Wishaw, 1996, p. 118). Perception is not, however, the passive absorption of environmental stimuli (i.e., sensation). Rather, perception is an active process that is rooted in preconceived notions of context:

> The clearest proof that perception is more than sensation is the transformation of the same sensory stimulation into totally different perceptions and the fact that perceptions are affected by the context of the sensory input. (Kolb & Wishaw, 1996, p. 119)

Functional systems in the brain determine the information to which the sensory organs attend. Our sensory organs also serve a vital limiting function, sheltering us from the tidal wave of surging environmental stimuli (Kolb & Wishaw, 1996).

Information attended to by the sensory organs is projected to working memory, located primarily in the principle sulcus, which allows for "short-term activation and storage of symbolic information" (Goldman-Rakic, 1999, p. 92). A projection to long-term memory (i.e., principle sulcus to hippocampus) allows information stored in short-term memory to be compared to learned associations. Working memory is also part of an elaborate network that connects, "major sensory, limbic and premotor areas of the cerebral cortex" (Goldman-Rakic, 1999, p. 97). A region of long-term memory (hippocampus), for example, projects to the center of emotional memory (lateral nucleus of amygdala), infusing emotional information associated with the context. In essence, information attended to by the sensory organs is analyzed and potentially stored by comparing the new information to learned associations and emotional memory, resulting frequently in the activation of the motor systems.

Link Six: Genotype and Phenotype

Phenotype is defined as "the appearance or other characteristics of an organism, resulting from the interaction of its genetic constitution with the environment" (Lewin, 1985, p. 689). Phenotype refers to the observable or physical characteristics of an individual, such as height, eye color, and hair color. Recall that genotype refers to the inherited potential of an individual whereas phenotype refers to the actual physical state of the individual, which is a product of both genotype and environment. Lewin (1985) offered an explanation of the essential difference between phenotype and genotype:

> "Visible or otherwise measurable properties are called the phenotype, while the genetic factors responsible for creating the phenotype are called the genotype" (p. 25).

A person's height can illustrate the difference between genotype and phenotype. If a person possesses the potential to be six feet tall (genotype) but if the availability of nutritious food (environmental characteristic) was scarce during the growth phase of the individual, the result might be an individual who grows to only five feet tall (phenotype). While separated for ease of explanation both the genotype and environment work in concert to develop the organism (Lewin, 1985).

Phenotype is similar, but not identical, to the construct of appearance. Appearance includes the subjective and culturally guided process of perception, whereas phenotype refers to objective biological characteristics. The metaphor of appearance as a "second skin" exemplifies the elemental difference between phenotype and appearance. Phenotype is a first skin (observable physical characteristics), whereas perception of phenotype (appearance) is a second skin, which is largely the result of social covenants regarding the meaning of physical attributes (Burgoon, Buller & Woodall, 1996, pp. 48-60).

Summary

The most complex human activity, communication, is located at the bustling crossroads of genotype, phenotype, sensory images, language, behavior and environment. At conception, we inherit instructions for a vertical and phylogenetically structured brain. As biological processes unfold in a physical and social environment, a phenotype emerges. Part of our initial development involves the formation of neural systems necessary for language acquisition, consisting of countless connections between cortical, limbic and subcortical regions. Language serves as a multifaceted social instrument, which functions to contain, categorize, contextualize and explain our dynamic environment. Finally, the complexity of human communication behavior echoes the intricacy of the neurological processes that produce it. In summary, communicative behavior is produced, shaped and limited by functional, integrated and adaptive neural systems.

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