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19. Corollary Discharge and "Relative Conjugate Movements"

Any **voluntary action** produced by a person involves not only the downward discharge to the peripheral effectors, but also a simultaneous central discharge **from motor to sensory systems**, preparing the latter for those changes that will occur as a result of the intended action. The motor systems mean here specifically the programming centres of the CNS. The sensory systems of the CNS are also those that integrate the afferent impulses coming from the various sensory modalities. This train of impulses coming from the motor to the sensory system is called **corollary discharge** (or **efference copy**). As an example, when I touch myself somewhere (on the knee or on the shoulder), it will not occur to me to ask who is touching me?'; or when I am talking, I will not ask 'who is talking here?', because the corollary discharge is preparing the sensory systems for the consequences of my doings.
Moreover, the presence or absence of a corollary discharge would determine whether an action is voluntary or involuntary
When an **action is repeated** several times (becoming "habitual"), the repeated (learned) coronary discharge converts anticipated sensory outcome into a **part of the pattern** (See also
(18) "The Constituents of a Pattern of Action, Sensory Anticipations")
In certain instances, as constituents, habitual patterns might have anticipated **limiting** outcomes (See "Defence Mechanisms (Anti-patterns)"). It might be desirable in certain instances (when there is no apparent structural impediment, for example) to "convince" the pupil to give up the restrictive anti-pattern, by using the idea of the **"relative conjugate movement".** For example, it circumvents the limiting anticipation, by changing the **moving of a distal part** of the body relative to a **stationary proximal part**, into **moving this proximal part** relative to **that distal part, which is now fixed.** It is changing a habitual pattern (having its anticipations ready) into a non-habitual pattern (devoid of limiting expectations).

I have permission from Walter J Freeman to quote him/ Eva Laser

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2. Meaning, representation and intentionality

"The relations among the three parts of this simple brain are crucial for understanding how they create intentional behaviour. In each hemisphere/ the sensory cortex receives input, the motor cortex implements action, and the hippo- campus provides multisensory integration and orientation m space and time. Each part has reciprocal connections to the others (Figure 3).

The entire hemisphere constructs goal states through its interactive neural activity patterns. Those patterned activities guide the body through complex sequences of actions, and prime the sensory cortex to select the smells, sights, sounds and tastes that are predicted as the Consequences of the impending goal-directed actions. This is a central process that we call preafference, and it provides the basis for what we experience as attention and expectation. It enables the sensory cortices to predict specifically how the actions to be taken will change the relations of the eyes, nose, ears and fingers to the world. **The messages are called corollary discharges.** Together they help us to distinguish between changes in the environment and apparent changes that are due to the intentional movement of our bodies, so that when we move our eyes, we do not perceive the world to move. They tell us whether the voice we hear, the hand we see or the odour we smell is our own or someone else's.

The somatosensory cortex also receives messages from the muscles and joints, confirming whether an intended action has been performed, but this process of feedback is called proprioception, to distinguish it from exteroception of the world and interoception of the internal organs. Proprioception and interoception differ from preafference and corollary discharge by going from the brain through the body, instead of remaining entirely within the brain. For all cortices, preafference is the process by which we imagine what things may be like, if or when they come. "p 44-45

"In the following chapters I will describe ten building blocks that allow us to understand how neural populations sustain he chaotic dynamics of intentionality, because the dynamics provides the biological basis for the flexibility, creativity and meaning of human behaviour. A As a preview, the ten steps are listed here. Terms in bold are technical words that are required to name previously unknown objects and processes that have been disclosed by brain imaging and neurodynamics.

9. The divergence of corollary discharges in **preafference** followed by **multisensory convergence** into the entorhinal cortex as the basis for Gestalt formation (Figure 17). "

5. Emotion and intentional action

"Figure 17 Pragmatists view perception as an active process, holding that humans and other animals maintain a stance of attention and expectation. This stance embodies a hypothesis that is initiated by intentional dynamics in the limbic system, indicated by the asterisk and that is transmitted by corollary discharge to all the sensory cortices in the process of preafference.

The arrival of stimuli confirms or denies the hypothesis. The hypothesis is tested by state transitions giving AM patterns that converge into the limbic system into the entorhinal cortex in mammals). A new hypothesis forms, which presages one of a range of possible actions, each with its corollary discharge. The focus of intention is on the limbic system, not in the thalamus or frontal lobe, because the hippocampus has the neural machinery for directing intentional action through space-time. Every sensory module must have a mechanism for organizing its patterns of meaning in space-time. It must either have its own or share one

mechanism after fusion of the multimodal patterns. Evolution has selected the parsimonious solution of time sharing. This does not preclude direct exchanges between sensory modules, but it indicates the unique importance of multisensory convergence into the entorhinal cortex, which is the ninth building block of the dynamics of intentionality. "p135

"The requests for cooperation sent from the limbic system to the motor systems are accompanied by transmissions of action potentials to the primary sensory cortices (Figure 18) in efference copies and corollary discharges. They are highly significant in perception, because they provide the basis on which the consequences of impending motor actions are predicted for the expected stimuli to each of the sensory ports (Chapter 2,).
The preafference precedes feedback by proprioception and interoception loops from the sensory receptors in the muscles and joints to the spinal cord, cerebellum, thalamus and somatosensory cortex. The corollary discharges convey information about what is to be sought by looking, listening and sniffing, and the returning afferent discharges convey the current state of the search. When an expected stimulus is present, we experience it. When it is not, we imagine it.
Preafference provides an order parameter that shapes the attractor landscapes, making it easier to capture expected or desired stimuli by enlarging or deepening the basins of their attractors. My view is that the corollary discharges do this by a mesoscopic bias that tilts the sensory attractor landscapes, facilitating entry into relevant basins and their attractors. The same limbic message is sent to all the sensory cortices, so that the choice of a goal orients the senses in the same context/ whether it is to find food, safety or the feeling of power and comprehension that occurs when dopamine receptors are activated. The organism has some idea, whether correct or mistaken, of what it is looking for. The scent of prey combined with the touch of wind on the skin instantly causes the ears to listen and the eyes to look for waving grass. Preafference provides the multimodal perceptual processes of expectation and attention. Without this pre- configuration, there could be neither search nor perception.
Without sensory recursion/ there would be no intentional action. Without emotion/ there would be no remembering. "p 145–147

From the same source

Corollary discharge/ efference copy:

"… The relations among the three parts of this simple brain are crucial for understanding how they **create intentional behaviour**. In each hemisphere, the sensory cortex receives input, the motor cortex implements action, and the hippocampus provides multisensory integration and orientation in space and time. Each part has reciprocal connections to the others. The entire hemisphere constructs goal states through its interactive neural activity patterns. Those patterned activities guide the body through complex sequences of actions, and prime the sensory cortex to select the smells, sights, sounds and tastes that are predicted as the consequences of the impending goal-directed actions. This is a central process that we call **preafference**, and it provides the basis for **what we experience as attention and expectation**. It **enables the sensory cortices to predict** specifically how the actions to be taken will change the relations of the eyes, nose, ears and fingers to the world. The **messages are called corollary discharges. Together they help us to distinguish between changes in the environment and apparent changes that are due to the intentional movement of our bodies, so that when we move our eyes, we do not perceive the world to move.** They tell us whether the voice we hear, the hand we see or the odour we smell is our own or someone else's.
The somatosensory cortex also receives messages from the muscles and joints, confirming whether an intended action has been performed, but this process of feedback is called **proprioception**[i], to distinguish it from **exteroception** of the world and **interoception** of the internal organs. Proprioception and interoception differ from preafference and corollary discharge by going from the brain through the body, instead of remaining entirely within the brain. For all cortices, preafference is the process by which we imagine what things may be like, if or when they come. The primary sensory cortices transmit their activity constantly and, if they have nothing to report, they transmit to our limbic system whatever their

priming has led them to construct.
The sensory receptors do not have that kind of selective autonomy for pattern formation. Cortices give visions and hallucinations. Receptors give itches and ringing in the ears.
The burning of fuel to maintain the metabolic ground state of your body and brain depletes your reserves and makes you hungry. As a hungry animal, you seek an odour of food by sniffing. When you locate it, you hold that smell, move your head and body, take another sample, and compare it with the first. Is it stronger or weaker? Do you go left, right or straight ahead? To decide that you must know where you were, where you are now, what you did to get from there to here, and how long you took. **Even this simple intentional task requires your brain to direct all sensory-induced activity patterns into the space-time** field in the hippocampus to confirm or deny the expected consequences of each action, so each part of the brain is constantly interacting with the others. The assembled activity is unified, whole and purposive.
As animals evolve in competition for resources, their success depends on increasing the range and complexity of their possible courses of action and constructions of meaning. Brains increase in size and the complexity of connections. The dynamics of the activity comprising meanings require increasingly elaborate stages between the primary sensory cortices and the limbic system, while preserving the basic feedback interactions. In humans, these new stages may become well known because of their accessibility by non- invasive brain imaging: the cingulate, inferotemporal and orbitofrontal cortices. The new parts and connections provide ever greater sophistication, forming the basis for language, mainly in the left lateral hemisphere, and for social behaviour, through enormous expansion of the ventral frontal lobes. Singular destruction of these 'add-ons' can lead to blindness, deafness, partial paralysis, loss of language, and the 'social blindness' that is characteristic of damage in the frontal lobes. Yet intentional behaviour persists, albeit with impoverished meanings, unless there is also destruction in the limbic system, as in advanced Alzheimer's disease, which has a particularly virulent predilection for destroying the final link of the sensory cortices to the hippocampus. But singular destruction of the medial temporal lobes in both hemispheres does not abolish all aspects of intentionality. Instead, it results in loss of space-time orientation and the ability to add new episodic memories, that is, unity and wholeness. Goal-directedness is not restricted to the limbic system by any means.
These, then, are the issues I raise in this book: **how patterns of brain activity are directed intentionally towards external objects, leading to the creation and assimilation of meaning through learning**. The specific properties of neuron populations explain how the patterns arise and how they guide behaviour into the world by coordinating the firings of the microscopic motor neurons. I view the neural populations that compose the limbic system as the key to understanding the biology of intentionality. Paul Maclean called this core system 'the reptilian brain', suggesting to some people that it is emotional and brutish with no higher cognitive function. On the contrary, I think we agree the limbic system is the principal agent of action in space-time….

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[i] Latin: proprius = enskild, egen; capere = ta, gripa.