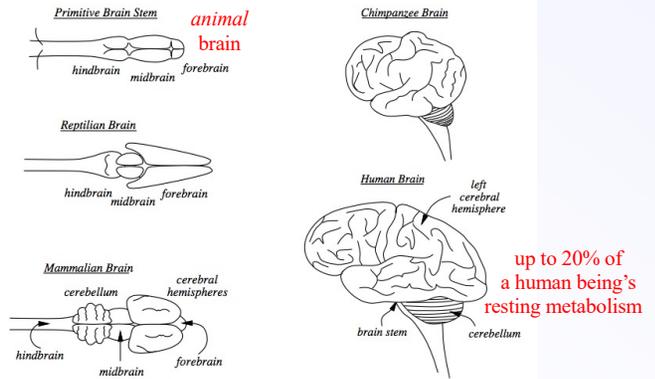


Developmental Neurology: A Human's First 12 Months



1

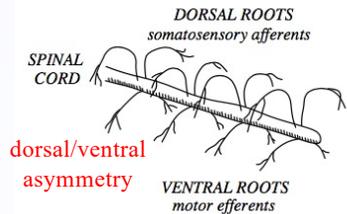
The Evolution of the Human Brain



2

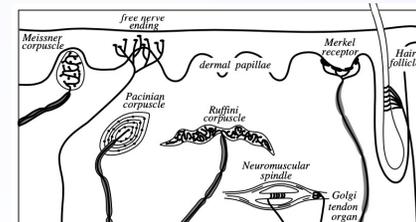
Phylum Chordata

- in its simplest form, a peripheral signal passes through a single synapse to innervate a **motor unit**
- prominent, elongated *ganglia* formed consisting of clusters of several, highly correlated clusters of related peripheral signals and motor units
- an elongated *neural tube*, consisting of several such ganglia, gave rise to specialized organs of the central nervous system
- **Chordates** – fishes, reptiles, birds, mammals, primates



3

Cutaneous Mechanoreceptors - Haptics



- independent response and sensitivity, massive redundancy
- *touch blend* from multi-sensory signals: temperature, pressure, and vibration ... distinguish wet, slimy, greasy, syrupy, mushy, doughy, gummy, spongy or dry, hardness, texture, compliance, size, shape, and curvature.
- exploratory movement and contact

4

Touch Performance

frequency response	0 to 400 Hz (+ very high freq)
sensitivity	approx. 0.2 grams/mm ²
max. response	100 grams/mm ² ⇒ 55dB dynamic range*
spatial resolution	1.8 mm (two-point discrimination tests)
signal propagation	motor neurons 100 m/sec sensory neurons 2 to 80 m/sec autonomic neurons 0.5 to 15 m/sec

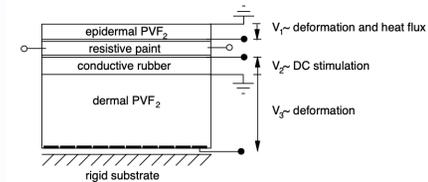
* - dynamic range = $20 \log_{10}(\frac{f_{max}}{f_{min}})$
 sound: ~ 100 dB ⇒ factor of 100,000 in amplitude and 10,000,000,000 in power
 sight: ~ 90 dB ⇒ factor of 1,000,000,000 in brightness.

5

A Robot Tactile Sensor

Piezo- and pyroelectric effects

PV F₂ (polyvinylidene fluoride)



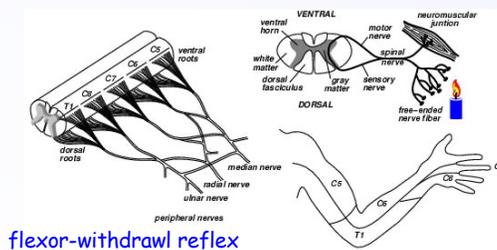
Paulo Dario, University of Pisa, ca. 1990

6

Motor Units

The CNS is organized in terms of movement patterns---the basic movement pattern is the reflex

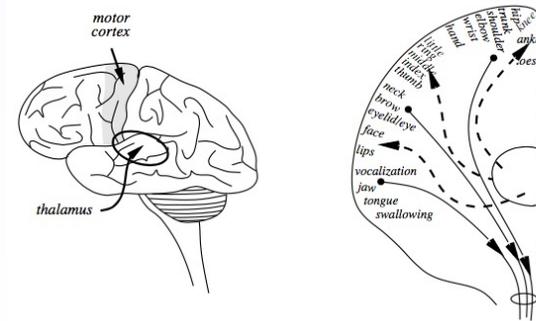
Descartes' reflex



flexor-withdraw reflex

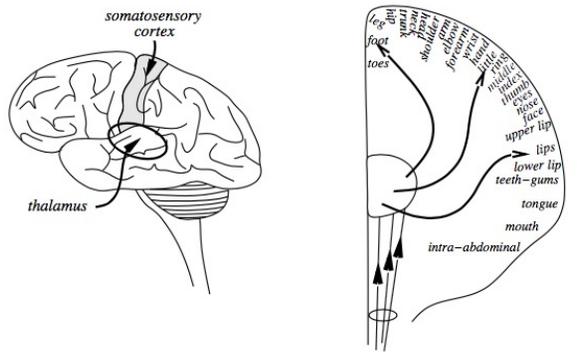
7

Primary Motor Cortex

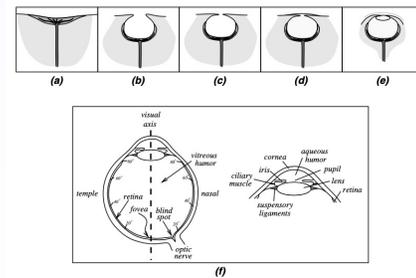


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Primary Somatosensory Cortex



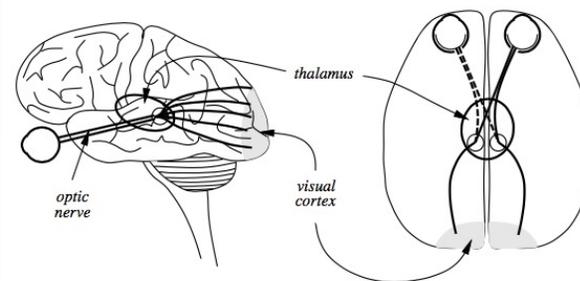
The Eye



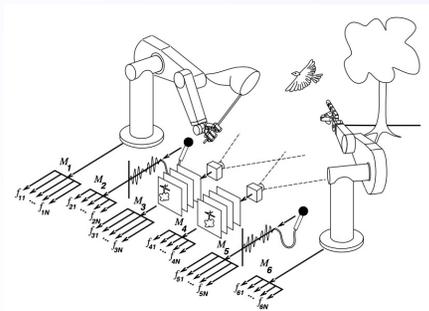
Natural Variation

- bees, fish, butterflies, birds and reptiles** - capable of seeing color, most mammals do not.
- herbivores** - Side facing (monocular) vision systems yield almost wrap around field of view.
- carnivores** - forward facing (stereo) system provides precision depth and a narrower field of view (< 180 degrees)
- cheetah** - wide, eccentric foveal region spanning horizontal band for locating prey against the horizon
- chamelion** - turret eyes capable of both side- and forward-looking configurations
- nocturnal** - reflective back surface of retina, small birds sacrifice muscles for size. The largest eye belongs to the giant squid—up to 15 inches in diameter.
- fishing** - fishing birds use polarizing lens
- rattlesnake** - eyes oriented to side, forward-looking stereo pit organs (no lens)

Primary Visual Cortex



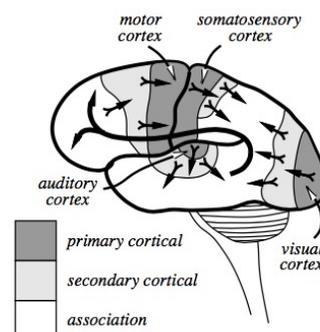
Where is the Information?



multimodal, spatiotemporal signals

13

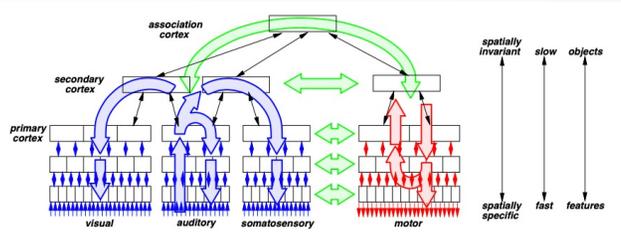
Flow of Information and Control



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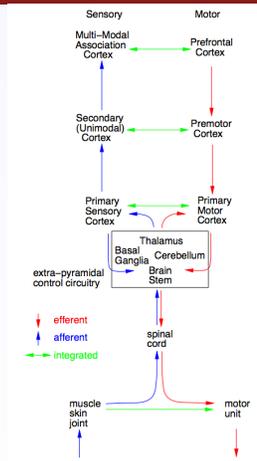
Cortical Association

conjecture: common six layer columnar structure across the 2 mm thickness of the cortical "bark" includes ascending (encoding) and descending (decoding) projections and forms the basic unit of cortical computation



15

Control Hierarchy in the CNS



16

Limbic Reflexes - Visceral, Vegetative, and Behavioral

- laryngeal** - cough in response to irritation of the larynx
- pharyngeal reflex** - "gag"
- sucking/rooting/tongue retrusion** - reflexive repertoire for finding, impelling, and expelling objects/food from the mouth, inhibit the gag reflex
- oculomotor reflexes** – pupillary response to brightness, eye blink in response to looming, corneal contact, pain
- acoustic stapedius reflex** - muscle attached to the stapedius muscle contracts to protect the middle ear from excessive noise
- eye blink** - defensive, stimulated by looming, corneal contact
- elimination** – urinary and sphincter
- attentional** – audito-oculogyric visual orientation to sound,

Brain Stem Mediated Neonatal/Primitive Reflexes

chemical, hormonal, motor, behavioral response to triggering stimuli
Moro- emerges 8-9 weeks in utero, inhibited by 16 weeks



after 16 weeks, transforms into the mature "startle" reflex that engages additional perceptual cortical areas

Brain Stem Mediated Neonatal/Primitive Reflexes

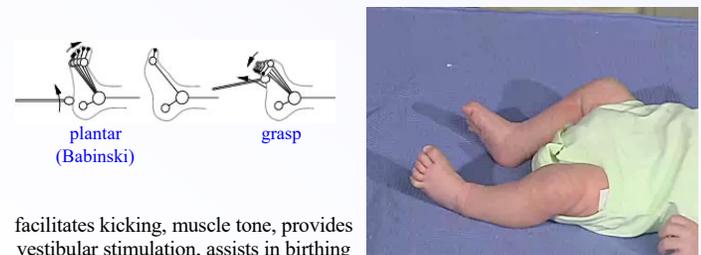
Palmar grasp - emerges 11 weeks in utero, inhibited 2-3 months after birth



if it persists too long, it may delay manual dexterity, hand-to-mouth coordination, cause swallowing problems and delayed speech
 about 36 weeks after birth, transforms into the adult pincer grasp

Brain Stem Mediated Neonatal/Primitive Reflexes

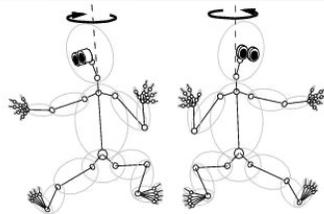
Plantar Reflex - emerges 18 weeks in utero, inhibited 6 months after birth



facilitates kicking, muscle tone, provides vestibular stimulation, assists in birthing process, begins process of myelination in CNS for creeping, laterality, hand-eye coordination, and integration of vestibular feedback

Brain Stem Mediated Neonatal/Primitive Reflexes

Asymmetric Tonic Neck Reflex (ATNR) - emerges 18 weeks in utero, inhibited 6 months after birth



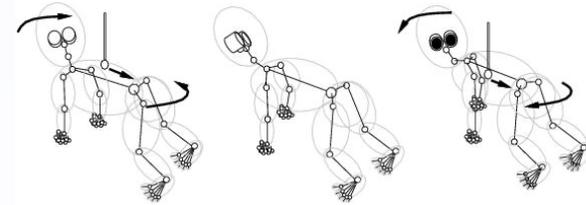
facilitates movement down birth canal, helps to maintain unobstructed airways, focuses eyes on outstretched hands, extend focal range from about 17 cm to arm's length. If it persists too long, may delay the ability to focus eyes to longer range targets and over generalize homolateral movements.

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Brain Stem Mediated Neonatal/Primitive Reflexes

Galant Reflex - emerges 20 weeks in utero, inhibited by 9 months after birth



ipsilateral curving of trunk in response to tactile stimulation on flank, helps learn to rotate, stimulates torso movement useful for crawling, creeping, walking. If it persists too long, induces hip rotation in walking posture and gait, interferes with amphibian and segmental rolling reflexes

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Brain Stem Mediated Neonatal/Primitive Reflexes

Galant Reflex - emerges 20 weeks in utero, inhibited by 9 months after birth



3 months

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Brain Stem Mediated Neonatal/Primitive Reflexes

Primary Stepping Reflex - spinal reflex, presents at birth, disappears in 3-4 weeks, re-appears at about 12-24 months



Labyrinthine Reflex - integrated at the brain stem, head rises off the floor in the prone position---one DOF inverted pendulum

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Postural Reflexes

Positive Supporting Reflex - emerges 3-4 months and persists throughout life, tactile stimuli on sole of foot causes a muscle stretch reflex and creates a pillar-like support for the body weight



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Postural Reflexes

Righting Reflex - reflexive turning of shoulders and trunk in the direction of the head, presents at birth and is observed until about 4 months, at which time, it is integrated into voluntary movements

Optical-Head Righting Reflex - emerges at 2-3 months, remains for life, related to balance and eye movement control, if delayed, can lead to poor visual tracking, motion sickness, and disorientation

Labyrinthine-Head Righting Reflex - emerges 2-3 months after birth and remains, vestibular counterpart of OHRR, essential for balance and integrated optical focus

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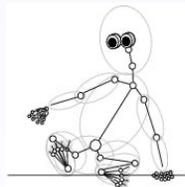
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Postural Reflexes

Amphibian Reflex - emerges 4-6 months and remains, essential for crawling, walking, running, persistence indicates a problem inhibiting primitive reflexes

Segmental Rolling Reflex - emerges around 6 months and persists, employed in cross-lateral movements - walking, running, jumping, swimming, allows baby to roll over and up into sitting position

Lateral Propping Reflex - analog of positive support reflex, weight bearing extension of the arm essential for protective bracing, emerges 5-7 months after birth and persists



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Postural Reflexes

Parachute Reflex - emerges 8-9 months after birth, and is retained, vestibular trigger

12 months



Landau Reflex - "superman" pose, legs reflexively drop down into flexion when the infant's head is pushed down

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