Lecture 1: 2/8/21

Two Videos: Spinning Balls and Life through pictures

- Big phases and stages to us is actually part of a continuous set of change that are going on
- What looks like simple things on the surface is part of a much more complex system underneath
- Patterns at multiple levels

Milestones vs. Mechanisms

- Milestones = description of an average trend
    - Does not tell you *how* development happens
    - Does not explain variation
    - Milestones change as the underlying science advances
        - Ex: babies in different cultures will take their first steps at different times
- Themes for mechanistic approach
    - Developmental psychobiology
        - Multicausality and levels of organization
        - Historically, a changing relationship between biology and psychology
        - Cartesian dualism: mind and body as separate
            - How to have beliefs that are certain?
            - Doubt as a method - anything that can be doubted away doesn't count
                - Reliability of sensory information?
                    - Can I believe the information coming from my eyes?
                    - No, you could be deceived
                        - Ex: swizzle stick in martini glass, light refraction causing an optical illusion
            - What is this "I" that is doing the thinking?
            - Dualism = wall between rational thought (reliable) and sensory information (unreliable)
                - Perception vs cognition
    - Comparative (cross-species) data
        - Working with animals
            - Faster development than humans - logistical reasons
    - Chronotropic organization
        - Cellular processes going on
            - How embryo organizes its cells
    - Reciprocal roles of theory and research
    - Breaking down cartesian wall

Lecture 2: 2/10/21

- Psychology and biology combined

        - Psychosomatic medicine: mind and body interact
            - Eg: stress and illness
        - Behavioral neuroscience
        - Behavioral immunology
        - Behavioral toxicology
        - Newer disciplines
            - Cognitive neuroscience
                - Social and developmental cognitive neuroscience
- A psychobiological approach to development
    - Integration of psychology and biology
        - Mechanisms have components at multiple levels of organization
            - Environment (physical, social, cultural)
            - Behavior
            - Neural activity
            - Genetic activity
    - Concern for context, environment
        - Where does mechanism stop and environment start
            - Ex: conspecifics as part of a learning system
            - Environment can extend in and mechanism can extend out
                - Outside influences can turn genes on and off
                - Mechanisms can be both outside and inside baby as well as environment can be both in and outside the baby
- Bidirectional causality
    - Changes in the neural activity affects the type of genes that are being expressed in that nuclei
    - Changes in social interaction affect genetic activity
    - Bidirectional influences at multiple organizations
    - How these various level organization and activity between them is driving developmental phenomenon
- Genes and their environments
    - Traditional approach: often a “Cake” metaphor used to relate the two
        - Genes as recipe (blueprint) for development
        - Experience as ingredients for development
        - Implication of dichotomy
        - Cake metaphor is problematic
            - The blueprint itself can be changed by even fetal experiences
                - Ex: cloned kitties
                    - CC vs rainbow
                        - Cc has different temperments and habits even though they have exactly same genome
                    - Evidence

- Small differences in timing (cellular timing in an embryo) can start a cascade creating a large difference overtime
    - A slight change in gene expression → cats with completely different color fur, temperament
- Genes and their environments
    - What's in a gene's environment?
        - Other genes
    - The question is not one of nature vs nurture
        - Figure out mechanisms that have components at multiple levels of organization
    - Psychobiologists study development in terms of multiple interacting influences

- Development is multicausal
    - Whole host of behaviors that mediate interactions between gene and environment and vice versa
        - Systems matter together
    - All effecting within a level and another level overtime
    - Example: the "A not B" error
        - Two targets in front of the baby
        - Train baby on reaching one side for the toy
            - Baby figures out to reach location A to get toy
        - Then hide it in the other location (baby sees this)
        - Babies before the age of 10 months still reach for A
        - Traditional explanation: testing object permanence
            - Maturational time table
                - Genes say go millenate which allows prefrontal cortex to allow object permanence to happen
        - Multicausality and "A not B"
            - Thelen: error without object
                - Changed the way the babies reached
                    - Memory for the location is built out of how I got to that location in space
                        - If you modify those dynamics you change the memory
                    - Took a weighted wristband and put it on or took it off right before the B trial
                        - Reach for the correct
                    - Turn them right before B trial
                        - They will past the test
                    - Sitting and standing change before B trial
                        - They will past the test
            - What are the underlying components of the error?

            - Turn error on and off depending how you position baby
                - Focus on moment-to-moment task dynamics and reaching
                    - Change reach trajectory
                    - Change object salience
                    - Assess at different levels of motor control
        - Conclusion: object memory is an embodied process
            - Seeing, motor control, and memory come together
            - Change trajectory change memory
            - Sensory motive processes are becoming the memories that build this cognitive process that allows you to recognize objects that are hidden from you
            - No singular controller
                - Set of behaviors that are being recruited by the task
            - Motor and perceptual process are exerting influence on cognitive processes
- A moment of methods
    - Independent variable
    - Dependent variable
    - Extraneous variable
        - Thing that is adding noise to the dependent measure
            - Ex: is the baby hungry or tired, is the baby a good reacher, is the baby interested in the task
    - Confounding variable
        - An extraneous variable that changes systematically with independent variable
- Nested timescales
    - Development happens at multiple time scales
        - Moment to moment time (real time)
            - Learning, social interaction (real time social interaction)
        - Developmental time (months, years)
            - Ontogenetic stages
        - Evolutionary time
            - Time scale of generations and beyond
            - Why do these changes happen vs how?
        - Timescale of analysis has implications for amount of continuity/ discontinuity seen in development

Lecture 3: 2/15/21

- Continuity and discontinuity
    - Discontinuity at one timescale may be due to continuous processes at another timescale
- Integrating timescales
    - Proximate cause

        - Developmental, mechanistic explanation
        - “How” question: what are the physiological and behavioral mechanisms at work?
    - Ultimate cause
        - Evolutionary explanation
        - “Why” question: What is the adaptive significance of the behavior?
- Barriers to integration
    - “Levels of analysis chauvinism”
        - Reification of biology and culture (Japanese macaque example)
    - Confusion of ultimate with proximate explanations
        - Nominal fallacy: mistaking a description for an explanation
        - Usually teleological
    - Attachment and embodied cognition
        - Traditional: early attachment caused by “internal working model”
            - Executive controller of behavior
                - Dualism?
                - Model of behavior already present in the baby’s head → evolution put it there
            - What are the proximal controls of attachment behavior
- Braitenberg: “vehicles”
    - Law of uphill analysis and downhill invention
        - Hard to do inference
        - Easier to design things with goals in mind
    - Small, simple changes can yield dramatic differences in behavior
    - Sensor is temp dependent and directly connected to flapper
        - Sensor is organizing behavior
            - Moves flipper faster in hot water, slower in colder
        - Given the way that temperature and water currents and objects are distributed in your room it's gonna be very hard to predict where this thing will be in your room
    - Light sensitive sensor
        - Robot encounters light
            - A: more light on the right side making wheel on right go faster → turn away from the light
                - Get as far away from light as it can
            - B: more light on left side connected to right wheel so it will turn towards the lights
            - No box in robots head that says avoid light go to light
                - Where does this organization of behavior come from
                    - Organization of vehicle: where the sensors are on the body
                    - Internal wiring: straight or crossed wires, morphology

                - Organization of information surrounding vehicle : layout of information in the environment
            - Simple mechanism can drive the emergence of complex behavior
    - Studying biological vehicles
        - Attachment to mom: come to mom after playing with toys
            - Using mom as a base and returning to her
                - Goes into the world goes back to mom loop
        - What's organizing behavior?
            - This is attachment
                - problem : doesn't tell us what the control is over the babies behavior
                    - Number of ways that the baby might be balancing some sensory preferences between mom and structure in the environment - balance between familiar stuff and exploration
                        - Mom: warmth, odor, movement
                        - World: shape, sound, color, and texture that are not familiar to mom
                - Attachment being caused and controlled by multiple coacting influences
                - Contingency and reliability of moms behavior
- Learning from biological and nonbiological interaction partners
- Nature vs Nurture
    - Definitions of "innate"
        - Congenital: present at birth
        - Criteria for predetermined:
            - Chronotypy: fixed sequence of development
            - Heritability (a pop measure): how variation in a trait varies with the DNA within population
                - But watch out for misattribution of causality
            - Coupling of sender and receiver (when studying communication systems)
    - Examples from species recognition
        - Nipple-seeking in rat pups: a strong role of experience
            - What is the developmental mechanism knowing to find nipple
                - Amniotic fluid spills all over moms ventrum → babies follow that and find nipple
                    - Genetic sensitivity to amniotic fluid?
                        - Predetermined information?
                        - How do you test the hypothesis that knowing about amniotic fluid is innate?
                - Injected citrol (lemon scent) into amniotic sac, cleaned off ventrum and rubbed nipple with regular scent and other with citrol. Rat pups go to citrol scented nipple

- Genes help olfactory systems be sensitive prenatally, but don't have genes that tell them what scents matter. They have to pick that up in environment
    - Not predetermined behavior
    - Biologically driven prenatal learning
        - Exposure not just teaching
        - Experience: tuning of biological system

Lecture 4: 2/17/21

- Acoustic recognition in crickets
    - Evidence of coupling, heritability
        - Female sensitive to different frequencies
    - Different species have different chirp rates
        - T. oceanicus : fast chirpers
        - T. commodus : really slow deep longer chirps
        - Hybrid: intermediate frequency
    - Predet
        - Genes that influence auditory system in females are on same chromosome as male's listening system
- Shift in filial preferences in rats
    - Day 15: shift in sensory control from thermal to olfactory
    - Chronotropic but mediated by thermal tactile stimulation
    - More than 10 days of experience to reliably learn context for thermal tactile cues
    - What's going on in those first 15 days?
        - First willing to huddle with either, but by day 15 it has to smell like a rat
        - Suckling not necessary
        - Milk unnecessary and non-additive
        - Thermal Tactile stimulation sufficient to induce preference and is equivalent to foster dam
    - Stable behaviors come from stable environments
        - Don't need an executive controller in head
        - In world there's a constant source of stimulation that allows for a cue to be learned
- What is development?
    - Habitat: "address" - where you are, various kinds of habitats
    - Niche: "occupation" - the functional relations between an organism's capacities and the environment
    - Development is a series of adaptive changes to a series of environmental challenges
        - Organism and environment change one another
        - Niche construction: through mutual modifications, new relationships emerge over developmental time

        - Development is a series of adaptive changes to a series of environmental changes
        - Where do the adaptive changes come from?
        - Development is the emergent product of many decentralized and local interactions that occur in real time (remember the “A not B” example)
- How to think like a developmental scientist
    - What are the mechanisms of change?
    - At what levels of organization do the mechanisms exist?
    - At what timescales do the mechanisms ope9 ie?
- Three principles for developing intelligence
    - Theme: the development of intelligence requires immaturity
        - Coordination of sensory-motor activity
            - Sticky mittens example
            - Perception and action is constructing cognition
                - Instead of cognition being a set of preexisting rules about how the world works, you build those skills by acting on the world in immature ways
        - Coupled to intelligent
            - Importance of structured social interaction
            - Babies don't exist in a social vacuum
                - Partners provide spatial and temporal structure for feedback
                - Social environment relatively tuned to your capacities
            - Social environment provides well timed information
                - Babies respond to babbling with simple speech
        - Overlapping coordinations
            - A-not-B example
            - Overlapping across domains of modalities
            - Everyday things constitute learning
            - What looks like different domains of development become coordinated through your everyday activity that acts you to operate in cognitively sophisticated ways like the A-not-B example
- Behavioral embryology
    - Prenatal life is not a passive experience, an active experience with lots of sources of stimulation
    - The questions
        - How and why does behavior, sensation, and learning develop prenatally?
            - First, an overview of the “how”
    - Human embryological development
        - Germinal period: conception - implantation in uterine wall (10 days)
            - Cell division and specialization: probabilistic epigenesis
                - Not predetermined; what a cell winds up being is influenced by other cells it bumps into

        - Cell determination organized by cell-cell interactions and exchange of proteins, which selectively activate or inhibit gene expression
        - Genome being selectively activated and inactivated by environment of cell and interaction with other cells
    - Blastocyst: pluripotent cells (cells that can do anything to more specialized cells
        - Ectoderm - skin nails teeth
        - Endoderm - digestive system lungs
        - Mesoderm - muscles bones circulatory system
        - 3 layer specialization

Lecture 5 and 6: February 22nd and 24th, 2021

- Human embryological development
    - Neural tube development
    - Embryonic period: 10 days (implantation) - 8 weeks
        - 3 weeks: heart begins to beat
        - 5 weeks: own heartbeat causes whole embryo to move
            - A lot of spontaneous movement starts to happen
    - Fetal period: 9-40 weeks
        - Early fetal period (9-16 weeks)
        - Myogenic response: if fetus strongly stimulated muscle contraction will occur
        - First neuromuscular behavior: turn away from touch near mouth
            - Area of sensitivity with time
        - Frist reflex (grasping)
            - Diaphragm contracts and expands
        - First discontinuity (17-22 weeks)
            - Decrease in fetal activity
            - Why: maturation of mid-brain regions (dorsal thalamus and striatum) inhibits activity of spinal/bulbar regions and resulting movement
        - State organization (24-32 weeks)
            - Onset of recurrent and predictable cycles of activity
                - 40 min cycle: retained after birth
                - 96 minute cycle: not retained
        - REM “sleep”
            - Rapid eye movement with qualitative changes in brain activity
            - Spends 78 percent of time in REM
        - Eyes open
        - Auditory system responsive (24-30 weeks)
            - Cardiac and motor reactions to vibroacoustic and air-coupled stimuli (120 dB ex utero, 90 dB intra-abdominal
            - Maternal speech is more salient than outside speech

        - Integrated expressions (32-36 weeks)
            - Facial muscles moving in coordinated patterns: grimaces, smiles present
    - Birth
        - Approximately 40 weeks
        - Continuity of sensory function from prenatal to neonatal environment
            - Birth does not represent a sudden change in sensory function
        - Implications of prenatal experience for postnatal behavior
            - Is early experience really a “buzzing blooming confusion” (William James) ?
            - We know that prenatal auditory learning has already happened, most of the world is blurry (limited visual system) -- allows for some clarity
                - Link between advanced auditory and limited visual systems helps with post natal learning
- Prenatal experience influences adaptive behavior postnatally examples:
    - Theme: sensory stimulation affects the functional development of sensory systems
    - Humans
        - Prenatal learning of speech sounds
        - Reinforcement paradigm using Ibi
            - Interburst intervals while sucking - shorter or longer
            - Babies actively preferring to hear their mother’s speech
                - Infants can hear mother’s speech in utero
            - Exposed in utero to Cat in the Hat or King and the Cheese
                - Neonates prefer story heard prenatally over new story (matched for number novel words, length)
        - Overview of human prenatal learning study
            - Moon and Fifer
                - Contingency paradigm
                - Infants prefer in utero maternal speech (low pass filtered with heartbeats) over nonfiltered maternal speech
                - Fifer and Moon (1995) prefer filtered (with heartbeats removed) over non-filtered maternal speech
                - General preference for familiar sounds
            - Moon, Bever, Fifer
                - Contingency paradigm
                - Infants prefer maternal speech over silence, non-maternal speech over silence, maternal over non-maternal speech
                - 2 day olds prefer female english (native language) over female spanish
    - Chickens
        - In ovo stimulation of head and neck muscles necessary for development of pecking behavior

        - Self stimulation: as a result of its movement, the -- chick embryo is tossed about “like a boat in a storm”
            - All the motion is stimulating other parts of the body - facilitating the adaptation of a critical skill
            - If there neck muscles haven’t been prenatally stimulated they can’t peck
            - Early spontaneous movement is influencing organization of the nervous system that allows development of specific motor commands that make pecking happen
    - Mallard ducklings: prenatal determination of species recognition
        - In ovo auditory experience necessary for recognition of maternal assembly call
        - Mallard ducklings approach and follow their mother in response to maternal assembly call
        - Development of response to call
            - Behavior not dependent on prior postnatal experience with call
            - What about prenatal development?
            - Premature (day 21 and 22) auditory exposure resulted in increased bill-clapping from day 21 through day 22
        - Predetermined or probabilistic
            - Prenatally devocalize embryos, control auditory exp, then test behavior (response to duck call) after hatching
                - Rearing condition: devocal- isolated
                    - Preference: none
                - Rearing condition: devocal-isolated-exposed to chicken call
                    - Preference: chicken
                - Vocal-isolated-exposed to chicken call
                    - Preference: none
                - Coval-with sibs- exposed to chicken call
                    - Preference: mallard
            - Species recognition depends upon prenatal experience with own and sibling’s vocalizations
    - Conclusions
        - Normally occurring sensory stimulation was critic al for development of a species-typical behavior
        - Behavior that seemed predetermined (instinctive and innate) turned out to be probabilistic, with multiple determinants both maturational and experiential
        - “Structure only fully realizes itself through function”
        - Experience = patterns of stimulation
- Experience as a developmental mechanism
    - Immature function can have an important effect on later development
    - Experience is not just teaching

        - Patterns of stimulation (multiple sources both external and internal)
            - History of your exposure to those patterns also matter
- Definitions of experience
    - Currently popular linear framework:
        - Genes → structure → function (at the proximate level)
    - Kuo
        - Genes → structure < -- > function
            - Strong effects of context/ environment
    - Oyama: The ontogeny of information
        - Can extend consideration of context to molecular/genetic level
        - Bidirectional influences between genes and their products
    - Gottlieb
        - Focus on structure < -- > function
        - Experience involves sensory or motor function whether evoked or spontaneous
        - Experience = stimulation = function
            - Implications for immature behavior
        - Implications for research:
            - Species - typical environments can help creat species-typical characteristics
            - Must perturb the environment to determine the (often multiple) causes of behavior
            - Perturbations yield neopheotypes if system is open to environmental effects
                - Like a ducking that can prefer chicken calls
    - Experience and stimulation play a huge roll in development
        - How do biological systems construct themselves in adaptive ways over time?
        - Maintenance
            - Most general, low-level mechanism
            - Ambient stimulation as stabilizing influence on nervous system function

Lecture 7: March 1st, 2021

- Roles of Experience: To discover mechanisms of development, need to
    - Examine structure-function relationships at multiple levels of organization
    - Use valide behavioral measures
    - Remember that development is characterized by probabilistic epigenesis
- Rats in space
    - How does gravity affect vestibular system
    - Pregnant rats move a lot → constitutes input to the developing fetus
        - Adaptive things moments after being born
        - Confounding variables: Acceleration on launch, a lot of Noise
            - Centrifuge: rats could handle this

        - Vomit Comet
            - Parabola: zero g to multiple gs
            - Rats seemed fine
                - Didn't seem to induce stress
        - Speakers test
            - Rats were fine
        - Controlled for stresses of launch
    - Remove gravity
    - Female behavior stimulate offspring in utero → activities that occur hundreds and thousands of times a day
        - Uterus is a very stimulating environment - both her maternal behavior and physiology
            - Acceleration , locomotion
            - Rearing stirring → head/body grooming
            - Abdominal grooming → providing pressure at different points
            - Hindlimb stretching
        - Control for the presence of stimuli by removing gravity
- Angular forces on offspring in utero
    - Rats in space and on ground pitch just about as much
    - On X axis: space rats do more rolling
    - On Y axis: similar amounts
- How would you test for vestibular system function in neonate rat pup
    - Dropped into a beaker of water on their backs
        - If they can write themselves they roll and right themselves in respect to gravity
        - By day 3 space rats still doing worse
        - By day 5 everyone is the same
    - Genes cue Neurons in vestibular system to start growing but the gravitational environment that determines where they grow
        - Rely on gravitational environment to tell them the right place to grow

- The birth transition
    - Bio-social-behavioral shift
    - Change in habitat but also a change in niche
    - Continuity of sensory function from prenatal to postnatal niches
    - Stage 1 (approx 14 hours for 1st birth)
        - Uterine contractions increase in frequency and duration
            - Approx 20 min to every minute
        - Cervical dilation
    - Stage 2
        - Baby pushed into and through birth canal
    - Stage 3
        - Baby emerges

        - Placenta expelled from uterus
- From infant's point of view
    - Extreme stress:
        - Pressure on head, body
        - Reduced oxygen
    - Reaction to stress
        - Catecholamine surge - increase in heart rate, blood pressure, and glucose level promotes breathing after birth
            - Implications for Cesarean births
                - Simulate pressure to cue that stress response
    - An ontogenetic adaptation?
        - Neonate morphology
            - Large head relative to body
            - Large eyes relative to head
            - Enhances caregiver responsiveness in humans
            - An ontogenetic adaptation?
                - Does it have adaptive value? Useful?
                    - Yes
                - Does it go away?
                    - Fades as you mature, yes
        - How do you get rid of an ontogenetic adaptation?
- Reflexes
    - What is a reflex? How would you differentiate it from other types of movements?
        - Simple, highly stereotyped, unlearned
    - Do reflexes develop?
        - Piaget (yes) ; Pavlov (no)
        - Depends what reflex
    - Development of some reflexive movements
        - Start out gross, diffuse, widespread
        - Become more specific with time
    - Blinking
        - Lights flash
    - Babinsky
        - Stroke foot and toes spread out
    - Moro
        - Arch their back and bring arms up when suddenly dropped
    - Rooting
        - Stimulate cheek baby will turn in that direction
    - Stepping
        - Hold a baby over a surface feet will bounce
        - Goes away after a month/month and a half
    - Sucking
        - Objects touch mouth automatically start sucking

- Grasping
    - Stimulate palm of hand → latching onto object
- Example: trigeminal “jaw jerk” reflex of guinea pig
    - Earlier: whole head moves
    - Weeks later: only jaw moves
- Are reflexes ontogenetic adaptation?
    - Some are: rooting
    - Some are not: stepping (does not go away, comes back), blinking

WIM Section 3/2/21

- Levels of Analysis

	Dynamic (explanation in terms of historic sequence)	Static (explanation of current form of species)
Proximate view (*How* an *individual* organism functions)	**Ontogeny** (development): Developmental changes in individuals	**Mechanism** (causation): Mechanistic explanation of how structures work
Ultimate view (*Why* a *species* evolved a trait/behavior)	**Phylogeny** (evolution): History of evolution of the trait in a species over time	**Function** (adaptation): Trait solves a reproductive or survival problem in current environment

- Do all levels of analysis always apply?
    - Spandrels (no clear function)
    - Innate behaviors (no clear ontogeny)
    - Completely novel behaviors (no clear phylogeny)
- Cat meowing
    - Why meow
        - Older cats pretty much exclusively meow at humans
        - Explanations
            - Ontogeny
                - Communication for food
            - Phylogeny?
                - Getting response
            - Function?
                - For food
        - Cat meowing similar acoustic properties to humans cry

            - Make noises for responses
            - As they became companions to humans this trait further developed
    - Innate behaviors - fixed action patterns
        - Gulls: specific place around parents beak where they peck to regurgitate
            - Experience can help : improved upon
        - Egg rolling
            - Benefits to both the adults and to the young
                - Protect offspring from predators
                - Let them know if they have to get more food for the children
            - Fixed action patterns are cue and stimuli based
    - Infant directed behavior
        - Meerkats
        - Environmental scaffolding
            - Expose the juvenile to different levels of complexity depending on their age and experience

Lecture 8: 3/8/21

- Piaget: Sensorimotor substages
    - Birth - 2 years
    - Themes
        - Infant plays active role in own development
        - Early immature and exploratory behavior crucial
    - Development of:
        - Coordination between sensory input and motor behavior
        - Voluntary control
        - Problem-solving behavior
        - Symbolic representation
    - Piaget: dynamics of development
        - Schema: a psychological unit of action
            - Used as building blocks for more complex behavior
        - Two processes of change: assimilation and accommodation
            - Assimilation: incorporate new experience into existing schema
                - Example: sucking reflex
            - Accommodation: modify schema to handle new context
                - Example: grasping
        - Combination of assimilation and accommodation results in oral exploration (everything goes in the mouth)
    - Six sensorimotor substages
        - 1: 0-1.5 mo: reflex schemas
        - 2: 1.5-4 mo: primary circular reactions
            - Repetition of pleasure acts
            - Making noise - seems to be fun for them

            - Not doing it to make something happen in the world
            -
        - 3: 4-8 mo: secondary circular reactions
            - Explore cause- effect relationships
        - 4: 8-12 mo: coordination of secondary circular reactions
            - Combine early schemas to solve problems
        - 5: 12-18 mo: tertiary circular reactions
            - Vary behavior to solve problems - experimentation
            - Discovering predictable patterns in the world
            - Making predictions and testing **systematically**
        - 18-24 mo: beginning of symbolic representation
            - Internalize those patterns
- Sensory development
    - Three principles of sensory ontogenesis
        - Sequential onsets of function
        - Heterochrony
        - Function prior to functional maturation
    - Invariat sequence of sensory system onset
        - Tactile
        - Vestibular
        - Auditory
        - Visual
        - Olfactory varies
        - Order is conserved across species, but the timing of birth is most certainly not
            - Rate and timing of development itself is subject to a selection pressure is called evo devo or evolution of development
    - Heterochrony
        - Evolution acts to coordinate rates of development of different components of a functional system
        - Systemogenesis: system- specific development
            - Example: grasping reflex in human infant
            - All parts of system mature as a unit
                - Sensory tissue in palm
                - Motor neurons in forearm
                - Arborization for hand in somatosensory cortex
    - Function does not equal maturity
        - Focus on onset of function rather than attainment of maturity
        - In altricial mammals, visual and auditory systems are often functional before they are exposed to input
    - Intersensory integration
        - Advantages of non-functional sensory system
            - Allows active sensory modality to create straightforward map
            - Allows new modality to “inherit” pre-existing pattern of stimulation

- For example:
    - Serial order of sensory dominance over development
        - Homing in kittens under olfactory/thermal, then gradually under visual control
        - Familiar smells with unfamiliar sights
    - Early onset in one system can disrupt disfunction in another
        - Early eye opening in rats caused reduction in olfactory discriminative ability
        - Creates sudden increase in visual salience, reorganizes behavior (increased visual homing)
- The able infant: competence in context
    - What to look for when studying the development of altricial species
- Developmental strategies
    - Precocial
        - More developed at birth
    - Altricial
        - To nourish
        - Less developed at birth
        - = incompotent?
            - Trend towards defining altricial animals in terms of what they can't do:
                - Motor
                - Sensory
                - Independent eating
                - Homeostasis
                - Hydrating
            - Advantages of altriciality
                - Aaltriciality, as an evolutionary strategy, outsources information to the social environment
                - Parent-offspring systems can drive learning
                - Infants are active social learners
                - The information content of parent behavior requires closer study
            - The flip side
                - When altricial young do demonstrate an ability, that ability is often thought to be innate and fixed (impervious to experience)
                    - Imitation (human)
                        - Neonates imitate facial movements (tongue protrusion, mouth opening)
                        - Adaptive behavior that gets adults to realize their babies are like them
                            - Promote attachment and caregiving

        - Have to do 3 minutes of a passive face, then do gesture
        - Mouth-opening repeatedly fails to replicate
        - Jones
            - Infants will tongue-protrude to interesting visual or auditory stimuli
            - Developmental changes in tongue protrusion
- Imitation develops
- Ontogney of imitative behaviors
    - Tap table - first behavior babies reliably imitate
    - Bye bye and clapping hands - second
        - More learning
        - Tutoring and reinforcement
        - Auditory and visual cues
    - Sequential finger movements and eh-eh
        - Require more fine motor control
        - Not a lot of tutoring
    - Last hand on head and tongue protrusion
        - No visual or auditory cues
    - Ability to imitate develops gradually
    - Mechanisms for imitation are entirely unknown

    - Thermoregulation (rats)