Encyclopedia of the Mind

Motor System, Development of

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Motor development involves advances in behavior across the entire body—the eyes and head for looking, the trunk for maintaining a stable postural base, the arms and hands for manual actions, and the limbs for locomotion. Development entails increasing coordination between active muscle forces and passive gravitational and inertial forces. However, there is more to the study of motor development than muscles and biomechanics. Goal-directed movement is inextricably linked with perception, cognition, and social interaction, and motor skill acquisition includes developmental changes in all of **[p. 533 ↓]** these domains. This entry summarizes four critical aspects of motor development: Movement is ubiquitous, prospective, creative, and malleable.

Movement is Ubiquitous

Movement is the most pervasive and fundamental of all psychological activity. The body is constantly in motion. Some movements occur in the background (breathing, swallowing, postural compensations), some are spontaneous by-products of arousal and brain activity (twitches, shakes, flails), and some are goal-directed (looking, talking, reaching, walking). The massive amounts and variety of children's motor experiences facilitate discovery of new skills and their improvement. New forms of movement also set the stage for changes in other psychological domains by creating new opportunities to explore the environment and engage in social interactions. Movements in the face and throat make possible behaviors that are fundamental for life, such as sucking, chewing, and swallowing; those required to produce speech are among the most sophisticated movements learned by humans.

The first self-produced movements occur prenatally. Fetuses nod and turn their heads, open and close their jaws, yawn, suck, and swallow amniotic fluid. They wrinkle their foreheads, move their lips and tongue, and, after 25 weeks, open and close their eyes. Whole body movements and large movements of the arms and legs peak at 14 to 16 weeks postconception, then decrease as the growing body fills the uterine space. Some fetal movements are not random: Fetuses direct hand movements toward their own faces and bodies, the wall of the uterus, and the umbilical cord.

The sheer amount of movement is staggering. By 3.5 months of age, infants have performed 3 to 6 million eye movements. By 10 months, infants have accumulated enough crawling steps to travel more than half the length of Manhattan. By 12 months, infants have experienced over 110,000 bouts of wiggles, waves, kicks, and flaps of 47 different types of spontaneous stereotypies. At 14 months of age, infants take about 15,000 walking steps per day. Sleep does not quiet newborns' active bodies. While sleeping, they stretch, roll, wave, and twitch.

Actions are Prospective

For motor actions to be adaptive, they must be controlled prospectively—guided into the future based on perceptual information about the body and environment. Even the simplest movements of the head and limbs require anticipation of disruptions to a stable postural base. Perceptual feedback from just prior movements informs the consequences of future actions.

Infants' earliest actions show inklings of prospectivity. At 1 month of age, infants predict the trajectory of a moving target and smoothly follow it with their eyes, but prospective control is fragile and easily disrupted. The target must be large and slow moving or eye movements will lag behind. The development of prospective looking is protracted over several months. By 4 to 5 months of age, predictive looking is sufficiently stable for infants to track targets moving behind an occluder, so that their eyes wait on the far side to spot the target when it reappears.

As with looking, the development of prehension involves increasing prospectivity. In general, infants demonstrate prospective control of looking before reaching, and once they can reach, they frequently bring objects to their eyes for visual inspection. Newborns are highly motivated to keep their hands in view. In a dim room illuminated with only a narrow shaft of light, newborns move their hand when the light beam moves and slow their arm movements before the hand arrives in the light, rather than after their hand appears. Reaching for stationary objects appears at 12 weeks and intercepting moving objects appears at 18 weeks, but infants' first reaches and catches are jerky and crooked. Infants' arms speed up, slow down, and change directions several times before the hand finally contacts the toy. After a few months, reaches and catches

become more adultlike, with one large movement to bring the hand near the target and a subsequent smaller movement to grasp it. Infants reach for glowing objects in the dark at the same age that they reach in the light, suggesting that they can gauge the location and size of the object and use muscle-joint information about arm position to guide the reach. By 9 months, infants pre-orient their hands to grasp in the dark. By 11 months, infants catch moving objects as they appear from behind an occluder.

Prospective control of locomotion also takes months to develop. When approaching a sheer drop-off or steep slope, novice crawlers and walkers plunge right over the edge. After several weeks of locomotor experience, they guide locomotion prospectively by using perceptual information gathered **[p. 534 ↓]** from exploratory looking and touching to decide when cliffs and slopes are safe or risky. With sufficient experience, infants —like adults—can adapt locomotor actions to changes in the environment and in their own bodies and skills. For example, when experimenters load experienced toddlers with lead-weighted shoulder-packs to make their bodies more top-heavy, infants instantly recalibrate their judgments of risky slopes to their new, restricted abilities. They correctly treat the same slopes as risky while wearing lead-filled shoulder-packs and safe while wearing feather-filled shoulder-packs.

The ability to create new possibilities for action with tools also requires prospective control, but before 1 year of age, infants have difficulty planning tool use strategies. For example, 9-month-olds grab a spoon by the bowl-end instead of the handle or hold it with the bowl pointing away from their mouths. They correct grasp errors reactively by switching hands or awkwardly rotating their hand to bring the bowl to their mouth. By 18 months of age, infants know which end of a tool to grasp, how to grasp it, and how to plan their motor actions in advance, but they are still inefficient when using a tool to act on another object (hairbrush on doll) rather than performing an action centered on their own body (hairbrush on self). By 24 months of age, infants prospectively adjust their typical strategies to use tools in a novel way, such as gripping a spoon with a bent handle to scoop food from a bowl.

Solutions are Creative and Enlist a Variety of Means

The movements of infants (and novices of any age) are notoriously variable and unreliable, whereas movements of adults and experts are smooth and consistent. Over weeks of practice, infants' visual scanning patterns, reaches, and steps become increasingly efficient, reliable, and predictable. However, all infants do not solve the problem of moving their bodies in the same way. More lethargic infants learn to reach by powering up the muscle forces; more lively infants hone reaching skills by dampening down inertial forces from ongoing arm flaps.

Variety in infants' spontaneous exploration provides information about objects and surfaces and about the efficacy of the self in control. Spontaneous leg kicks in 2- to 4-month-olds transform into deliberate one-legged, alternating, or simultaneous two-legged kicks as infants explore the contingencies between their movements and the jiggling of an overhead mobile yoked to their legs. By the second half of the first year, infants explore the sound-making properties of objects and surfaces and eventually bang the hard side of objects against the hard side of a tabletop. Visual, manual, and oral exploration are coordinated into bouts of rotating, fingering, and mouthing objects.

Variable routes to development suggest that individual infants explore multiple solutions before settling on the most efficient solution. For example, prior to crawling on hands and knees, infants display a variety of locomotor strategies. They hitch in a sitting position, crab on their backs, and log roll. Belly crawling is so variable that infants change the configuration of limbs used for support and propulsion and the timing between limbs from cycle to cycle. Infants move ipsilateral limbs together like a camel, move contralateral arms and legs together in a near-trot, lift front then back limbs like a bunny hop, and "swim" with all four limbs lifted into the air at once.

When the constraints of infants' growing bodies and nascent skills preclude adultlike solutions, infants find temporary "placeholder" actions that get the job done. Although 12-month-olds chew well enough to break down food and swallow it, they chew with lateral rather than rotary jaw movements. It takes years before the lips and tongue are

involved and cooperating in a planful and deliberate way and before rotary movements are incorporated into the chewing action. Moreover, infants chew the same way for every kind of food, whereas older children flexibly adapt their jaw movements to the food consistency and to the emergence of new teeth and molars. Even habitual actions such as moving the bolus to a consistent “working” side of the mouth take years to develop.

Sometimes infants’ ignorance about conventional motor solutions opens up new means for solving motor dilemmas. When challenged to cross narrow bridges with only a wobbly rubber handrail for support, 16-month-olds use a “light touch” strategy, grazing their hands along the rail to generate somatosensory information for controlling posture, and a “heavy touch” strategy, where they exploit the deformability of the handrail to rappel as if mountain climbing or lean back as if wind surfing. When faced with impossibly steep slopes, infants descend **[p. 535 ↓]** in a conventional sitting position but also slide down backward feet first or head first with arms outstretched like Superman.

Development is Malleable

Traditionally, motor development was described as a universal series of stages with little deviation in order and timing. However, the apparently invariant sequence resulted from ordering normative data by average onset ages. In actuality, infants acquire skills such as rolling, sitting, crawling, cruising, walking, and stair ascent and descent in a large variety of orders, and infants can skip “optional” skills such as crawling and cruising.

Moreover, onset ages are extremely malleable. True experiments with random assignment to treatment and control groups and historical/cultural differences in child-rearing practices show that the age at acquisition of motor skills can be hugely accelerated with practice and delayed with lack of opportunity. For example, 3-month-olds normally lack the motor skill to grasp and manipulate objects. But after practice wearing “sticky mittens” with Velcrocovered palms as they play with Velcro-edged toys, 3-month-olds pick up toys and explore them as well as 5-month-olds who have acquired their manual skills naturally. With a few minutes of daily practice moving their legs in an

upright position, infants begin walking at younger ages than infants in a control group who received only passive experiences moving their legs.

“Natural” experiments resulting from differences in how caregivers hold, carry, bathe, dress, exercise, and toilet their infants provide additional evidence for malleability. In some regions of Africa, the Caribbean, and India, caregivers vigorously massage and exercise infants as part of daily bathing routines, stretching infants’ limbs, tossing them into the air, and propping them into sitting and walking positions. Infants who receive massage and exercise begin sitting and walking at earlier ages than infants who do not. Infants with stairs in their home learn to ascend stairs at a younger age than children without stairs in their home.

Lack of opportunity to practice movements has the opposite effect. In northern China, the practice of toileting infants by laying them on their backs in sandbags for most of the day delays the onset of sitting, crawling, and walking by several months. In the United States, the recent practice of putting infants to sleep on their backs rather than their stomachs has resulted in delayed onset of crawling and other prone skills. In cultures that do not encourage crawling (including American infants circa 1900), large proportions of infants skip crawling altogether, either bum-shuffling or proceeding straight to walking.

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See also

- Motor Learning, Practical Aspects

Further Readings

Adolph, K. E., & Berger, S. E. (2005). Physical and motor development . In M. H. Bornstein, ed. & M. E. Lamb (Eds.), Developmental science: An advanced textbook (5th ed., pp. 223–281). Mahwah, NJ: Erlbaum.

Adolph, K. E., & Berger, S. E. (2006). Motor development . In W. Damon, ed. & R. Lerner (Eds.), Handbook of child psychology: Vol. 2. Cognition, perception, and

language (D. Kuhn, ed. & R. S. Siegler [Vol. Eds.]) (6th ed., pp. 161–213). New York, NY: Wiley.

Bertenthal, B. I., & Clifton, R. K. (1998). Perception and action . In W. Damon, ed. & R. Lerner (Eds.), Handbook of child psychology: Vol. 2. Cognition, perception, and language (D. Kuhn, ed. & R. S. Siegler [Vol. Eds.]) (5th ed., pp. 51–102). New York, NY: Wiley.

Campos, J. J., Anderson, D. I., Barbu-Roth, M. A., Hubbard, E. M., Hertenstein, M. J., & Witherington, D. C. (2000). Travel broadens the mind . Infancy, 1, 149–219. http://dx.doi.org/10.1207/S15327078IN0102_1

Gibson, E. J. (1988). Exploratory behavior in the development of perceiving, acting and the acquiring of knowledge . Annual Review of Psychology, 39, 1–41. http://dx.doi.org/10.1146/annurev.ps.39.020188.000245

Gibson, E. J., & Pick, A. D. (2000). An ecological approach to perceptual learning and development . New York, NY: Oxford University Press.

Thelen, E., & Smith, L. B. (1994). A dynamic systems approach to the development of cognition and action . Cambridge, MA: MIT Press.

von Hofsten, C. (2004). An action perspective on motor development . Trends in Cognitive Sciences, 8, 266–272. http://dx.doi.org/10.1016/j.tics.2004.04.002