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Developmental Pediatrics: Streams of Development

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There are different ways of looking at how children develop skills. I am presenting these processes as "Streams of Development", breaking them down into Motor, Language, Non-verbal/Cognitive, Adaptive and Social/Emotional.

Motor development is subdivided into Gross Motor, that of large muscle functions and Fine Motor, that of small motor actions. Motor development proceeds from proximal to distal; head and trunk control (gross motor) is established before grasping (fine motor).

Language development can be divided into Expressive, Receptive and Pragmatic. Expressive language includes speaking and writing. Receptive language includes understanding speech and reading. Pragmatic language refers to the ways we use quality of voice, facial expression, eye gaze, gestures, and body postures to convey meaning to communication; the difference between a smile and a scowl when welcoming someone.

Non-verbal/Cognitive development refers to the learning that occurs through manipulating objects in our environment to solve problems; for children, these are essentially play skills.

Adaptive behaviors refer to how we care for ourselves or activities of daily living.

Social/Emotional development includes how we engage with others in meaningful ways including meeting expectations for social norms and relating to one another.

All streams of development are inter-related. Gross motor skills of head and trunk control are required for the stability to "launch" reaching/grasping. Reaching and grasping skills are needed to manipulate toys for learning (non-verbal/cognitive). All adaptive skills, like buttoning a shirt, are non-verbal learning and require fine motor control of hands. The adaptive skills needed for any particular child are in part determined by social expectations. All three elements of language development are directly related to social/emotional development. For example different tones of voice carry different meanings in different social situations and different word choices are appropriate in different social contexts, such as speaking to children or to adults.

It is critical to remember that all streams of development are also culturally and/or socioeconomically determined. This must be kept in mind as we assess or measure progress against milestones lists.

The concept of milestones applies to all streams of development. The pattern of progression through each stream and across streams of development can provide clues to diagnosis.

Typical development describes a child meeting milestones as expected across all streams.

Delay refers to milestones being met slower than expected but in typical sequence.

Deviation in development indicates milestones are acquired out of sequence within a single steam of development.

Dissociation refers to differing rates of development across the streams.

Regression indicates loss of previously acquired milestones.

A ratio of developmental level to age in young children can quantify and help track development overall and within/between streams.

$$\frac{\text{Developmental Level}}{\text{Age}} \times 100 = \text{Developmental Quotient (DQ)}$$

100 = 50th percentile

1 standard deviation: 85 – 115; range of average

2 standard deviations: <70, delayed

"borderline"- 70 - 84

The strongest correlates to general intelligence are receptive language and non-verbal/cognitive skills while the weakest is gross motor development.

All of the above are descriptors not diagnoses. Neither atypical patterns of development, atypical quality of performance nor delayed developmental quotients are diagnoses. The information, however, in conjunction with a full history and detailed physical examination may provide guidance in formulating a differential diagnosis and determining need for any diagnostic testing.

The following clinical vignettes provide *examples* of how children with different diagnoses may present relative to patterns of development across the different streams but in *none* of the examples is there sufficient evidence to *make* a diagnosis.

A four year old boy shows the following developmental skills
gross motor: alternates feet on stairs, jumps, does not ride a trike
fine motor: displays a palmar grasp when using a pencil
expressive language: 20 words; no 2-word sentences
receptive language: points to 1 picture, does not understand prepositions
pragmatic language: extends hand to indicate needs but does not point
non-verbal/cognitive: cannot complete a simple puzzle, cannot stack 3 blocks
adaptive: does not dress self, requires some help in undressing
social/emotional: parallel play but no group play

This pattern demonstrates *delays* across all streams of development, with gross motor being the least impacted. (Keep in mind that whether one rides a trike or not is unimportant. It is culturally and socioeconomically dependent. If one has access to riding a trike, however, in addition to it being a gross motor skill, it is also a non-verbal cognitive one; understanding that moving ones feet in a circle can propel one in a straight line is a 3 year old cognitive skill).

This pattern of delay across all streams is seen in Intellectual Disability. A family history of maternal male cousins with intellectual disability, a mother with learning disability and physical exam which may include large, simply folded ears and low muscle tone would suggest a diagnosis Fragile X Syndrome, the most common cause of inherited intellectual disability.

A 15 month old girl shows the following developmental skills:

gross motor: sits independently, does not crawl, pulls to stand
fine motor: reaches with either hand, has a mature pincer grasp
expressive language: specific "mama", "dada" and 5 other words
receptive language: inhibits to "no", follows one step direction without gesture
pragmatic communication: points, shifts gaze between parent and what is wanted
non-verbal/cognitive: places cube in a cup, dumps things out of a bottle
adaptive: cooperates with dressing
social/emotional: comes when called, imitates actions

This child's development shows a *deviation* within one stream of development, that of motor, specifically gross motor. All other skills are appropriate for age. If there were a history of prematurity with a grade III interventricular hemorrhage, and an exam showing increased tone, pattern of extension and increased DTR's in lower extremities, a diagnosis of spastic diplegia would be suggested. (However, at this young age, we would be hesitant to assign a formal diagnosis of cerebral palsy quite yet). Spastic diplegia affects primarily lower extremities, where motor fibers from the legs are coursing nearest the ventricles. The vascular supply and stability of blood flow to that area is particularly fragile in an infant delivered prematurely. Increased lower extremity tone and pattern of extension impairs coordination of lower extremities for crawling or to use legs to power a "pull up" maneuver. The "pull up" can often be accomplished atypically, however, by using only the upper extremities with lower's "popping" up together.

A 2 year old boy shows the following developmental skills
gross motor: walks, runs, climbs stairs without help
fine motor: has an accurate direct reach and manipulates small items with ease
expressive language: specific "mama/dada", no other words
receptive language: does not follow directions with or without gesture
pragmatic language: little facial expression to indicate needs, no joint attention.
non-verbal/cognitive: completes complex puzzles for age
adaptive: finger feeds only, does not help with dressing.
social/emotional: fleeting eye contact, no imitation, no gesture games

This history is an example of *dissociation* between streams of development. Communication in all its forms, adaptive skills and social/emotional development are all impaired while there is a relative strength in motor and non-verbal cognitive development. The pattern suggests a diagnosis of Autism Spectrum Disorder. The Dissociation also illustrates the interrelationship of the streams. Since all adaptive skills are non-verbal/cognitive (problem solving) tasks and this child's non-verbal/cognitive skills are age appropriate, he should have not problems using utensils to eat. But use of utensils as an adaptive skill is also strongly linked to social/emotional development which is markedly impaired in this child.

3 year old girl had typical development to 18 months.

Since then she lost language and functional hand skills. Gross motor skills also declined and movement pattern is ataxic. She now engages in repetitive hand wringing behavior. Linear growth rate has slowed as has head circumference. She has also developed seizures

The history describes regression. Regression of milestones requires prompt attention as it can be seen in some life threatening conditions. For this child, her behavioral phenotype, the neurologic exam presented and growth pattern suggests a diagnosis of Rett Syndrome. Classic Rett Syndrome is caused by a mutation in the MECP2 on the X chromosome, usually spontaneous.

In summary, developmental milestones can be tracked along different Streams of Development with all streams inter-related, some more strongly than others, and all, to some degree, culturally and socioeconomically dependent. Degree of delay overall or within a stream can be quantified as a Developmental Quotient. Recognizing patterns of atypical development across, within or between different streams can provide important information in formulating a differential diagnosis in a child demonstrating delays.