Time takes time to pass; considerations about neuro-motor development and early intervention

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Publication date:
2007

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The aim of this thesis is to find out if the data derived from chapter 2-5 transformed by ordering to information fits the theoretical framework on motor-development by Gerald Edelman, especially his view on Brain Body Devices, (BBD) and Neuronal Group Selection Theory (NGST). Hadders-Algra stated several times that Edelman's theory offers a promising framework to describe both typical and abnormal infant development. According to Edelman, development is characterized by plasticity and does not stem from any kind of pre-programming or pre-determination. Moreover, characteristics of both the nervous system and the body must be taken into account, in order for the organism to survive in a world dominated by physics, and physical and social laws and constants. In the introduction chapter, ideas on development are sketched in order to locate Edelman's developmental theory within the developmental tradition. Of course, the overview is very limited; a complete overview would justify a complete thesis. Especially Werner's orthogenetic principle, dynamical system theory (DST) and Waddington's epigenesis, are highlighted. In the introduction chapter considerations about human development and in more detail motor-development are described from theoretical point of view. In the other chapters we depart from data to find out whether or not it fits in with the specific developmental framework that laid at the basis of the research design.

Chapter 2 reviews current data on the structural development of the human nervous system. Focus is on the timing of ontogenetic events in the telencephalon. During the first half of gestation especially neuronal proliferation and migration occur. The period of the existence of the functionally important transient structure 'subplate' and the major period of

glial cell proliferation and programmed cell death takes place in the second half of gestation. During the last trimester of gestation and the first postnatal year there is a peak in axon and dendrite sprouting and synapse formation. Major part of telencephalic myelination occurs during the first year after birth. Many developmental processes continue throughout childhood and adolescence, such as myelination, synapse formation and synapse elimination. Evidence is emerging that the peak of synapse elimination occurs between puberty and the onset of adulthood. From early foetal life onwards neurotransmitter systems are present and their pre- and perinatal development is characterized by periods of transient overexpression. The latter is for instance true for the acetylcholinergic, catecholaminergic and glutamate systems. The continuous changes of the nervous system have consequences for vulnerability to adverse conditions, for diagnostics and for physiotherapeutical intervention.

The study of chapter 3 aims at evaluating the effect of specific postural support on motor behaviour of infants with and without minor neurological dysfunction (MND). The presence of pillows does not affect the time spent with General Movements (GMs) or Specific Movements (SpM) or GM-quality. GMs are complex and variable movements which involve the whole body. GMs start at 8 weeks post menstrual age (PMA) and continue to be common until 4-5 months postnatal age. Specific movements are movement's displayed in a repeatable and definable way, like touching the trunk. Specific postural support, however, did promote variation in motor behaviour of young infants. This is particularly true for infants with MND.

Chapter 4 and 5 describe the development of postural control in children. In the development of postural control two functional levels are distinguished. The first level deals with direction specificity. Direction specific postural adjustments on the dorsal side of the body are found when the disturbance of balance induces a forward sway and on the ventral side of the body during a backward sway. The second level of postural control is the fine-tuning of these direction specific postural adjustments. This fine-tuning can be achieved various ways, for instance, by changing the number muscles which are part of the postural pattern, order of recruitment (cranial-caudal or vice versa), and modulation of the amplitude (Forssberg & Hirschfeld 1994).

In chapter 4 the development of the relationship between the kinematical features of reaching movements and the accompanying postural adjustments in young infants is evaluated. At 4 and 6 months of age about 50% of reaching movements in lying and sitting infants are accompanied by direction-specific postural adjustments. At 4 months the adjustments are characterized by variation, but at 6 months a preference to recruit muscles in a top-down order (during sitting) and in the configuration of the complete pattern, i.e. the pattern in which all dorsal neck- and trunk muscles are activated in concert, (both conditions) emerges. The postural characteristics such as the presence of direction-specificity, recruitment of the complete pattern and top-down recruitment, are related to how successful the reaching was and the kinematics of reaching. It seems that the presence of direction-specific activity is not a prerequisite for the emergence of reaching movements. Nevertheless, already from 4 months onwards a better postural control is associated with a larger success and a better quality of reaching.

In chapter 5 data about the development of postural control in typically developing children and children with CP is reviewed. The basic level of postural control is functionally active from early infancy onwards: young infants possess a repertoire of direction-specific postural adjustments. Whether or not direction-specific adjustments are used depends on the child's age and the nature of the postural task. The second level of control emerges after 3 months: children start to develop the capacity to adapt postural activity to environmental constraints. But the adult form of postural adaptation first emerges after adolescence.

Children with cerebral palsy (CP) in general have the ability to generate direction-specific adjustments, but they show a delayed development in the capacity to recruit direction-specific adjustments in tasks with a mild postural challenge. Children with CP virtually always have difficulties in the adaptation of direction-specific activity. The limited data available on the effect of intervention on postural development suggest that intervention involving active trial and error experience may accelerate postural development in typically developing infants and may improve postural control in children with or at high risk for a developmental motor disorder.

In chapter 6 we depart from the previous chapters to find out whether or not it fits in with the specific developmental framework (bottom-up) that laid at the basis of the research design in order to transform data by ordering to information and eventually scientific knowledge about development, intervention, in case of deviant development. Data derived from typically developing infants fit within the framework of Edelman Brain Body Devices From variability selection emerges. In addition, from this point of view, I think it is doubtful whether or not the first level of postural control has an innate origin, at least in so far that innate is defined as a pre-determined structure or device, like the assumed central pattern generator (CPG). In chapter 6 it is suggested that feedforward processes may be regarded as instances of *central control* and the feedback mechanism stemming from *peripheral coordination*. Edelman's value systems could be envisioned as a feedback mechanism acting on peripheral coordination. The difference in affecting the quality of GMs and SpM seems to be based on the influence of this value system. The effect is more prominent after the age of 3 months. Three months of age can be regarded as an age of a major transition. It is assumable that at this age the value system starts to interact with motor-development and that it is the most promising age to start successfully with intervention. In the time window derived from biological data, three months of age is exactly which suggest that intervention should start between 28 weeks PMA and 15 months of age. The success of intervention starting at 3 months of age is supported by preliminary data of an early intervention project. It seems the new COPCA intervention increases the ability to generate direction-specific postural activity, is able to increase the repertoire of postural muscle activity and to promote situation appropriate selection out of the repertoire. However, lots of research needs to be done to establish above mentioned notions. In this last chapter indications for ongoing research are given.