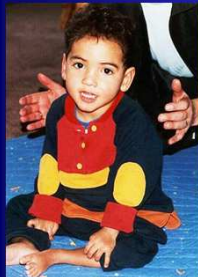


TYPICAL AND ATYPICAL DEVELOPMENT OF POSTURAL CONTROL

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POSTURAL CONTROL

- Maintaining balance, keeping COM within the margins of the support surface.
- Orientation of body segments to other body segments and to the external world.

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POSTURAL CONTROL IS VERY COMPLEX

- **Phylogeny:** upper limbs increasingly less involved in postural control → two limb based postural control → high demands on neural control
- **Protracted course of human postural development**
- **Complex control system easily affected in developmental motor disorders**

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ORGANIZATION OF POSTURAL ADJUSTMENTS TWO LEVELS OF CONTROL

- ① **Repertoire of direction specific adjustments**
 - Backward sway of the body
 - primary activation of the 'ventral' postural muscles
 - Forward sway of the body
 - primary activation of the 'dorsal' postural muscles
- ② **Fine-tuning of direction specific adjustment to task-specific conditions**
 - Selection of specific pattern out of direction specific repertoire
 - Adaptation of activity of antagonistic muscles
 - Adaptation of recruitment order of direction specific muscles
 - Adaptation of degree of contraction of direction specific muscles

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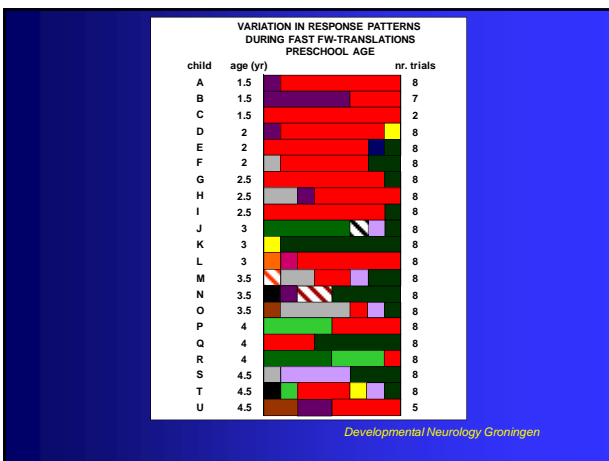
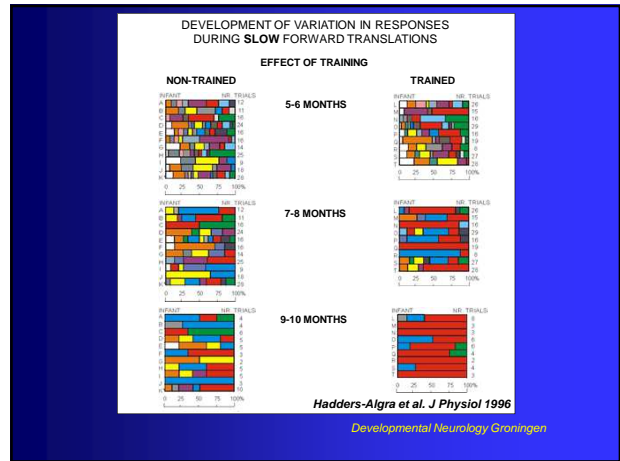
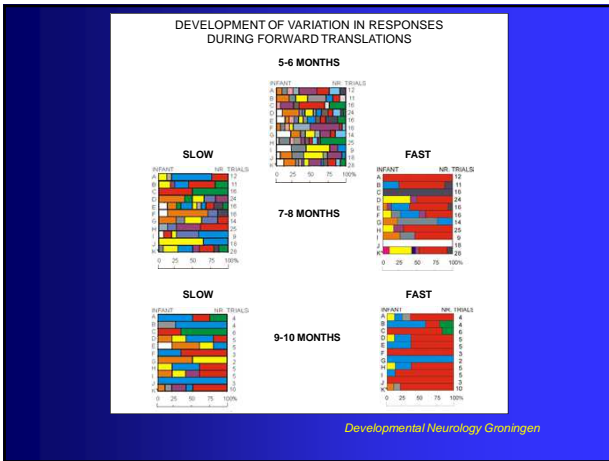
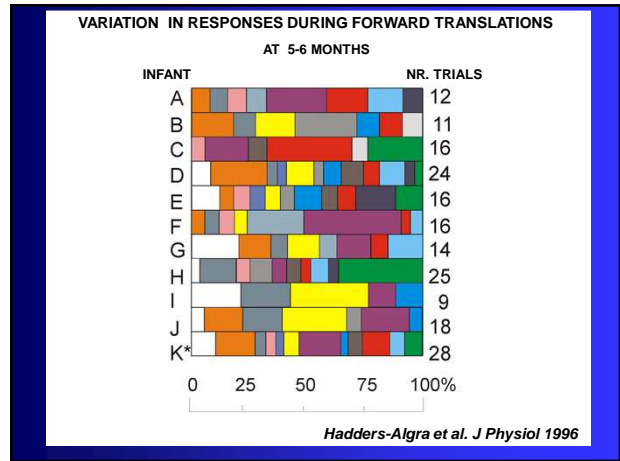
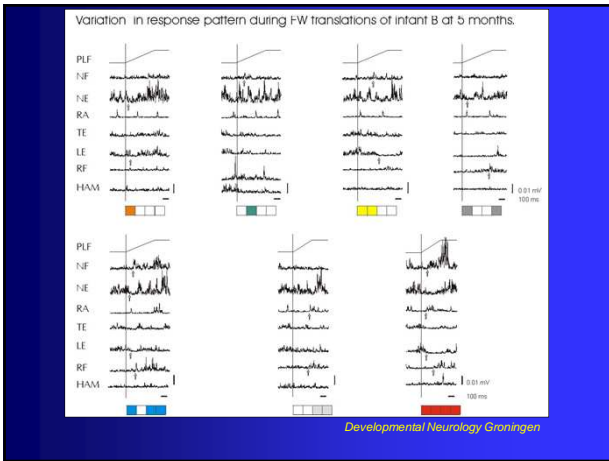
GENERATION OF POSTURAL ADJUSTMENTS

- During external perturbations.
- During self-generated voluntary movements.

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SUMMARY PERTURBATION STUDIES (1)

- Direction-specificity present early after term age → probably innate origin
- Early life: variable repertoire of direction-specific postural adjustments: primary variability

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SUMMARY PERTURBATION STUDIES (2)

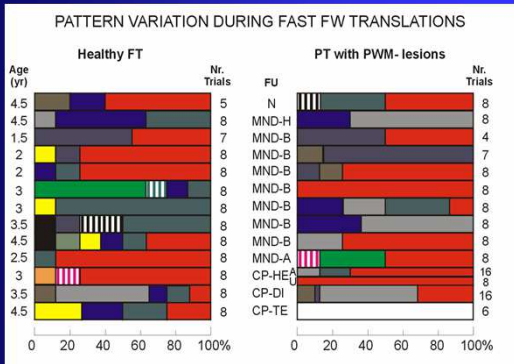
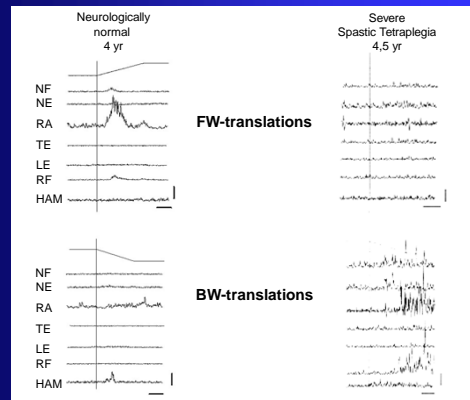
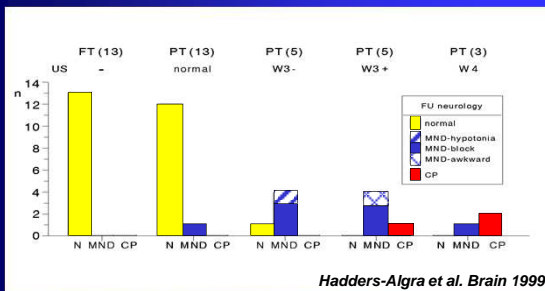
- From 3 months onwards: selection of specific adjustments which fit situation best; selection based on trial and error based experience
- From 9-10 months emergence of EMG amplitude modulation; ability affected by trial and error based experience

STUDY GROUPS

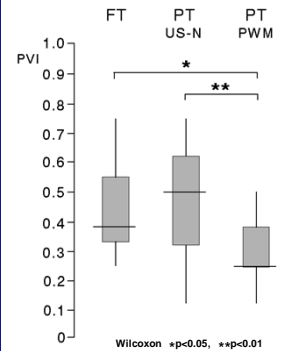
- 13 preterm children ($\leq 1500g$) with ultrasound lesions of the periventricular white matter (PWM):
n = 10, periventricular cyst formation (W3),
n = 3, large, intense echodensities extending into the deep layers of the white matter (W4),
gestational age of birth: 25-34 weeks (median: 28),
age at assessment: 1.5-4.5 years.
- 13 preterm children without brain lesions:
matched to group A concerning GA, SGA, sex and age at assessment.
- 13 healthy full-term children:
matched to group A concerning sex and age at assessment.

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US BRAIN LESION AND NEUROLOGICAL CONDITION AT PRE-SCHOOL AGE



PATTERN VARIATION INDEX (PVI) DURING FAST FW TRANSLATIONS



Results

- All children direction specific postural adjustments, except child with spastic tetraplegia.
- PWM-group significantly less variation in responses during FW-translations than PT-N ($p < 0.01$) and FT-group ($p < 0.05$).
- PWM-group > 2 years significantly shorter latencies to postural responses than other children > 2 years.
- Preterm children (PWM and PT-N) higher sensitivity to platform velocity than FT-children.
- In contrast to FT-children, preterm children (PWM and PT-N) unable to modulate EMG-amplitude with respect to initial pelvis position during FW-translations.

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Conclusions

- PWM-lesions and preterm birth have a different adverse effect on postural adjustments.
 - PWM-lesions are associated with:
 - * a limited repertoire of postural response variation
 - * shortened latencies to the onset of the responses, indicating reduced processing time.
 - Preterm birth is associated with:
 - * an inability to modulate EMG-amplitude with respect to initial sitting position
 - * an increased sensitivity to platform velocity, i.e. muscle stretch.
- This implies a shift of postural control, which is guided by feedforward processes based on prior experience, to a form of postural control, which is dominated by feedback mechanisms.

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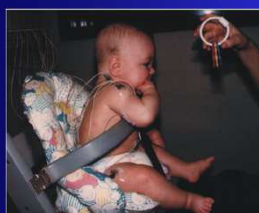
GENERATION OF POSTURAL ADJUSTMENTS

- During external perturbations.
- During self-generated voluntary movements.

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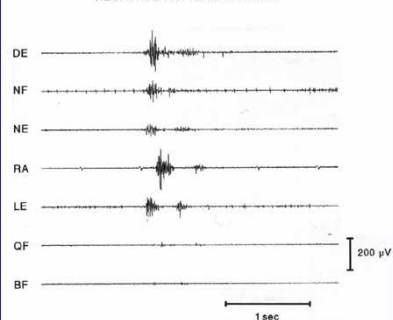
Postural control during reaching

(Van der Fits et al.,
Van der Heide et al.,
De Graaf-Peters et al.,
Van Balen et al.)



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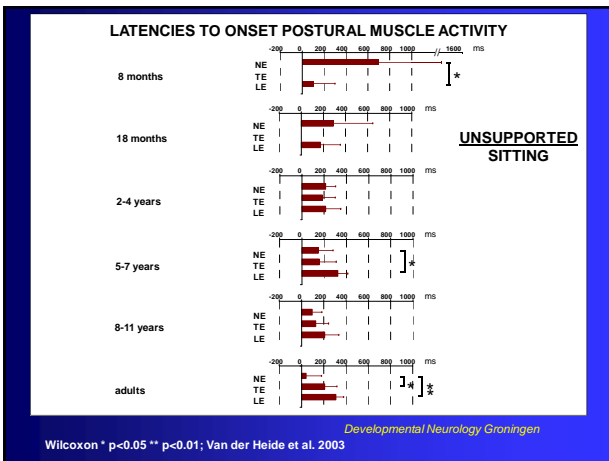
REACHING DURING SITTING RESPONSE PATTERN OF ADULT



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POSTURAL ADJUSTMENTS DURING REACHING IN INFANCY (De Graaf-Peters et al. EBR, 2007; Van Balen et al. EBR, 2012)

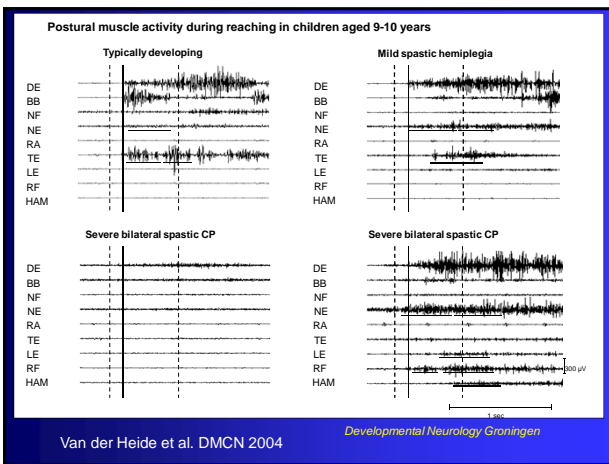
- Around 4 mo: $\pm 40\%$ of reaches accompanied by direction-specificity, at 18 mo $\pm 60\%$, and at 2 years reaches virtually always accompanied by direction specificity
- Primary variability: varied use of repertoire of direction specific adjustments
- Selection emerges between 4 and 6 mo
- Recruitment order: variation, with gradual change in preference from top-down to bottom-up
- Amplitude modulation emerges at 9-10 mo



POSTURAL ADJUSTMENTS IN CHILDREN WITH CP

- 58 children with CP (born PT) 2-11 year
- 29 age-matched typically developing (TD) children
- Reaching while sitting
- Surface EMGs of arm-, neck-, trunk- and legmuscles.
- Kinematics (ELITE)

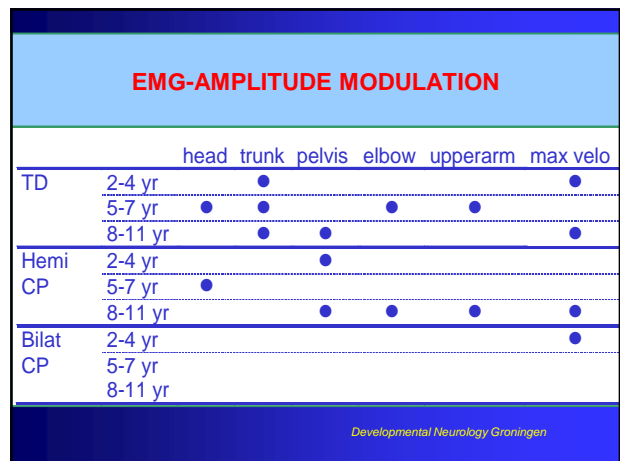
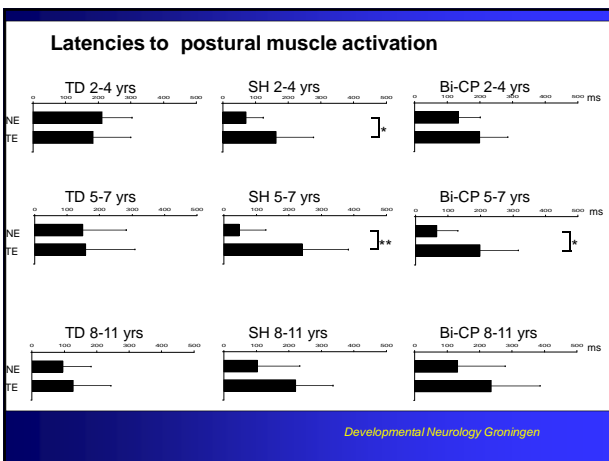
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POSTURAL CONTROL IN CHILDREN WITH CP DURING REACHING (1)

- Basic level of control, i.e. direction specificity in children who are able to reach generally intact.
- Children with severe forms of CP who can reach may have some problems in direction specificity, in particular in leg muscles

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POSTURAL CONTROL IN CHILDREN WITH CP DURING REACHING (2)

- Stereotyped top-down recruitment
- Absent or reduced ability to adapt the degree of muscle contraction to condition
- Reduced capacity to modulate postural muscle activity related to PEDI scores, i.e. activities of daily life
- Indications that foot and/or back support facilitated capacity to modulate postural activity

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POSTURAL CONTROL IN CHILDREN WITH CP PRACTICAL IMPLICATIONS (1)

- Children with severe forms of CP
 - i.e. not able to sit independently by the age of 4 years
 - basic level of postural control lacking
- **MANAGEMENT:** should focus on provision of adequate postural support

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POSTURAL CONTROL IN CHILDREN WITH CP PRACTICAL IMPLICATIONS (2)

- Children with less severe forms of CP
 1. Limited repertoire of postural strategies
MANAGEMENT: accept atypical postural strategies
 2. Problems in adaptation of postural activity to specific situation

POSTURAL CONTROL IN CHILDREN WITH CP PRACTICAL IMPLICATIONS (3)

- Strategies to cope with problems in adaptation:
 - stereotyped top-down recruitment (focus on stabilization head in space)
 - antagonistic co-activation in case of serious disturbance of balance
 - Strategies should not be 'treated away'
- Adaptation can be improved by active training
- Adaptation can be facilitated by proper support

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THANKS TO COLLABORATORS

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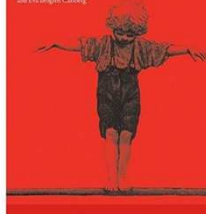
OSLO

Björg Fallang

MORE INFORMATION?

*Postural Control:
A key issue in
developmental disorders*

Maria Hadders-Algra
and Eva Brogren Carlberg



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