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Editorial

Preface special issue 'Advances in Developmental Cognitive Neuroscience'

This special issue was inspired by an interdisciplinary conference entitled 'Advances in Developmental Cognitive Neuroscience', held at the University of Amsterdam in April 2005. Developmental cognitive neuroscience is an evolving field that investigates the relations between brain maturation and cognitive development. The objective of the conference was to bring together researchers from various disciplines to discuss central issues in developmental cognitive neuroscience from multiple perspectives. The conference attracted junior and senior researchers from different fields, and succeeded in generating much discussion. Several participants contributed articles to this special issue, in addition to other researchers who are key players in the field of developmental cognitive neuroscience.

The special issue represents the various approaches to studying developmental cognitive neuroscience today. The first set of four papers concentrates on behavioral indices of cognitive development, especially in the domain of cognitive control. Huizinga et al. use structural equation modelling to understand the developmental trajectories of three frequently postulated executive functions: working memory, cognitive flexibility, and response inhibition. The researchers demonstrate that these functions have separable developmental trajectories that contribute differently to performance on complex executive function tasks, such as the Wisconsin Card Sorting Task and the Tower of London Task. A study by Davidson et al. focuses on specific aspects of cognitive control involved in the ability to flexibly switch between several tasks for action. In this study, the interdependence of working memory and inhibition was investigated in a large sample of participants. The results show large developmental changes but also correlations between these measures. Importantly, the authors reveal that adult levels of performance are not reached until at least age 13, suggesting that cognitive flexibility has a slow developmental trajectory. The focus of Schmittmann et al. is on different learning modes to solve a single task. Using finite mixture distribution models, Schmittmann et al. demonstrate pronounced developmental changes in 'sudden rational' learning relative to 'slow incremental' learning, and they link these changes to the maturation of separable brain regions. Scheres et al. focus on the ability to delay gratification and the ability to differentiate between probabilities of reward. These researchers demonstrate large changes in both functions in the school-aged period, showing that affective decision-making is very sensitive to developmental change. In addition, they show how the ability to delay reward gratification is compromised when development went astray as in children with Attention Deficit Hyperactivity Disorder. Together, these behavioral studies have important implications for concepts of the changing orchestration of brain regions involved in cognitive control during development.

Maurer et al. report a study that is different from other papers in this issue. Using a longitudinal analysis, the authors show that visual deprivation has a pronounced effect of contrast sensitivity. Interestingly, by comparing children from two age groups, they provide exciting evidence of neural plasticity in young children especially.

Developmental cognitive neuroscience has benefited from the use of event-related potential research. This is a technique that can be applied in children as young as 3 months. For example, Macchi Cassia et al. nicely integrate behavioral research with ERP research in infants. Using a face differentiation design, they show that in 3-month-old children, ERPs can differentiate between face processing, especially during the late ERP components relative to early components. In somewhat older children, Sanders et al. show that ERPs can differentiate between attention demands during story telling in children aged 3–5 years. The most important message from this study is that attention modulation is already at adult-level at a very young age. Finally, Lamm et al. demonstrate using ERPs and source localization that changes in brain activity underlie developmental changes in response inhibition, which is relatively independent of the development of other executive functions.

The introduction of functional neuroimaging techniques, such as functional MRI (fMRI), has had a tremendous impact in the developmental cognitive neuroscience field in the last decade. The paper by Durston and Casey critically reviews the developmental fMRI research to date and the authors argue that changes in cognitive development are associated with increased specificity of prefrontal cortex activity during childhood. Their review covers the functional brain changes associated with development of a wide range of cognitive tasks and they argue that this maturation is associated with both enhanced activation in prefrontal cortex, as well as with attenuation in non-critical areas. Event-related fMRI is starting to be used to test specific predictions about cognitive development. For example,

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Van Leijenhorst et al. demonstrate using fMRI that children use partly overlapping brain regions as adults in a decision-making paradigm. Both children and adults show increased activation in dorsolateral prefrontal cortex, orbitofrontal cortex and anterior cingulate cortex when anticipating risk outcomes, but children show more activation in specific brain regions (especially anterior cingulate cortex) when resolving response conflict associated with risk. These findings illustrate that fMRI can be informative for understanding the development of specific underlying processes that are not easily observed based on behavior only. Finally, the last two articles describe the advantages of studying structural maturation of white matter tracks using diffusion tensor magnetic resonance imaging (DTI). Klingberg reviews literature – much of his own – on white matter development and its relation to working memory development. In the first part of the review he argues that the superior frontal sulcus and parietal cortex become more involved in working memory during development and with increased practice. In addition, white matter maturation in prefrontal cortex is associated with better performance on a spatial working memory task. Finally, the paper by Niogi et al. describes how DTI can be informative for understanding individual differences in reading ability. Maturation of left temporal-parietal cortex maturation was found to be associated with increased performance on standardized reading scores in healthy developing children. In addition, this study proves that changes in white matter tract circuitry are linked to specific domains of cognitive functioning, such as seen in children with reading disorders.

While invited, all of the contributions were subjected to external peer-review, and not all submissions were accepted. I thank all the authors for their efforts with what in several cases were multiple rounds of revisions under a tight schedule. I would like to thank Maurits van der Molen who encouraged Mariette Huizinga and me to hold a conference on this topic, and Shlomo Bentin for supporting this special issue.

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