Editorial

Developmental cognitive neuroscience

It is with a sense of excitement that we launch this new journal. This feeling reflects not only an excitement about the field—the rapidly expanding body of knowledge about brain development—but also an enthusiastic anticipation about the opportunities for this journal to contribute to the growth and maturation of the rapidly emerging field.

At the most straightforward level, the journal can provide a vehicle for rapid and effective communication of the best conceptual, methodological, and empirical advances in developmental cognitive neuroscience. More broadly, however, we believe the journal can provide a forum for dialogue and discussion in ways that can support and shape a growing and multi-dimensional field.

This is an unusual, important opportunity. As a field, developmental cognitive neuroscience has been emerging at the interface of several different disciplines, including cognitive neuroscience, developmental neuroscience, developmental psychology, and developmental psychopathology. As such, the field encompasses the overlapping dimensions of social, affective and cognitive neuroscience. Accordingly, we believe there is great value in promoting communication focused on integration across these approaches. Specifically, this might contribute to the emerging identity of the field and help create bridges between basic and clinical advances in understanding normal and abnormal brain development, thereby elucidating the broad clinical and social policy implications of this work.

1. Background

Fifty years ago, we knew almost nothing about how the human brain develops. The subsequent 50 years of research generated great interest in brain development, but this interest produced relatively limited empirical data on development of the human brain. This was due to the formidable technical challenges of carrying out research on the thinking, feeling, and continuously learning and adapting human brain. Important empirical work did occur, nevertheless. For example, developmental neuroscience produced important studies in non-human animal model systems, revealing much about early-life neuronal and synaptic development starting with the groundbreaking work of David Hubel and Torsten Wiesel, for which the Nobel Prize in Physiology or Medicine was awarded. These advances were paralleled by advances in developmental psychology, which occurred independently from neuroscience. For example, research on the observation of children’s behavior, by Jean Piaget, Lev Semyonovich Vygotsky and others, changed contemporary thinking about children’s minds. Through such work, children were increasingly seen as more than just miniature versions of adults. But these pioneering developmental psychologists focused minimally on the developing brain. Developmental psychology remained relatively removed from developmental neuroscience.

Hence, multiple forces interested in development converged in the final years of the 20th century, but these forces tended to operate independently from one another. This created a call for integrative research approaches that placed equal weight on neuroscience, psychology, and development. Fifty years ago, it might have been hard to imagine that half a century later scientists would be able to answer this call by looking inside the brains of living humans of all ages, to track changes in brain structure and function across development, in typically developing individuals and in individuals with developmental disorders. It was both strong historical trends in psychology and neuroscience, coupled with technical advances, which ultimately gave birth to a new field, developmental cognitive neuroscience, one that embraces the powerful combined forces of neuroscience, psychology and development.

2. New methodologies in developmental neuroscience

In the past decade, the field of developmental cognitive neuroscience has undergone unprecedented expansion. This can at least in part be attributed to technological advances. Several different neuroimaging techniques have matured to the point where they can be used reliably...
to view the living, developing human brain. Electroencephalography (EEG) and event-related potentials (ERP) have long been regarded as the methods of choice with young children. They have obvious appeal, given their safety, ease of use, and excellent temporal resolution. Moreover, work using these methods has revealed a great deal about the infant developing brain, particularly in the early preference for social stimuli such as faces and facial expressions. This work is discussed in this issue in the theoretical framework provided by Mark Johnson, a pioneer of developmental cognitive neuroscience.

What about imaging methods such as magnetic resonance imaging (MRI) and magnetoencephalography (MEG), which have only recently acquired widespread use? When experience with these methods was still sparse, their use with children was restricted. Furthermore, these techniques require children to remain still for considerable periods; this undoubtedly presents another obstacle. Conditions such as autism, dyslexia and attention deficit hyperactivity disorder (ADHD) originate early but can last an entire lifetime. Thus, at first, imaging techniques were applied in research among adult participants. One early example is a positron emission tomography (PET) study of dyslexic adults (Pauls et al., 1996), which revealed a characteristic signature of brain abnormality, and thus gave credence to the notion that the neurological condition underlying dyslexia remains even when compensatory learning had occurred. Dyslexia research has since flourished through work using MRI and MEG in different populations of different ages, languages, and writing systems. Following an initial period of solely adult-based work, the promise of brain imaging studies of normal and abnormal development truly began to emerge. This occurred as studies increasingly demonstrated the insights that might emerge from application of safe, tolerable imaging methods in children and adolescents. In tandem with this emerging promise, we are starting to see an increasing number of neurocognitive studies with younger and older individuals with developmental disorders, and eventually we will have studies that will reveal the course of the abnormal brain development in conditions such as autism, ADHD and dyslexia. This will not happen overnight. A truly informed understanding of developmental trajectories requires repeated assessment of brain structure and function, within the same individuals, together with assessments of thought and behavior.

In recent years, probably more than any other advance, the increased use of MRI in pediatric populations has created new opportunities to track structural and functional changes in the developing human brain. This work has pushed forward our knowledge of how the human brain develops, and the data from developmental imaging studies has in turn spurred new interest in the changing structure and function of the brain over the lifespan. Until relatively recently, it was widely believed that any changes in the brain after early development are comparably minimal. Research in the past decade, especially that emanating from the NIH pediatric neuroimaging project, has shown that this is far from true. This large-scale longitudinal study has generated large amounts of MRI data from children from the age of four years, and has revealed that the human brain continues to develop for many decades. This work strongly supports the notion that developmental cognitive neuroscience includes the study of the developing brain at all stages of development, from infancy through childhood, adolescence, adulthood and even into old age.

It is challenging to scan children younger than about four years because of movement-related artifacts. However, a groundbreaking fMRI study carried out with three-month old infants in Ghislaine Dehaene-Lambertz’s laboratory showed that this can be done and inspired others to do similar studies. This study showed that language specific areas of the left hemisphere responded to language stimuli already at this very young age. This finding lent support to theories of mental development that proposed a role for localized neural ‘start-up’ systems that operate relatively independent of experience. Such systems are thought to provide the innate basis to support later development of complex mental functions, such as language, that are sculpted by experience. Of course there are theoretical controversies about the relative weight of the role of nature and nurture in language development, and no one denies that both factors interact with each other. The development of near infrared spectroscopy (NIRS) is providing a new means to look at cortical activation in infants, since it is non-invasive and relatively low cost and portable. We are delighted that in this issue a review of NIRS methodology and findings obtained with this technique, is presented by Gervain and colleagues. We are confident that this review will encourage others to use this still very experimental technique.

3. The title of the new journal

The title of this new journal, Developmental Cognitive Neuroscience, has been an interesting bone of contention, one that has divided opinions among the editors. The focal point of this division is using the single term ‘cognitive’ versus including the terms ‘affective’ and ‘social’ in the title to reflect explicitly the broader interpretation of what we mean by ‘cognitive’.

We refer to cognitive neuroscience to distinguish ourselves from molecular neuroscience. There is still a gap between molecular neuroscience and neuroscience research at the systems level. In the former we have research at the level of the single neuron; in the latter we have research on brain functions associated with activity of distributed neural networks comprising hundreds of thousands or even millions of neurons. A major task for the future is to close this gap by building bridges...
from both sides. This journal is focused on the macro, systems-level perspective, that is, mental (or cognitive) phenomena that form the mind, studied as expressions of functioning within these multi-component neural networks.

Contention among editors reflects the many different uses of the term “cognitive”, which creates some ambiguity that we seek to clarify here. We can identify several exciting areas of research that are part of a new era of developmental cognitive neuroscience. Nevertheless, we acknowledge that there is both a wide and a narrow view of the term “cognitive”; we embrace the broad view.

A narrow view of the term “cognitive” has led some to view many important areas of research as outside of cognitive neuroscience. For example, in the wake of psychology’s “information-processing revolution” of the early 1970s, developmental psychology too was changed. Piaget and Vygotsky were to some extent overshadowed by this revolution, which created new encouragement for investigation of mental processes and mechanisms of complex behavior, such as social communication. In our opinion, the development of social communication in the broadest sense represents a crucial dimension of developmental cognitive neuroscience. Similarly, learning theory has once again garnered considerable attention, as it has been used to shape research in a new biologically based framework. For example, integration of learning theory and neuroscience emerges in research on reward value, prediction errors, and utility functions. We seek to publish studies modeling learning in typical and atypical development, though we will restrict our focus to studies examining these issues using a conceptual framework and methods of neuroscience. In a similar way, research on emotion and motivation has become increasingly prominent, following advances in research on a range of mammalian species. Areas of research on emotion have included investigation of the neural basis of recognition of emotions in faces and voices, complex human emotions such as guilt, embarrassment, shame, emotional contagion, empathy for others’ emotions and the embodied perception of emotions.

Within this broader conceptualization of developmental cognitive neuroscience, we believe there is great value in research targeting more narrowly defined aspects of the field. For example, we are planning a special issue on affective developmental neuroscience focusing on emotion and motivation, which we believe can contribute uniquely to advancing understanding of normal and abnormal brain development.

More generally, we use the term “cognitive” in cognitive neuroscience with the goal of embracing all of these areas of science, be they focused on information processing, narrowly construed, as well as areas focused more broadly on learning, social processes, emotion, or motivation. To put it another way, by cognition we mean anything that refers to the ‘mental domain’. A distinction between cold and hot cognition has sometimes been made to emphasize the fact that emotional factors are more in focus in some cognitive processes than in others, but it would be wrong to think that emotion is absent in any aspect of our thinking, perception or memory. For us, therefore, the term ‘cognitive’ is the same as ‘mental’ and has a close and immediate link with ‘neural’ on the one side and ‘behavioral’ on the other. Thus cognition includes thinking, memory, attention, learning, mental attitudes and, importantly, emotions and social processing. As shown in the figure above, cognition forms the important link between, brain and behavior. The link is the ‘mind’ (Fig. 1).

4. Why a new journal?

The creation of a new journal is designed to meet the need for a new forum, to encourage dialogue through communication of novel research findings, focused specifically on the interface between neuroscience, psychology, and development. Creation of the journal responds to new and ever-growing interest in developmental cognitive neuroscience, as can be seen at many levels. There have been high profile books, special issues of scientific journals and conferences dedicated to this new field. There has been a year-on-year increase in the number of papers reporting studies on pediatric neuroimaging published since 2000, as shown on the graph above (Fig. 2).
However, a core setting has not emerged where research findings in this area can be consolidated. It is the need for a home to house this increasing number of publications in this new field that provides the stimulus for this journal.

Neuroscience research is revealing, and will continue to reveal, a great deal about the developing brain. In addition to the benefits of studying development in itself, developmental data can also address outstanding general questions such as how specific areas become specialized for a particular stimulus group. For example, is there an area in the brain that is uniquely dedicated to processing faces, or will various areas initially process face stimuli before the final face network emerges? The brain is a dynamic and ever changing (plastic) system that does not cease to change even after adulthood has been reached, but what are the limits to plasticity? Development in some sense can be seen as a life-long process, and we certainly do not wish to restrict papers published in this journal to the childhood years. Studies on neurodevelopment across the lifespan are welcomed. The emphasis here is not on studying youth, but rather on investigations that advance understanding of developmental processes in the brain, at whatever age.

As mentioned, our primary aim is to publish the best conceptual, methodological, and empirical research in developmental cognitive neuroscience, broadly defined. Although the field of developmental cognitive neuroscience is young, it builds on a variety of well established disciplines including developmental psychology, developmental neuroscience, evolutionary biology, neuropsychology, computer science and cognitive neuroscience. We invite papers reporting findings from a variety of disciplines, including brain imaging of development at all ages, the influence of genetics and environment on neurocognitive development, animal studies, neuropsychology of brain damaged patients and brain development in children with developmental disorders.

However, our goal is not only to showcase the best research and reviews from our field, but also to serve the rapidly growing community of researchers working in this field. We want this journal to promote dialogue and discussion in ways that contribute to the growth, maturation, and emerging identity of our field.

We recognize that these are ambitious goals, which are likely to raise considerable challenges and controversies. Accordingly, we welcome a wide range of differing opinions, seek input and expertise from individuals with a broad range of backgrounds and disciplines, and look forward to innovative suggestions about integrative approaches. It is truly an exciting time of opportunity.