

# Piaget revisited

Recent research backs up Piaget's theory of how the infant brain develops, as *Annette Karmiloff-Smith* explains

**W**hen in 1963, John Flavell translated Piaget's *La Naissance de l'Intelligence chez l'Enfant (The Birth of Intelligence in the Child, 1936)*, many developmental psychologists opted for a Piagetian view over Empiricist notions of the child mind as a blank slate or Nativist claims of innately specified cognitive structures. Piaget's theory offered developmentalists a way of capturing the dynamics of progressive development and of considering the child as an active participant in his own cognitive growth.

There followed a flourish of research on sensori-motor development, object permanence, concrete and formal operations, many with the purpose of demonstrating that the ages at which children achieved these milestones were much younger than Piaget's theory claimed. But, in my view, those efforts missed the point.

For Piaget, his stages – sensori-motor, pre-operational, concrete oper-

ational, and formal operational – were the least important aspect of his theory. Yet it is on stages that the majority of scientists focused. Far more important was, and still is, Piaget's epistemology: Constructivism.

Piaget focused on the mechanisms by which knowledge becomes progressively internalised. Three biologically-inspired mechanisms were invoked:

- assimilation
- accommodation
- equilibration.

According to Piaget, learners construct their knowledge by first attempting to assimilate new information into existing structures. When only assimilation occurs, the learner fails to notice new features. In this case, the child makes the world fit his internal representations.

However, when the child becomes sensitive to the fact that incoming information challenges existing structures, he accommodates existing structures to the novel aspects of the stimulus. In this case, the child makes

the internal representations fit the world.

Finally, Piaget invoked a spontaneous process of equilibration by which developing cognitive structures in different domains (for example, number, language, space, physical causality) aligned themselves towards creating a higher-level, domain-general structure.

## PIAGET IN THE LATTER PART OF THE 20TH CENTURY

As the popularity of Piagetian approaches to infant development began to wane, the Nativist approach, arguing for innate core knowledge, became particularly influential. At least four arguments were used to support the claims.

First, Nativists drew on adult neuropsychology, in which patients whose brains had previously developed normally subsequently suffer a brain trauma, resulting in a pattern of dissociated impairments – for example, agrammatism (vocabulary fine, but words strung together without grammar), prosopagnosia (object recognition fine, but inability to recognise faces), or agnosia (face processing fine, but inability to recognise objects). This, theorists argued, indicates that the brain is composed of independently functioning, domain-specific modules.

The second argument emanated from a version of evolutionary psychology, which maintains that the newborn brain can be compared to a Swiss army knife in which each module is exquisitely pre-adapted for a specific, independent function.

The third argument was based on the capacities of the so-called 'competent infant' – claims that young infants possess innately-specified, core knowledge/core principles about faces, objects, number, language, etc. In Nativist accounts, learning is relegated to a minor explanatory role.

Finally, the fourth argument invoked studies of children with genetic disorders who present with uneven cognitive profiles and display a juxtaposition of scores 'in the normal range' in one or more domains alongside serious deficits in others. This was argued to illustrate the dissociation of general intelligence from independently functioning domains like grammar, number, face processing and the like.

So, why should we consider these four arguments to be less compelling than they initially seem, and why the current return to Piagetian-inspired epistemology?



**By about eight months of age, the infant brain will have about one thousand-trillion connections between neurons, which is twice the amount of connections in adult brains**



Observe children's physical skills to understand how cognitive ones develop

**The brain is like a large, very wrinkled walnut! Yet if its wrinkled layers and folds were flattened out, it would cover a full-sized football pitch**

cover a full-sized football pitch. Within the folds are nearly a billion neurons. By about eight months old, the infant brain will have about one thousand-trillion connections between neurons, which is twice the amount of connections in adult brains. But this is a temporary difference. With time, the connections that have proven useful will get strengthened, whereas those that haven't been active will be 'pruned'.

The fine-tuning of functional brain organisation is activity-dependent, in which the processing of environmental input gradually moulds the way in which the microstructure of the brain emerges.

In young infants, neural processing tends initially to be diffuse across several regions in both hemispheres, but over time, brain activity becomes restricted to more specific networks in the left or right hemispheres.

A recent study examined language-specific contrasts (eg, difference between /ba/ and /pa/) in infants from three months to 28 months and found that the onset of activation in different areas of cortex was not general, but very gradual and age-specific.

Another study suggests that comprehension of single words moves from processing in both hemispheres between 13 and 17 months to left lateralised processing by 20 months.

Likewise, processing of human faces starts out bilaterally, but by 12 months, the brain becomes increasingly fine-tuned for processing human faces in right hemisphere networks. So, many aspects of brain development start out with processing in both hemispheres and progressively become specialised in the left or right. ▶

First, these arguments are all static. They ignore the developmental history of the organism. Indeed, a crucial component of Piaget's epistemology focused on the progressive growth of knowledge over time, not a snapshot of knowledge at one specific time point, like birth.

Second, they involve claims about hardwired structures, rather than structures that are emergent from child/environment interactions.

Third, they disregard everything we now know about the progressive development of the infant brain.

### PIAGET IN THE 21ST CENTURY AND THE DYNAMICS OF INFANT BRAIN DEVELOPMENT

Although Piaget was by no means an Empiricist, his Constructivist theory does embody domain-general mechanisms of change (assimilation, accommodation, equilibration), purported to apply to all cognitive domains such as number, space, physical causality, social cognition and language.

While strongly supporting Piaget's Constructivist view that infants are active participants in their own learning and that cognitive structures are emergent, Neuroconstructivism places a greater emphasis on mapping behavioural/cognitive changes to brain changes across developmental time.

Neuroconstructivism proposes a 'domain-relevant' view, which argues that the brain starts out with some basic-level biases (for example, the ability to process features of objects, shapes, colours, the ability to make comparisons of same/different), each of which is somewhat more relevant to the processing of certain kinds of input over others, and which



become domain-specific over time.

Just as Piaget stressed the ways in which children build their own cognitive structures, so neuroscientists focus on how the child's activities sculpt the resulting brain structure.

The brain is like a large, very wrinkled walnut! Yet if its wrinkled layers and folds were flattened out, it would





A child's brain develops dynamically in interaction with the environment

Of course, many questions about the developing brain remain to be answered. By what is clear is that the brain develops dynamically in interaction with the environment. Even the brains of identical twins end up relatively different, highlighting the role of gene-environment interactions.

This process is most evident in brain organisation in people who lack one sensory modality. In individuals blind from an early age, visual cortex is recruited for the tactile modality – for example, Braille reading. In the congenitally deaf, auditory cortex is taken over by the processing of visual inputs.

London taxi drivers, who spend their days navigating space, have larger hippocampi regions than persons of equivalent intelligence but who do not drive around all day. Thus the functional development of the brain is constrained by available sensory inputs and by specific experiences.

### WITH PIAGET, TAKING DEVELOPMENT SERIOUSLY

The Constructivist and Neuroconstructivist perspectives embrace a truly developmental way of thinking. To understand developmental outcomes, it is vital to identify full developmental trajectories, to assess how progressive change occurs from infancy onwards, and how parts of the developing system may interact with other parts differently at different times. Indeed, developmental timing is among the most important of factors underlying human development. Even when scores are 'in the normal range', this doesn't necessarily imply a normal developmental trajectory, without examining the cognitive and neural levels underlying the behaviour.

Yet researchers of a Nativist persuasion will often label the domain in

which scores fall in the normal range as 'intact' alongside other domains that are considered to be impaired. The very notion of 'intactness' has a static connotation and implies genetic determinism, as if states in the brain were hard-wired, unchanging and unaffected by developmental or environmental factors.

The Neuroconstructivist view, by contrast, considers the brain as a self-structuring, dynamically changing organism over developmental time as a function of multiple interactions, including gene expression.

Research on early mammalian development underlines the potential role of the environment in shaping patterns of gene expression. A recent study focused on rodent pups traced how differences in the amount of postnatal pup grooming change the amount of expression of the genes involved in the body's responses to



### FURTHER READING

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stress, and that these changes last the pups' lifetime. So, the more the mother tends her pups, the more genes protecting against stress are expressed.

### IMPLICATIONS OF A NEUROCONSTRUCTIVIST APPROACH FOR ATYPICAL DEVELOPMENT

Rather than invoking 'intact' and 'impaired' modules, atypical development should be assessed in terms of cascading developmental effects of early perturbations. However, perhaps the notion of impaired versus intact brain systems is useful for clinical or educational practice, even if theoretically it underplays the role of development.

If a child has scores in the normal range in a specific domain, surely there is no need to consider remediation in that domain? The Nativist would focus solely on the domains of deficit. However, the Neuroconstructivist would not rule out intervention also in a proficient domain.

Take, for instance, the case of a child who presents with a serious deficit in, say, number, yet scores in the normal range for all other domains. Here, it would be tempting to tailor remediation solely to the domain of number. But that misses the point of the Neuroconstructivist framework. The scientist would need to trace back to infancy the origins of the number deficit which might not be in the number domain directly; it could be a deficit in the visual system – in other words, an impairment in visually scanning different numbers of arrays of objects.

Such a scanning deficit might affect other domains too, but to a lesser degree, meaning that these other domains could look normal in subsequent development but may camouflage subtle deficits. In other words, some seemingly 'normal' behaviours may also require remediation.

The infant brain is not a collection of static, built-in modules handed down by Evolution. Rather, the Neuroconstructivist view is that it is the emergent property of dynamic multi-directional interactions between biological, physical and social constraints, a position completely in tune with Piaget's Constructivism. ■

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