

Varied Developmental Trajectories: Lessons for Educators

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ABSTRACT—Methodological ingenuity and deep knowledge of expected development are combined by Immordino-Yang to produce an enlightening analysis of 2 hemispherectomized youths. Specific lessons to be drawn from her article include the following: the limitations of anatomy in predicting function; the need for educators to understand fully the multifunctionality, plasticity, and experience-driven development of cortical structures; the importance of a wide-ranging and multilayered approach to assessment when it is being used for diagnostic purposes; and, finally, the difficulty (and importance) of distinguishing task accomplishment from procedures undertaken while performing the task. Carefully documented stories like those told by Immordino-Yang in this important article serve as a salutary reminder to educators that there are multiple pathways to the achievement of many developmental goals and that the educator's role is to support the student's optimal trajectory rather than imposing a normative trajectory.

Immordino-Yang's article documenting the performance of two hemispherectomized youths and drawing out the implications for education represents a model of inventive methods, innovative analysis, and thoughtful interpretation. It is important to recognize how complex it was to puzzle out the patterns of behavior shown by Nico and Brooke, individually, in comparison to one another and in comparison to their non-brain damaged comparisons; it required considerable expertise, knowledge of normal or expected development in the domains studied, and mucking about in initially surprising sets of findings. The coherence of the story we see here reflects the skill of the analyst/narrator as much as the clarity of the data themselves.

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Getting to that pattern of results also required extensive methodological ingenuity. Cases of complete hemispherectomy are rare enough (fortunately) that optimal contralateral comparisons can almost never be found. Ideally, the two boys Immordino-Yang compared would have had the same first language, country and culture of origin, age at surgery, age at testing, family constellation, and presurgical intelligence and proclivities. Nico and Brooke varied on most, if not all, of these dimensions. Only by adopting the methodologically innovative (and time-intensive) approach of collecting data from same-language comparison groups across a range of ages and developmental levels was it possible for Immordino-Yang to interpret the behavior of either Nico or Brooke in sensible ways. Furthermore, given their surprisingly good performance compared to normally developing age-mates on many of the measures, it took further ingenuity to devise testing and analytic procedures that could reveal the challenges they faced and the strategies they had adopted, consciously or not, to enable them to perform so well.

This work contributes in substantive ways to the case studies of these two young men, both of whom had of course been studied before from different perspectives. As such, the work Immordino-Yang did constitutes an enhancement of the research literature on human neuroscience. Her express purpose, though, was to go beyond such a focused contribution to making the interdisciplinary move of marrying high-quality human neuroscience to serious thinking about education. Does this article represent a substantive contribution to education and/or to the multidisciplinary work of human neuroscience and education? I would argue that it has a number of lessons for educators, and I will try to develop just four here.

First, it is salutary to remind ourselves of the limitations on claims that brain anatomy is destiny. As we foresee a time when children's educational records might encompass information from MRIs, computerized axial tomography scans, and genotyping, we need to ensure educators remember the implications of cases like Nico and Brooke, who functioned at very high level across a range of domains even after radical brain surgery.

Second, as Immordino-Yang points out, the major contribution of neuroscientific understanding to education does not consist in pinpointing where in the brain a particular activity occurs, how cortical anatomy relates to particular talents or challenges, or what the age limits are on periods of species-typical learning. Rather, modern human and animal neuroscience should be offering educators a view of the brain that differs radically from that sketched in the early work of Penfield (e.g., Penfield & Roberts, 1959), Lenneberg (1967), Sperry (1961), Milner (e.g., Milner, Pribram & Broadbent, 1970), and the other pioneers of human neuroscience. The cortex, which used to be thought of as an interconnected set of specialized units, has been reconceptualized as a single, multipurpose, dynamic, and malleable organ shaped by experience. Localization of function, one of the great discoveries of early neurology, has been reenvisioned as the product not of prior anatomical destiny but rather of how the brain responds to experience. Sensitive periods, long thought of as related to the efficiency and universality of the development of vision and language, have been reinterpreted as the product of disorganization and multifunctionality rather than as windows for quick, efficient, species-specific learning. The traditional view of the brain represented a coherent and well-developed model that was deeply rooted in both scientific and popular understanding. Replacing it with a view of the brain that is both more correct and more helpful to educators will require many arresting stories of the type told so well by Immordino-Yang.

The third lesson of Immordino-Yang's study is the importance of a wide-ranging and multilayered approach to assessment when it is being used for diagnostic purposes. The detailed and nuanced picture that emerged of both Nico's and Brooke's skills came not from any one of the assessment procedures used but rather from the combination of structured testing, spontaneous production, and interview data revealing aspects of their metacognition. It came, furthermore, from assessments that strategically required a convergence of perceptual, emotional, and social capacities; it was striking that both boys, despite their neurological challenges, performed quite well on tasks tapping only one of those domains. Only by requiring that the information from all three domains be used could Immordino-Yang fully display their difficulties, and even then understanding those difficulties was greatly enhanced by access to interview responses in which Nico and Brooke explained how they came to their judgments.

Finally, this work carries a crucial message about the difficulty (and importance) of distinguishing task accomplishment from task performance. Very often, educators, having equipped themselves with specific procedures for teaching particular tasks, equate good performance on the task with performance according to those procedures. Examples of such procedures include "borrowing" as an algorithm when subtracting, remembering rules of thumb like "when two vowels go

walking the first one does the talking," or learning to apply strategies such as visualization, prediction, and self-questioning as the solution for comprehension difficulties. Of course, borrowing while subtracting or mnemonics for vowel pronunciation or comprehension strategies can be enormously helpful to some students struggling with the tasks for which they are designed, but learning these specific procedures can be a waste of time or an actual obstacle for others. Students who subtract well, or who are already fluent word readers or good comprehenders, may well be using tricks, reminders, and strategies that differ from those their teachers use and try to inculcate. Their performance on the outcome—answers to subtraction sums, correct pronunciation of words, and comprehension of text—is the important measure, not whether they reach that outcome the "right way." Yet, classroom time is wasted every day by insistence on teaching and testing the procedures rather than the outcomes. Purely oral phonological awareness tasks, for example, are being widely used with older poor readers on the theory that they are a crucial step to fluent reading, when in fact they constitute a helpful entrée for many young emergent readers but only one of the possible routes to insights about alphabetic representation of sound and one that is unlikely to be helpful to older readers struggling with other aspects of the system. Similarly, in writing instruction, "process writing procedures," also a helpful entrée for many writers, become an end in themselves, and the processes of brainstorming and revision become as important as the final product in evaluating student writers.

In short, these case studies come as a welcome reminder to educators that very few developmental challenges can be solved in only one way. For many challenges, there is an "easy way," the way that the majority of learners adopt and that teachers might usefully offer to their students, but also alternative routes to the same end. Most children start to talk by babbling, then producing single words, and then gradually increasing the length and complexity of their utterances. But some never babble, some start with longer, only partially segmented utterances, and some rely on gesture for a long period before moving to speech. Most children crawl, then "cruise" by walking upright with support, and then walk independently. But some scoot instead of crawling; others prefer to be upright from a very early age and never either scoot or crawl before walking. As far as we can tell, the linguistic and locomotive skills of the "easy route" groups end up indistinguishable from those of the ones who have taken alternative paths.

Nico and Brooke, both of whom achieved high levels of performance on tasks they approached in very different ways, remind us that student outcomes are what matter, not adhering to particular procedures for achieving that outcome. Other examples of inventive learner solutions to performance challenges, of course, abound. Late second-language learners report achieving native-like production of sounds they find difficult to distinguish (e.g., /l/ and /r/ for Japanese speakers of English)

not by following their teacher admonitions to practice listening but rather by learning the articulation of the sounds and memorizing the spelling of the target items; they substitute an articulatory for a phonological strategy, thus end up performing like native speakers through a different route than that available to young first-language learners (Ugorji, 2007). Similarly, dyslexics who transcend their initial difficulties to become good readers report following a more top-down approach to reading than normally developing readers, relying more on background knowledge of the topic, on prediction, and on nontextual material; though their word reading might be relatively inaccurate and their text reading dysfluent, they nonetheless achieve a level of understanding (especially for texts on topics of high interest to them) that can match or transcend that of normal fluent readers (Fink, 1998).

Immordino-Yang's groundbreaking study is located at the precise nexus of mind, brain, and education. It takes advantage of the somewhat disrupted development of two young men to puzzle out details of developmental trajectories that often occur too fast and too automatically to be easily studied. In the process, it illustrates some general principles, including the fact of dedicated brain tissue coexisting with exten-

sive plasticity, especially in the domain of how problems get solved rather than what brain tissue is used to solve them. It has lessons for cognitive neuroscientists and for educators and represents an existence proof of the mutual informativeness of these two fields.

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