Digital Natives, Digital Immigrants, *Part II:*

Do They Really *Think* Differently?

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Different kinds of experiences lead to different brain structures.
-Dr. Bruce D. Perry, Baylor College of Medicine

Our children today are being socialized in a way that is vastly different from their parents. The numbers are overwhelming: over 10,000 hours playing videogames, over 200,000 emails and instant messages sent and received; over 10,000 hours talking on digital cell phones; over 20,000 hours watching TV (a high percentage fast speed MTV), over 500,000 commercials seen—all before the kids leave college. And, maybe, *at the very most,* 5,000 hours of book reading. These are today's "Digital Native" students. [1]

In *Digital Natives, Digital Immigrants: Part I,* I discussed how the differences between our Digital Native students and their Digital Immigrant teachers lie at the root of a great many of today's educational problems. I suggested that Digital Natives' brains are likely *physically different* as a result of the digital input they received growing up. And I submitted that learning via digital games is one good way to reach Digital Natives in their "native language."

Here I present evidence for why I think this is so. It comes from neurobiology, social psychology, and from studies done on children using games for learning.

Neuroplasticity

Although the vast majority of today's educators and teachers grew up with the understanding that the human brain doesn't physically change based on stimulation it receives from the outside—especially after the age of 3— it turns out that that view is, in fact, *incorrect.*

Based on the latest research in neurobiology, there is no longer any question that stimulation of various kinds actually changes brain structures and affects the way people think, and that these transformations go on *throughout life.* The brain is, to an extent not at all understood or believed to be when Baby Boomers were growing up, *massively plastic.* It can be, and is, constantly reorganized. (Although the popular term *rewired* is somewhat misleading, the overall idea is

right—the brain changes and organizes itself differently based on the inputs it receives.) The old idea that we have a fixed number of brain cells that die off one by one has been replaced by research showing that our supply of brain cells is replenished constantly. [2] The brain *constantly* reorganizes itself all our child and adult lives, a phenomenon technically known as *neuroplasticity*.

One of the earliest pioneers in this field of neurological research found that rats in "enriched" environments showed brain changes compared with those in "impoverished" environments after as little as two weeks. Sensory areas of their brains were thicker, other layers heavier. Changes showed consistent overall growth, leading to the conclusion that *the brain maintains its plasticity for life*. [3]

Other experiments leading to similar conclusions include the following:

- Ferrets' brains were physically rewired, with inputs from the eyes switched to where the hearing nerves went and vice versa. Their brains changed to accommodate the new inputs. [4]
- Imaging experiments have shown that when bind people learn Braille, "visual" areas of their brains lit up. Similarly, deaf people use their auditory cortex to read signs. [5]
- Scans of brains of people who tapped their fingers in a complicated sequence that they had practiced for weeks showed a larger area of motor cortex becoming activated then when they performed sequences they hadn't practiced. [6]
- Japanese subjects were able learn to "reprogram" their circuitry for distinguishing "ra" from "la," a skill they "forget" soon after birth because their language doesn't require it. [7]
- Researchers found that an additional language learned later in life goes into a different place in the brain than the language or languages learned as children. [8]
- Intensive reading instruction experiments with students aged 10 and up appeared to create lasting chemical changes in key areas of the subjects' brains. [9]
- A comparison of musicians versus nonplayers brains via magnetic resonance imaging showed a 5 percent greater volume in the musicians' cerebellums, ascribed to adaptations in the brain's structure resulting from intensive musical training and practice. [10]

We are only at the very beginning of understanding and applying brain plasticity research. The goal of many who are—such as the company Scientific Learning—is "neuroscience-based education." [11]

Malleability

Social psychology also provides strong evidence that one's thinking patterns change depending on one's experiences. Until very recently Western philosophers and psychologists took it for granted that the same basic processes underlie all human thought. While cultural differences might dictate what people think *about*, the *strategies* and *processes* of thought, which include logical reasoning and a desire to understand situations and events in linear terms of cause and effect, were assumed to be the same for everyone. However this, too, appears to be wrong.

Research by social psychologists [12] shows that people who grow up in different cultures do not just think about different things, they actually *think differently*. The environment and culture in which people are raised affects and even determines many of their thought processes.

"We used to think that everybody uses categories in the same way, that logic plays the same kind of role for everyone in the understanding of everyday life, that memory, perception, rule application and so on are the same," says one. "But we're now arguing that cognitive processes themselves are just far more malleable than mainstream psychology assumed." [13]

We now know that brains that undergo different developmental experiences develop differently, and that people who undergo different inputs from the culture that surrounds them think differently. And while we haven't yet directly observed Digital Natives' brains to see whether they are physically different (such as musicians' appear to be) the indirect evidence for this is extremely strong.

However, brains and thinking patterns do not just change overnight. A key finding of brain plasticity research is that brains do *not* reorganize casually, easily, or arbitrarily. "Brain reorganization takes place only when the animal pays attention to the sensory input and to the task." [14] "It requires very hard work."[15] Biofeedback requires upwards of 50 sessions to produce results. [16] Scientific Learning's Fast ForWard program requires students to spend 100 minutes a day, 5 days a week, for 5 to 10 weeks to create desired changes, because "it takes sharply focused attention to rewire a brain." [17]

Several hours a day, five days a week, sharply focused attention—does that remind you of anything? Oh, yes—video games! That is exactly what kids have been doing ever since *Pong* arrived in 1974. They have been adjusting or programming their brains to the speed, interactivity, and other factors in the games, much as boomers' brains were programmed to accommodate television, and literate man's brains were reprogrammed to deal with the invention of written language and reading (where the brain had to be retrained to deal with things in a highly linear way.) [18] "Reading does not just happen, it is a terrible struggle." [19] "Reading [has] a different neurology to it than the things that are built into our brain, like spoken language." [20] One of the main focuses of schools for the hundreds of years since reading became a mass phenomenon has been retraining our speech-oriented brains to be able to read. Again, the training involves several hours a day, five days a week, and sharply focused attention.

Of course just when we'd figured out (more or less) how to retrain brains for reading, they were retrained again by television. And now things have changed *yet again*, and our children are furiously retraining their brains in even newer ways, many of which are antithetical to our older ways of thinking.

Children raised with the computer "think differently from the rest of us. They develop hypertext minds. They leap around. It's as though their cognitive structures were parallel, not sequential." [21] "Linear thought processes that dominate educational systems now can actually retard learning for brains developed through game and Web-surfing processes on the computer." [22]

Some have surmised that teenagers use different parts of their brain and think in different ways than adults when at the computer. [23] We now know that it goes even further—their brains are almost certainly *physiologically different*. But these differences, most observers agree, are less a matter of kind than a difference of degree. For example as a result of repeated experiences, particular brain areas are larger and more highly developed, and others are less so.

For example, thinking skills enhanced by repeated exposure to computer games and other digital media include reading visual images as representations of three-dimensional space (representational competence), multidimensional visual-spatial skills, mental maps, "mental paper folding" (i.e. picturing the results of various origami-like folds in your mind without actually doing them), "inductive discovery" (i.e. making observations, formulating hypotheses and figuring out the rules governing the behavior of a dynamic representation), "attentional deployment" (such as monitoring multiple locations simultaneously), and responding faster to expected and unexpected stimuli. [24]

While these individual cognitive skills may not be new, the particular combination and intensity is. We now have a new generation with a very different blend of cognitive skills than its predecessors—the Digital Natives.

What About Attention Spans?

We hear teachers complain so often about the Digital Natives' attention spans that the phrase "the attention span of a gnat" has become a cliché. But is it really true?

"Sure they have short attention spans—for the old ways of learning," says a professor. [25] Their attention spans are *not* short for games, for example, or for anything else that actually interests them. As a result of their experiences Digital Natives crave *interactivity*—an immediate response to their each and every action. Traditional schooling provides very little of this compared to the rest of their world (one study showed that students in class get to ask a question every *10 hours*) [26] So it generally isn't that Digital Natives *can't* pay attention, it's that they *choose not to.*

Research done for *Sesame Street* reveals that children do not actually watch television continuously, but "in bursts." They tune in just enough to get the gist and be sure it makes sense. In one key experiment, half the children were shown the program in a room filled with toys. As expected, the group with toys was distracted and watched the show only about 47 percent of the time as opposed to 87 percent in the group without toys. But when the children were tested for how much of the show they remembered and understood, the scores were exactly the same. "We were led to the conclusion that the 5-year-olds in the toys group were attending quite strategically, distributing their attention between toy play and viewing so that they looked at what was for them the most informative part of the program. The strategy was so effective that the children could gain no more from increased attention." [27]

What Have We Lost?

Still, we often hear from teachers about increasing problems their students have with reading and thinking. What about this? Has anything been *lost* in the Digital Natives' "reprogramming" process?

One key area that appears to have been affected is *reflection.* Reflection is what enables us, according to many theorists, to generalize, as we create "mental models" from our experience. It is, in many ways, the *process* of "learning from experience." In our twitch-speed world, there is less and less time and opportunity for reflection, and this development concerns many people. One of the most interesting challenges and opportunities in teaching Digital Natives is to figure out and invent ways to *include* reflection and critical thinking in the learning (either built into the instruction or through a process of instructor-led debriefing) *but still do it in the Digital Native language*. We can and must do more in this area.

Digital Natives accustomed to the twitch-speed, multitasking, random-access, graphics-first, active, connected, fun, fantasy, quick-payoff world of their video games, MTV, and Internet are *bored* by most of today's education, well meaning as it may be. But worse, the many skills that new technologies *have* actually enhanced (e.g., parallel processing, graphics awareness, and random access)—which have profound implications for their learning—are almost totally ignored by educators.

The cognitive differences of the Digital Natives *cry out* for new approaches to education with a better "fit." And, interestingly enough, it turns out that one of the few structures capable of meeting the Digital Natives' changing learning needs and requirements is the very video and computer games they so enjoy. This is why "Digital Game-Based Learning" is beginning to emerge and thrive.

But Does It Work?

Of course many criticize today's learning games, and there is much to criticize. But if some of these games don't produce learning it is *not* because they are games, or because the concept of "game-based learning" is faulty. It's because *those particular games are badly designed.* There is a great deal of evidence that children's learning games that *are* well designed *do* produce learning, and lots of it — by and while engaging kids.

While some educators refer to games as "sugar coating," giving that a strongly negative connotation—and often a sneer—it is a big help to the Digital Natives. After all, this is a medium they are very familiar with and really enjoy.

Elementary school, when you strip out the recesses and the lunch and the in-between times, actually consists of about three hours of instruction time in a typical 9 to 3 day. [28] So assuming, for example, that learning games were only 50% educational, if you could get kids to play them for six hours over a weekend, you'd effectively add a day a week to their schooling! Six hours is far less than a Digital Native would typically spend over a weekend watching TV and playing videogames. The trick, though, is to make the learning games compelling enough to actually be used in their place. They must be *real* games, not just drill with eye-candy, combined creatively with *real* content.

The numbers back this up. The Lightspan Partnership, which created PlayStation games for curricular reinforcement, conducted studies in over 400 individual school districts and a "meta-analysis" as well. Their findings were increases in vocabulary and language arts of 24 and 25 percent respectively over the control groups, while the math problem solving and math procedures and algorithms scores were 51 and 30 percent higher. [29]

Click Health, which makes games to help kids self-manage their health issues, did clinical trials funded by the National Institutes of Health. They found, in the case of diabetes, that kids playing their games (as compared to a control group playing a pinball game) showed measurable gains in self-efficacy, communication with parents and diabetes self-care. And more importantly, urgent doctor visits for diabetes-related problems declined 77 percent in the treatment group. [30]

Scientific Learning's *Fast ForWard* game-based program for retraining kids with reading problems conducted National Field Trials using 60 independent professionals at 35 sites across the US and Canada. Using standardized tests, each of the 35 sites reported conclusive validation of the program's effectiveness, with 90 percent of the children achieving significant gains in one or more tested areas. [31]

Again and again it's the same simple story. Practice—time spent on learning—*works*. Kid's don't like to practice. Games capture their attention and make it happen. And of course they must be practicing the right things, so *design* is important.

The US military, which has a quarter of a million 18-year-olds to educate every year, is a big believer in learning games as a way to reach their Digital Natives. They know their volunteers expect this: "If we don't do things that way, they're not going to want to be in our environment." [32]

What's more, they've observed it working operationally in the field. "We've seen it time and time again in flying airplanes, in our mission simulators." Practical-minded Department of Defense trainers are perplexed by educators who say "We don't know that educational technology works—we need to do some more studies." "We KNOW the technology works," they retort. We just want to get on with using it." [33]

So, today's neurobiologists and social psychologists agree that brains can and do change with new input. And today's educators with the most crucial learning missions—teaching the handicapped and the military—are already using custom designed computer and video games as an effective way of reaching Digital Natives. But the bulk of today's tradition-bound educational establishment seem in no hurry to follow their lead.

Yet these educators know *something* is wrong, because they are not reaching their Digital Native students as well as they reached students in the past. So they face an important choice.

On the one hand, they can choose to ignore their eyes, ears and intuition, pretend the Digital Native/Digital Immigrant issue does not exist, and continue to use their suddenly-much-less-effective traditional methods until they retire and the Digital Natives take over.

Or they can chose instead to *accept* the fact that they have become Immigrants into a new Digital world, and to look to their own creativity, their Digital Native students, their sympathetic administrators and other sources to help them communicate their still-valuable knowledge and wisdom in that world's new language.

The route they ultimately choose—and the education of their Digital Native students—depends very much on us.

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Notes

1. These numbers are intended purely as "order of magnitude" approximations; they obviously vary widely for individuals. They were arrived at in the following ways (Note: I am very interested in any additional data anyone has on this):

   Videogames: Average play time: 1.5 hours/day (Source: "Interactive Videogames, *Mediascope*, June 1966.) It is likely to be higher five years later, so 1.8 x 365 x 15 years = 9,855 hours.

   E-mails and Instant Messages: Average 40 per day x 365 x 15 years = 219, 000. This is not unrealistic even for pre-teens – in just one instant messaging connection there may be over 100 exchanges per day – and most people do multiple connections.

   TV: "Television in the Home, 1998: Third Annual Survey of Parent and Children, Annenburg Policy Center, June 22, 1998, gives the number of TV hours watched per day as 2.55. M. Chen, in the *Smart Parents Guide to Kid's TV*, (1994) gives the number as 4 hours/day. Taking the average, 3.3 hrs/day x 365 days x 18 years = 21,681.

   Commercials: There are roughly 18 30-second commercials during a TV hour. 18 commercials/hour x 3.3 hours/day x 365 days x 20 years (infants *love* commercials) = 433,620.

   Reading: Eric Leuliette, a voracious (and meticulous) reader who has listed online every book he has ever read (www.csr.utexas.edu/personal/leuliette/fw_table_home.html), read about 1300 books through college. If we take 1300 books x 200 pages per book x 400 words per page, we get 10,400,000,000 words. Read at 400 words/that gives 260,000 minutes, or 4,333 hours. This represents a little over 3 hours/book. Although others may read more slowly, most have read far fewer books than Leuliette.

2. Paul Perry in *American Way*, May 15, 2000.

3. Renate Numella Caine and Geoffrey Caine, *Making Connections: Teaching and the Human Brain*, Addison-Wesley, 1991, p.31.

4. Dr. Mriganka Sur, *Nature*, April 20, 2000.

5. Sandra Blakeslee, *New York Times*, April 24, 2000.

6. Leslie Ungerlieder, National Institutes of Health.

7. James McLelland, University of Pittsburgh.

8. Cited in *Inferential Focus Briefing*, September 30, 1997.

9. Virginia Berninger, University of Washington, *American Journal of Neuroradiology*, May 2000.

10. Dr. Mark Jude Tramano of Harvard. Reported in *USA Today* December 10, 1998.

11. *Newsweek*, January 1, 2000.

12. They include Alexandr Romanovich Luria (1902-1977), Soviet pioneer in neuropsychology, author of *The Human Brain and Psychological Processes* (1963), and, more recently, Dr. Richard Nisbett of the University of Michigan.

13. Quoted in Erica Goode, "How Culture Molds Habits of Thought," *New York Times*, August 8, 2000.

14. John T. Bruer, *The Myth of the First Three Years*, The Free Press, 1999, p. 155.

15. G. Ried Lyon, a neuropsychologist who directs reading research funded by the National Institutes of Health, quoted in Frank D. Roylance "Intensive Teaching Changes Brain," *SunSpot*, Maryland's Online Community, May 27, 2000.

16. Alan T. Pope, research psychologist, Human Engineering Methods, NASA. Private communication.

17. *Time*, July 5, 1999.

18. *The Economist*, December 6, 1997.

19. Kathleen Baynes, neurology researcher, University of California – Davis, quoted in Robert Lee Hotz "In Art of Language, the Brain Matters " *Los Angeles Times*, October 18, 1998.

20. Dr. Michael S. Gazzaniga, neuroscientist at Dartmouth College quoted in Robert Lee Hotz "In Art of Language, the Brain Matters " *Los Angeles Times*, October 18, 1998.

21. William D. Winn, Director of the Learning Center, Human Interface Technology Laboratory, University of Washington, quoted in Moore, *Inferential Focus Briefing* (see 22).

22. Peter Moore, *Inferential Focus Briefing*, September 30, 1997.

23. *Ibid.*

24. Patricia Marks Greenfield, *Mind and Media, The Effects of Television, Video Games and Computers*, Harvard University Press, 1984.

25. Dr. Edward Westhead, professor of biochemistry (retired), University of Massachusetts.

26. Graesser, A.C., & Person, N.K. (1994) "Question asking during tutoring,". *American Educational Research Journal*, 31, 104-107.

27. Elizabeth Lorch, psychologist, Amherst College, quoted in Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference*, Little Brown & Company, 2000, p. 101.

28. John Kernan, President, The Lightspan Partnership. Personal communication.

29. "Evaluation of Lightspan. Research Results from 403 schools and over 14,580 students," February 2000, CD ROM.

30. Debra A. Lieberman, "Health Education Video Games for Children and Adolescents: Theory, Design and Research Findings," paper presented at the annual meeting of the International Communications Association, Jerusalem, 1998.

31. Scientific Learning Corporation, National Field Trial Results (pamphlet.) See also Merzenich *et al.*, "Temporal Processing Deficits of language-Learning Impaired Children Ameliorated by Training" and Tallal, *et al.*, "Language Comprehension in Language Learning Impaired Children Improved with Acoustically Modified Speech," in *Science*, Vol. 271, January 5, 1996, pp 27-28 & 77-84.

32. Michael Parmentier, Director, Office of Readiness and Training, Department of Defense, The Pentagon. Private briefing.

33. Don Johnson, Office of Readiness and Training, Department of Defense, The Pentagon. Private briefing.