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"Use-It-or-Lose-It"? Interrogating an Educational Message from Teen Brain Research

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Abstract: Recent neuroimaging research has encouraged a fundamental shift in psychological thinking about cognitive development in adolescence. Challenging the existing view that early childhood was the most critical period for intellectually hard-wiring the brain, findings led researchers to speculate that early adolescence might be the more important use-it-or-lose-it period. Despite cautions from critics and some neuroscientists themselves, the new story seems to be following its predecessor in acquiring the status of hard fact. An eclectic sampling of texts examines possible implications of the penetration of this hypothesis into educational discourse. Elements of classism and adultism are identified, and considered with reference to contemporary understandings of adolescence as a period when lifelong habits and lifestyles are established.

Introduction

In the mid-20th century Konrad Lorenz and others identified *critical periods* in many animals' early lives, including precisely limited times for bonding with the mother and developing certain perceptual skills (Burkhardt, 2005; Lorenz, 1981). Transferring this concept to understandings of human development proved controversial, but maintained considerable scientific and intuitive appeal (Kagan, 1998). In particular, viewing infancy as a make-or-break period for parent-child attachment (Bowlby, 1979) continues to influence Western childrearing advice; therefore it was not entirely surprising that towards the end of the century so many parents and educationalists were willing to embrace claims for infancy as also a critical period for intellectual development. As *Newsweek* explained for a general readership:

> When a baby comes into the world her brain is a jumble of neurons, all waiting to be woven into the intricate tapestry of the mind. … If the neurons are used, they become integrated into the circuitry of the brain by connecting to other neurons; if they are not used, they may die. It is the experiences of childhood, determining which neurons are used, that wire the circuits of the brain … [and determine] whether the child grows up to be intelligent or dull, fearful or self-assured, articulate or tongue-tied. Early experiences are so powerful, says pediatric neurobiologist Harry Chugani of Wayne State University, that "they can completely change the way a person turns out." (Begley, 1996, p. 54)

One Colorado mother became an especially famous convert: "'The first three years of life are incredibly important,' said Julie Clark, a former teacher and now full-time mother of

a 2-year-old girl. 'We know now that babies are really in desperate need of stimulation'" (Etheridge, 1997, para. 2). Clark put her daughter on a daily routine of mind-enhancing games, and began creating *Baby Einstein* videos so others could do likewise.

Not all academics were convinced. In *The Myth of the First Three Years* (1999), a comprehensive critique of what he saw as hasty political rhetoric and poorly informed educational policymaking, psychologist John Bruer identified a glaring lack of proof either that synaptic connections were not made after this early window of opportunity closed, or that the more synapses "saved from pruning" the more intelligent a child would be. Likewise, neuroscientist Charles Nelson likewise suggested to colleagues and educators:

> The point that has been driven home again and again is … that unless a child is reared by near-perfect parents, attends a near-perfect pre-school, has a near-perfect diet, is read near-perfect books, and listens to near-perfect music (preferably Mozart), the child's future may be jeopardized. [But] when one looks at the myriad of factors that correlate with positive developmental outcomes, one is hard pressed to point to only the first 3 years of life as holding all the cards. (Nelson, 1999, p. 235)

Aspects of this debate became instantly obsolete when longitudinal data collected by Jay Giedd and others at the U.S. National Institute of Mental Health (NIMH) unexpectedly revealed another period of major increase in cortical gray matter in preadolescence followed by subsequent decrease (Giedd et al., 1999). Timing of onset of neuronal decrease, or *pruning*, was shown to vary in different areas of the cortex, beginning around age 12 for the frontal and parietal lobes. Data also increasingly confirmed the notion that developing an effective brain is *not* about maximizing the number of neural connections: rather, pruning of gray matter after a period of rapid growth is essential so connections of greatest importance can be most quickly prepared — through myelination (growth of white matter) — to work efficiently (Lenroot & Giedd, 2006).

Educators already convinced the changing technological demands of contemporary life meant students' brains were also changing (e.g., Sousa, 1998) constituted a receptive audience for these findings, which became the "scientific centrepiece" (Bruer, 2002) for the May 2000 White House Conference on Teenagers. The NIMH factsheet issued subsequently emphasized the key hypothesis:

> New imaging studies are revealing—for the first time—patterns of brain development that extend into the teenage years. Although scientists don't yet know what accounts for the observed changes, they may parallel a pruning process that occurs early in life that appears to follow the principle of "use-it-or-lose-it:" neural connections, or synapses, that get exercised are retained, while those that don't are lost. *At least, this is what studies of animals' developing visual systems suggest* [italics added]. (NIMH, 2001, para. 1)

Bruer (2002) noted how brain enthusiasts and the media fixated on this message, expressing dismay that once again so many influential players seemed willing to run with such highly speculative material. Among neuroscientists themselves some caution remained — a *Time* magazine article (Wallis & Park, 2004) described them as feeling "a little burned" by apparent misapplication of earlier findings (and growing doubts about *Baby Einstein*). Sarah-Jayne Blakemore and Uta Frith called Giedd's ideas "still speculation" (2005, p. 120); interviewed for *Nature,* Elizabeth Sowell observed: "Jay likes to say 'use it or lose it' and that we should put kids in enriched environments. That

makes perfect intuitive sense, but we just don't have the data to say that" (Powell, 2006, p. 866). Consistent with Sowell's remarks Giedd himself was presented in the same article as less circumspect —"If synaptic pruning is accelerated during adolescence, says Giedd, it follows that this is a time of 'use it or lose it' in the brain. The more environmental input there is to guide that pruning, he says, the better" (p. 866) — although in his own writing he can still be found advocating caution (Johnson, Blum, & Giedd, 2009). Nevertheless, it was arguably an earlier interview posted on the website for the 2002 U.S. Public Broadcasting System documentary series *Inside the Teenage Brain* that more than anything else had set in motion the widespread uptake and unqualified acceptance of this "intuitively sensible" package of neuroscientific fact and sociocultural supposition:

> I think the exuberant growth during the pre-puberty years gives the brain enormous potential. … But the pruning-down phase is perhaps even more interesting, because our leading hypothesis for that is the "Use it or lose it" principle. Those cells and connections that are used will survive and flourish. Those cells and connections that are not used will wither and die. So if a teen is doing music or sports or academics, those are the cells and connections that will be hard-wired. If they're lying on the couch or playing video games or MTV, those are the cells and connections that are going to survive. … Are schools doing a good job? Are we as parents doing a good job? … What can we do to help the teen optimize the development of their own brain? ("Interview: Jay Giedd," 2002, paras. 3-4, 16)

The perceived need for teachers to keep abreast of developments in brain research is of course nothing new, although many writers suggest rapid advances in neuroscience make this now especially crucial (Ansari, 2008; Blakemore & Frith, 2005; Crawford, 2007; Jensen, 2008; Philp, 2007). However it is equally acknowledged that ideas from both neuroscience and cognitive science have previously led to enthusiasms for pedagogical practices subsequently revealed of little worth (for critiques see, e.g., Bransford, Brown, & Cocking, 1999; Kagan & Herschkowitz, 2005). Although funding is increasingly available for systematic multidisciplinary pre-emptive evaluation of new practice (Gura, 2005), I am proposing it may also be informative just to take a more informal critical look at how ideas can unobtrusively establish a foothold. In taking this approach here with regard to Giedd's use-it-or-lose-it hypothesis, I first present a compilation of the story's appearance in an eclectic sampling of (mostly online) sources, all currently (i.e., end July 2010) accessible. Direct quotation is generally used in preference to paraphrasing to capture significant discursive qualities of the texts. I then identify some key issues in terms of their educational and broader developmental ramifications.

Using Use-It-Or-Lose-It: A Sampling of Texts

> The pruning process appears to follow the principle of "use-it-or-lose-it," according to experts. Thus, neural connections or circuitry that gets exercised as we grow up are retained, while the connections that are not activated or used, get pruned away. Dr Giedd refers to this process in this way: "Ineffective or weak connections are pruned in much the same way a gardener would

> prune a tree or bush, giving the plant the desired shape."
> (Winters, 2008, para. 4)

Despite the use-it-or-lose-it argument being still clearly identified in the academic literature as stemming from the work of Jay Giedd and colleagues, my search suggested readers encountering them elsewhere may only occasionally find his name mentioned — as in Ken Winters' report for the Philadelphia (drug) Treatment Research Institute above. It is an indication of the already widely assumed proven status of this hypothesis that it is much more likely to be found both uncontested and unreferenced, simply embedded within broader discussions of adolescent issues. For example, a regional newsletter tells Oregon public health professionals "during adolescence, the brain adopts a 'use-it-or-lose-it' pruning system, resulting in a decreasing number of connections among brain cell even as the speed of these connections increases" (Ramowski & Nystrom, 2007, p. 24), and in a lengthy and quite widely distributed online article on the teen brain epidemiologist and educator Linda Chamberlain writes: "Similar to early childhood, adolescent brain development is a period of *"use it or lose it"* — brain connections that are stimulated and used repeatedly are strengthened while unused connections wither away" (Chamberlain, 2008, para. 3). Australian psychologist Andrew Fuller regularly offers presentations for teachers and parents and was a consultant for the 2009 television series *Whatever! The Science of Teens*; his perspective, from, respectively, an article based on his "Don't waste your breath" seminar and promotional material on the *Whatever!* website, appears unequivocal:

> Between ten years of age and puberty, the brain ruthlessly destroys its weakest connections, preserving only those that experience has shown to be useful. The adage here is *use it or lose it* ... This *synaptic pruning* continues throughout life but occurs mostly during the late childhood and teenage years so that the synapses that carry the most messages get stronger and the weaker ones get cut out. This helps in refinement and specialisation. This is why the experiences we give children and young people between their 9th and 18th years are so important.
> (Fuller, 2005, p. 16)

> The teen brain undergoes rapid fire synaptic wiring, ruthlessly destroying and creating connections at lightning speed; it's use it or lose it time, where what you learn (or don't) gets hardwired into your brain for the rest of your life.
> (www.abc.net.au/tv/documentaries/interactive/whatever)

Studies with nonhuman animals have suggested environmental opportunity and experience (as opposed to internal biological factors) significantly influence which connections are retained during periods of pruning (Giedd et al., 1999). While experimental animals usually have their environments controlled meticulously, growing humans typically do not — although, during infancy at least, enthusiastic caregivers might attempt reasonably structured regimes of stimulation. Shifting the critical period to late childhood/early adolescence, however, required promoting the notion of children themselves "choosing their brains". Physician Richard Restak, researcher and author of several books on the brain for public readership, follows Giedd closely on this:

> Several experts contend that music, math and sports can help structure the brain faster and better than simply hanging out or watching television. "The adolescent brain exhibits tremendous

> plasticity," Restak says. "Indeed, the adolescent's choices determine the quality of his brain." (Wendel, 2003, para. 10)

Likewise, a 2002 factsheet from the Act for Youth Upstate Center of Excellence (supported by Cornell University, University of Rochester and the New York Center for School Safety) stated:

> Following the overproduction of gray matter, the brain undergoes a process called "pruning" where connections among neurons in the brain that are not used wither away, while those that are used stay—the "use it or lose it" principle. …Kids who "exercise" their brains by learning to order their thoughts, understand abstract concepts, and control their impulses are laying the neural foundations that will serve them for the rest of their lives. "This argues for doing a lot of things as a teenager," says Dr. Giedd. "You are hard-wiring your brain in adolescence. Do you want to hard-wire it for sports and playing music and doing mathematics - or for lying on the couch in front of the television?" (Act for Youth, 2002, p. 1)

Chamberlain emphasized the active/passive distinction with these examples:

> How teens spend their time and use their brains influences the organization and capacity of their brains. This raises important questions for families about how much time a teenager spends with technology (television, computer games, videos) versus active learning and skill development whether it is learning a new language, playing a musical instrument, engaging in physical activities, or spending quality time with adults. (2008, para. 3)

A British report for mental health workers opted for a nonspecific adaptive/maladaptive binary, advising that "the activities undertaken by adolescents are critical to ensuring that circuits (or processing systems) which underpin adaptive, rather than maladaptive, functioning strengthen and grow" (YoungMinds, 2006, p. 2), while the Wyoming-based online Parent Education Network explains simply (2008, para. 3): "Teens are creating their own brains, in a way. Whatever they choose to learn or experience will be hardwired and kept". Alternatively, *The Christian Post* used advice from the Medical Institute for Sexual Health that "The nerve cells themselves physically grow different, depending on what they're exposed to" (Phan, 2004, para. 5) to highlight the very specific issue of risking "bad" connections when teens are allowed to explore sexually explicit internet sites.

Thus, although adolescents' experiences cannot be controlled by adults to the same extent as those of infants it is still considered important for adults to be aware of what is happening, and materials aimed primarily at teachers regularly incorporate these ideas. For example, in her book advocating "adolescent-centered" teaching, Glenda Crawford advises:

> Important to parents and educators is the implication that the experiences in which adolescents are involved can play a role in determining which neural structures survive. …Those who engage actively in music, sports, or academics, for example, potentially strengthen and sustain synaptic connections in the associated areas. (Crawford, 2007, p. 12)

Author of a recent text on "brain-compatible" teaching (Philp, 2007), Raleigh Philp has explained in interview:

> At about age twelve, thirteen, fourteen, the brain goes through a major pruning, much as it did around age two or three. Many of the neurons have two choices, if you will: They can develop into a neural network threaded together as a result of experience, or they're pruned away. …Unless teenagers put together those neural networks, they may *never* [italics added] develop successful relationships with academics, with skills of all sorts. So, if the kid is sitting in front of a TV all day and not getting experiences, acquiring skills, we have a more serious problem than anyone had realized. (Standen, 2007, paras. 9-10)

The main implication for teachers, Philp said, is to recognize their students' need for guidance: "We've known for a long time … that if we let kids do their own things, they'll first seek out adult role models, but if these are not available for them, they'll seek out teen role models" (para. 11).

A New South Wales government curriculum support document (using Andrew Fuller's work as a main reference) tells teachers that students' learning experiences "dictate" how their brains develop and what connections are pruned. Key skills for optimal learning through experience are listed as: reflect on learning; link new knowledge to existing knowledge; establish what is true and accurate; and challenge what knowledge is untrue and inaccurate (NSW Department of Education & Training, 2006, para. 19). An online document from the Career and Technical School, Capital Region Board of Cooperative Educational Services, New York State, authoritatively advises:

> Brain growth is basically a "use-it-or-lose-it" process. The brain's ability to acquire and retain new information will expand if stimulated or shrink if neglected. … According to Dr. Jay Giedd, the lead scientist who conducted the NIMH research, "Teens have the power to determine (the direction of) their own brain development. Whether they do art, music or sports, video games or books, those brain structures are adapted accordingly." And those areas that are not stimulated may be pruned away to make room for the areas that are growing. …For brains to grow they need proper stimulation. Teens who spend too much of their time overdosing on nonverbal, sedentary activities like watching television or surfing the Internet risk losing their brain's capacity to process and strengthen other more challenging and useful skills. (Capital Region BOCES, 2005, pp. 2-3)

Finally, although most information is directed to adults it is worth noting its appearance in advice to teenagers themselves; for example:

> The quality of your experiences actually develops your brain; your environment will determine your abilities. But it's not simply an expansion of capacity; information and experience you judge as not important is "strained out" and only data meaningful to you is kept. (Peterson, 2000, paras. 5-6)

> Knowing about your teen brain is important. As you head into adulthood, your daily experiences shape your brain. Brain paths for skills you don't often use are trimmed away. Pathways for skills and experiences you repeat are made stronger. This "brain

> pruning" is one reason why it is important for teens to have positive experiences. (D'Angelo, 2004, para. 7)
>
> What you choose to do or not do, whether to live constructively or destructively, be part of the world actively or watch television passively, all of this will be wired into your brain circuits and *affect the rest of your life* [italics added]. (Carlson, 2004, p. 10)

Discussion

Over many years the teacher education literature has charted debate between enthusiasts, sceptics, and those in-between regarding the usefulness of data from cognitive science and neuroscience for classroom practice. Despite the periodic emergence of (sometimes stubborn) misconceptions — such as oversimplified notions of left brain/right brain learning styles (see, e.g., Willis, 2008) — the importance of an up-to-date working knowledge of research in these fields is widely accepted. Indeed, Restak (2006) predicted brain research will soon revolutionize understandings of human behaviour so powerfully we can meaningfully speak of a *neurosociety*, while in the new journal *Mind, Brain, and Education* Howard Gardner proposes another neologism — *neuroeducator* — for "a professional who is grounded both in the theories and research of neuroscience and in the practice of education" (2008, p. 165). Teacher educator Raleigh Philp articulates the mood of resistance toward those who repeatedly advocate caution in the face of these developments:

> What John Bruer and others have failed to see is the overwhelming enthusiasm from educators for understanding how people learn. For those of us in the classroom, it's easy to support the arguments in favor of incorporating neuroscience into the field of education. (Philp, 2007, p. 6).

Material presented in this paper documents that the adolescent use-it-or-lose-it hypothesis has enjoyed widespread dissemination since its introduction in 1999, being on-sold to educational and health workers via professional literature and training, and to the general public via news reports, magazine articles and television documentaries. It has been offered as having a major role in helping teachers "take advantage of the time when their students' brains change the most" ("The adolescent brain," n.d., para. 5). But, at this point in time at least, should educators opt for enthusiasm or caution, and on what grounds?

Like the "first three years" story before it, Giedd's hypothetical proposals presented themselves as an appealing package, both logically persuasive and, subsequently, emotionally compelling. It has appeared to be quite difficult, even for those understanding caution is warranted, to completely resist the better-safe-than-sorry position that it is, on balance, wise to assume the basic premise is true. Thus, for example, the Act for Youth factsheet concluded:

> It is important to note that experts caution careful interpretation of this new information … as it is still very early in the analysis and understanding of what it all means. Yet it is also true that these findings add new dimensions to issues facing young people, as well as their parents and teachers, and they pose a challenge to policy makers. If the choices adolescents make … have long-term and irreversible consequences for the development of their brains,

> then discouraging harmful choices and encouraging healthy ones is all the more urgent. (2002, p. 3)

More recently Ramowski and Nystrom (2007), while acknowledging concerns that findings could be used "to squelch teen independence or rights", similarly went ahead to recommend that from a use-it-or-lose-it perspective "it would be most productive for caring adults to provide meaningful opportunities for adolescents to exercise brain functions that require analytical, decision-making, and valuing skills" (p. 24). But while brain scan data have confirmed the increase and subsequent loss of neurons and synaptic connections during late childhood and adolescence, the associated use-it-or-*permanently*-lose-it implications, and threats of *irreversible* harm, remain much more contentious. It is, I suggest, important to continue debating just what deliberate efforts on the part of "caring adults" are either necessary or desirable.

Referring some years earlier to recommended interventions with infants, Nelson (1999) had argued that, given human evolutionary history, many of the so-called "enriched experiences" some parents had come to believe essential would likely *not* matter later in life, as our species would not have long survived if development depended heavily on specific experiences occurring at precise points in time. Bruer had also argued the importance of differentiating "describing complexity" from "prescribing enrichment", noting the value-laden nature of the latter which tended to prioritise middle-class activities for children like piano lessons, playing chess, and organized dance and sport, and to deride the value of things like MTV, video games and playing pool. He had warned against using neuroscience to provide "biological pseudo-argument in favour of our culture and our political values and prejudices" (1998, p. 18). Yet extracts presented here show recommendations for teenagers not only providing some questionable labelling of behaviours as passive or active but also copying previous patterns of priority and derision in their designation as good or bad. (The fairly ubiquitous listing of music as a positive element raises questions perhaps, given adults' common condemnation of teenagers' listening preferences; possibly authors were not thinking of all musical genres, or had pianos and violins more in mind than drums and amplified guitars?)

Particularly in evidence is the assumption that time spent engaged with technology has, for one reason or another, deleterious effects. News reporters seem to have rarely encountered (or perhaps rarely sought out) academics with a dissenting view. In an unusually even-handed exception (Clark, 2006), educationalist Megan Boler and psychologist Kaveri Subrahmanyam are quoted as noting every new era of technology has raised similar concerns, and although "tech overload" may have some negatives the internet is less passive than the television or radio adults grew up with. Moreover, many new media deliberately promote and reinforce self-expression and bring benefits for teens finding face-to-face social interaction difficult.

A small group of researchers voice particular objection to the almost universal denigration of video/computer gaming: whatever other criticisms may be laid at the door of games, they say, studies increasingly demonstrate lack of cognitive challenge is not typically one of them. That games are a "waste of time" — when the teenage brain could be engaged in something far more demanding — they see as a rather adultist notion, which detractors might soon realize if they actually tried to play them. Recent summaries of research report experienced action video gamers showing improved hand-eye coordination, increased visual processing in the periphery, enhanced mental-rotation skills, and enhanced visuo-spatial memory (Dye, Green, & Bavelier, 2009), and that most adolescents don't see game playing as the passive and solitary pursuit most adults describe but as something almost entirely social that enables players to feel a real sense of "agency, ownership, and control" (Gee, 2007, p. 217). A professor of learning sciences,

James Gee further proposes that good video games, which stress strategic thinking and problem solving, often collaboratively, compare with the best sorts of school science instruction — even provocatively concluding that, given the current "teach and test" climate predominating in U.S. schools, the theory of learning in games often tends to fit *better* with the modern, high-tech, global world today's children and teenagers live than do theories (and practices) of learning they encounter in classrooms. He asks: "What will young people come to think if they consistently see deeper learning principles in their popular culture than they do in school?" (p. 218).

The value of enriched experience in infancy has also come under ever more extensive scrutiny, culminating in recent decisions that *Baby Einstein* products can no longer be advertised as having educational value, and that parents who bought them hoping to make their babies smarter could claim a refund (Campaign for a Commercial Free Childhood, 2006; "CCFC victory," 2009). Concerns have in fact been raised that today's children and adolescents are typically encouraged to do *too much* rather than too little, with the *over-scheduling hypothesis* proposing the developing brain does not necessarily benefit from having to balance having a social life and sufficient leisure time with homework assignments and projects and increasingly crowded schedules of sports and after-school activities (Bloom, Beal, & Kupfer, 2006). However, like other arguments under consideration here this also has its critics, who see it as a problem likely to be significantly affecting only a small minority of students (e.g., Mahoney, Harris, & Eccles, 2006).

Finally, aside from the merits or otherwise of specific activities and experiences, or the amount or regularity of time devoted to them, the discussion must be recognized as located within a bigger picture of developmental assumptions both biological and cultural. Research is likely to soon reveal secrets of brain development throughout the lifespan. Indeed writers who by the late 1990s were critical of the first three years hypothesis were typically already open to ideas that neural plasticity continued, to a considerable degree, into adulthood (Nelson & Bloom, 1999). Bruer (1998) was arguing that the notion of critical periods would continue to be concerned primarily with species-wide skills and behaviours rather than acquisition of culturally transmitted skills like reading or mathematics. So far as we know, he suggested, people can acquire and improve the latter abilities at any age, given the right opportunities. Since then, studies have shown myelination continuing well into adulthood and demonstrated the human brain can make new cells throughout life (see Faull, 2008). Campaigns around the world, like the Neurological Foundation of New Zealand's annual BrainWeek encourage people to accept that "A good *think* cultivates new brain cells, new brain connections" at any age (www.brainweek.co.nz). It would not appear too imprudent, therefore, to suggest that, as exemplifying a *critical* period, the adolescent use-it-or-lose-it hypothesis might soon be as obsolete as its pre-school predecessor.

Nevertheless, the bigger picture also highlights the undeniable timeliness of the hypothesis within a contemporary sociopolitical context that wants adults (particularly educational and health professionals and parents) to view adolescence as a time when habits of a lifetime are ingrained. Even as postmodern scholars increasingly questioned developmentalist assumptions of unalterable causal links between early experience and adult outcomes (see, e.g., Dannefer, 2003; Morss, 1996), this theoretical position was expanding its remit into the early teenage years within mainstream developmental psychology (Crockett & Crouter, 1995; Levine & McAnarney, 1988). Currently, via manifestations of the expert voice from professional seminars to reality television, adults are increasingly pressured to accept the premise that behaviour in adolescence seals an individual's fate, and they must do everything possible to save teenagers from

themselves. In terms of interventionist campaigns, this is to date being most extensively and zealously pursued around issues of establishing good eating and exercise habits. Yet there are growing concerns that mandates of this kind are far from helpful, as Jenny O'Dea (2008) has argued with regard to Australian solutions for dealing with the "obesity epidemic", through frequently being poorly conceived and/or inappropriately targeted.

Given how much remains to be known about the adult brain it would seem at least worth advising that both potential advantages and counterproductive possibilities are comprehensively assessed before implementation of campaigns/interventions to ensure teenagers are "using their brains properly". The pros and cons of teaching the use-it-or-lose-it message to adolescents and passing responsibility to them require similar examination. In an Australian interview in 2006 British neuroscientist Sarah-Jayne Blakemore considered it "a shame" that (according to her) "You don't learn about the brain anymore in schools". However, when considering whether it would really be useful for students to learn how their own brains were developing, she was uncertain: "It's an open question, and we don't know what effect that would have" ("Teenagers' brains," 2006, para. 12). Like being encouraged to worry constantly about what you eat, is concern about how you're hard-wiring your brain something students should have to deal with?

Conclusion

Evidence for a period of major synaptic growth and pruning in late childhood/early adolescence caused revision of existing arguments for the first three years as a critical period for establishing important neural networks for later learning, but has not killed debate around the importance of early intervention programmes. Increased neuroscientific understanding of the adult brain (not to mention everyday observation of old dogs learning new tricks) strongly suggests current assumptions about the teen brain will in turn require revision, but this is equally unlikely to kill debate around "brain-based" education at the middle and high school levels. Nevertheless, reflecting on the dwindling fortunes of some educational stories constructed around intellectual development in infancy, it is important to avoid similar prejudices and misplaced pedagogical enthusiasms regarding adolescence. Visions of neuroeducators operating in neurosocieties surely serve to increase rather than diminish the need to scrutinize how new knowledge is utilized by teacher educators and relates to the personal beliefs and preferences of classroom practitioners themselves (Howard-Jones, Pickering, & Diack, 2007). That said, memories can be short when there is money to be made from shifting a now-or-never discourse from the first to the second decade of life, whether this be funding for research or intervention programmes, or the marketing of educational or other advisory materials. Perhaps before too much more is done in the name of helping adolescents not to "lose it", it might be worth looking in a little more depth and with a little more respect at *their* perspectives on how they currently choose to "use it".

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