

Bioscience and the sociology of education

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Bioscience and the sociology of education: the case for biosocial education

Abstract

This paper makes a case for *biosocial education* as a field of research and as a potential framework for education practice. It engages with sociology of education's contemporary interests in embodiment and affect, the possibilities offered by concept studies, and uses of assemblage and complexity theory for thinking about educational phenomena. It also considers broader social science and political theory engagements with epigenetics and neuroscience. The paper examines the legacy of the biology/sociology split and the risks, limits and potentialities of *degrounded* collaborative trans-disciplinary biosocial research. The paper considers developments in biosciences that may have particular resonance and promise for education, in particular the epigenetics of care and stress and the metabolomics of diet. The paper argues that sociology of education should engage with bioscience to interrogate the folding together of the social, cultural, biographical, pedagogic, political, affective, neurological, and biological in the interactive production of students and learning.

Keywords: biosocial; epigenetics; omega-3; complexity; assemblage; degrounding.

Introduction

We are at an important juncture in sociology of education as a confluence of movements in policy, biological sciences, and sociology of education itself suggest the need for sociology and biology to re-engage each other. The relationship between sociology of education and the life sciences has not been a comfortable one, and scholars within the sociology of education continue to critique, resist, and/or call for caution in engagements with biological sciences (Gillborn 2016; Gilles 2008; Evans 2014). While mindful of these well-grounded and persuasive warnings, in this paper I make a case for *biosocial education* as a field of research and scholarship and as a framework for approaching the practice of education.

The biosocial approach advocated here does not jettison the deep insights that sociology of education has developed over the last 50 or more years. Rather, I suggest biosocial analysis that interrogates the folding together of the social, cultural, biographical, pedagogic, political, affective, neurological, and biological in the interactive production of students and learning. In this sense it has much in common with the 'bio-psycho-social' analyses of Celia Roberts (2015) and the 'concept studies' explored by Evans (2014). I extend the careful 'ideational border crossing' that Evans (2014: 45) advocates to also suggest substantive and procedural border crossing applied through biosocial research and, potentially, education practice. The paper proposes a move beyond the trans-disciplinary interrogation of the origins, representations, definitions and applications of concepts such as learning,

pedagogy, embodiment or inclusion (Evans 2014), to enact trans-disciplinary empirical investigation of educational phenomena.

This is a risky case to make, and one that anticipates criticism from sociology of education on a number of grounds: failing to recognise the damaging forces of science itself or science in the hands of policy makers pursuing agendas that are not compatible with social justice (Evans and Davies 2015; Gillborn 2016; Rose and Rose 2013; Wastell and White 2012); contributing to discriminatory accounts of educational failure that 'blame the victim' of racist and otherwise biased institutions (Gillborn 2009; Gillies 2008); naively imagining that researchers in the life sciences will team up with sociologists of education in higher education research contexts that are tightly demarcated, stratified, individualized, competitive and resource-tight (Sparkes 2013; Evans 2014).

Nevertheless, I advance an account of the potential for a productive interaction between sociology and biology. I consider emerging areas of human biology and set out directions for working across the social and biological – living with the degrounding and dissensus (Butler *et al* 1994 cited in Atkinson and de Palma 2009) that comes with working across distinct ways of seeing the world and the object of research, and integrating, albeit awkwardly, research traditions and methods. I suggest that such approaches pursued carefully might generate new biosocial insights that expand massively our thinking about education.

A confluence of forces

My advocacy of biosocial education research and practice is underpinned by the confluence of a series of productive forces that make biosocial approaches necessary. First, we are working in a trans-national education and early years policy context which is firmly in the mode of policy 'problem' and 'solution' (Webb 2013), committed to particular forms of quantitative 'evidence' (Sellars and Lingard 2014; Sparkes 2013), and leaning heavily towards research in the neuro- and genetic- sciences for both insight and 'solution' (Gillborn 2016; Wastell and White 2016). Second, the contracted and particularised research-funding environment (already noted) increasingly sidelines qualitative, intellectually curious and social justice orientated sociological research (Sparkes 2015). Third, there is currently an invigorated interest in embodiment in sociology of education that is drawing on and developing a range of new conceptual and research tools to move beyond enduring rationalist accounts of education and account for the body itself in education (Evans *et al* 2009; Ivinson 2012; Leahy 2009; Stolz 2015; Youdell 2011, Lindley and Youdell 2016). Fourth, and relatedly, there is growing engagement with a range of theories of complexity to understanding persistent educational phenomena (Evans 2014; Ivinson 2012; Webb 2009; Youdell 2011, Youdell and MCGimpsey 2015). Fifth, and perhaps most importantly, there is emerging evidence in epigenetics of the ongoing and persistent enfolding of the social into the biological (Meloni 2016; Moore 2015; Roberts 2015).

The biology/sociology split and the risks of the biosocial

In *Political Biology* Maurizio Meloni (2016) offers a compelling account of how sociology emerged out of, and dependent upon, the movement of biology towards a hard heredity concerned with the sealed interiority of the body. Meloni shows how this turn from the interaction of the social, environmental and the biological in the first half of the 20th Century set the conditions for sociology as a discreet field of knowledge positioned as untainted by the alignment of the science of hard heredity and right wing political agendas (Meloni 2016). In the sociology of education we inherit and are caught up in the multiple re-makings of this nature/nurture divide.

This foundational and deeply engrained split, and the good reasons for critical sociology's objections to scientism, present challenges for sociology of education imagining the border crossings needed to engage with work that is emerging in the biological sciences. One of these is the possible expropriation of biosocial research to further the agendas of divisive politics and policy. While this is a real risk and one seen played out in some of the uses of neuroimaging data (Wastell and Wise 2012), it is not peculiar to biosocial research and, while we must be alert to this, in the end it may not be within our control. Another is the need to navigate the multiple sub-fields within biological sciences (e.g. genetics, genomics, behavioural genetics, medical genetics, neuroscience, molecular psychiatry and psychology, molecular biology, epigenetics, nutrigenetics, nutrigenomics, metabolomics), which themselves work with a range of methods, at different scales and with

different orientations to the biological and the social. Becoming expert enough to engage selectively, critically and creatively with this work in order to generate new trans-disciplinary and trans-scalar thinking is demanding (Evans 2014; Frost 2014). Yet another challenge is the difficulty of defining common projects between education sociologists with clear social justice agendas and biologists who work in a paradigm that insists their ethical and/or political commitments are 'left at the lab door'.

Ultimately, these challenges suggest the need for collaborative trans-disciplinary work where researchers' orientations allow productive alignments, even when the possibility for epistemic and methodological agreement seems unclear. In this sense I suggest we try to collaborate while 'degrounded'.

Judith Butler writes:

I think we need to pursue the moments of degrounding, when we're standing in two different places at once; or we don't know exactly where we're standing; or when we've produced an aesthetic practice that shakes the ground. That's where resistance to recuperation happens. It's like a breaking through to a new set of paradigms. (Butler, Osborne, and Segal 1994, 35).

The prospect of engaging in collaborative trans-disciplinary research while not knowing exactly where we stand may be unsettling but, as Butler suggests, new paradigms may emerge from collaborations between sociologists and bioscientists who are willing to work from this (non-)place.

Valid doubts have been expressed that collaboration will be forthcoming (Evans 2014; Sparkes 2013), but there are examples emerging. For instance, the Urban Brain Lab's work on the interplay of city living, brain functioning, and wellbeing (Fitzgerald *et al* 2016); the newly established Biosocial Research Laboratory at Manchester Metropolitan University; and my own developing collaborations with the Translational Chemical Biology Research Group at Loughborough University, the Centre for Human Brain Health at the University of Birmingham, and The IPRH-Mellon Bio-humanities Research Group at University Illinois-Urbana-Champaign. Of course, such collaborations risk disintegrating back onto the safe ground of familiar disciplines, or one discipline being subsumed by another (Sparkes 2013).

A biosocial framing

In biosocial education insights from sociology of education into the production of persistent educational inequalities and exclusions remain crucial, as does the orientation towards the intolerability of these (Foucault 1988). Carried into biosocial analysis are analyses of how educational systems, curriculum, pedagogy, selection and assessment, and day to day school life all produce inequalities (Ball, Maguire, Braun 2012; Bradbury 2014; Gillborn and Youdell 2000; Whitty 2002); how these practices involve processes of recognition and identification that produce a range of subjectivities, including those of learner and of outsider (Youdell 2006, 2011); and how the psychic, affective, embodied and relational, as well as the rational, are fundamental aspects of education (Youdell 2011; Boler 1999; Bibby 2011). Biosocial analysis also

builds on existing moves in sociology of education to better account for the role of the body in pedagogy, learning and educational inclusion and exclusion. For instance, much has been written drawing on Bourdieu's notions of habitus, the disposition of a bodily hexis, and how this connects to feeling (Lingard 2014, Reay 2015) and how it functions as a performative (Butler 1997, Youdell 2006). 'Embodied learning' has built on Bernstein to suggest the 'corporeal device' for understanding the body in pedagogic practice and student's learning (Evans *et al* 2008, 2009; Ivinson 2012). Sociologists of education have used Deleuze and Guattari's work on affectivities to incorporate the flows of corporeal feeling in pedagogic encounters (Hickey-Moody 2013, Leahy 2009, Youdell 2011). And Stolz (2013) has sought to incorporate emotion, practice, and the aesthetic through embodied pedagogy. Yet across these engagements with the fundamentally embodied nature of learning and the place of the body in learning as 'a material relay of and for itself' (Evans *et al* 2010 p179 cited in Ivinson 2012), our encounter with the body remains interpretive, and the interior of the body – from beating hearts to processes within cells and movements across membranes – remain out of reach.

The biosocial move I suggest aims to analyse together a whole range of factors that span multiple orders and scales, and which might ordinarily be thought of as belonging to different fields or domains. It owes much to Deleuze and Guattari's (2008) notion of the assemblage in which components come together in mobile productive relations. And it builds on Samatha Frost's (2016) account of the human as biocultural creature, traversing scales from

the molecular to the cultural. This turn to biosocial thinking also resonates with currents in 'new materialism' (see for example Coole and Frost 2010) which foreground the material in a framing that refuses a special status for the human and insists on the capacity of the non-human to make things happen (Bennett 2010), including Karan Barad's (2007) work between quantum physics and feminist theory which establishes the notions of the productive intra-actions of actants in phenomena. While I have found the assemblage particularly generative, others in education have engaged further instantiations of complexity theory to think about dynamic, interactional, complex causality (Ivinson 2012), and the consideration of concept studies has extended this (Evans 2014 citing Davis and Sumara 2010).

The biosocial education that I am suggesting, then, builds on this substantive, conceptual and methodological work to extend a concern with institutional and classroom practices, pedagogies and subjectivation to incorporate a wider set of forces including the workings of the molecular body and its intra-action with environment. As such biosocial education might be said to take 'education', 'pedagogy', the 'teacher' and the 'learner' as phenomena produced through the intra-action of a diverse field of forces that includes the mechanisms and functions of the molecular body.

A biosocial age?

Nikolas Rose has suggested that genetics and neuroscience, and their policy and popular take up, have inaugurated a 'biological age' (Rose 2013). Indeed, these new biosciences have been put to substantial work in expert discourse

and policy relating to the early years and education (Gulson and Webb 2016), uses that have been critiqued as over-claiming and even misleading (Wastell and White 2012; Edwards *et al* 2015; Gillies 2008). Likewise, claims to genetic intelligence continue to have significant influence in education policy. Policy in the UK has been particularly sympathetic to the work of Robert Plomin's laboratory which offers the notion of 'g'; generalized genetic intelligence (Ashbury and Plomin 2014). Much of this work has been based on twin studies, but as genetic science and the technologies to study the genome have moved, this work has expanded into 'evolutionary genetics' drawing on genome-wide association studies (GWAS) or gene-wide complex trait analysis (GCTA). Twin studies asserted that around half of variance in intelligence is hereditary (Plomin 2014), a claim that has been dismantled in critical sociological work (Gillborn 2010, 2016). Initial gene-wide association studies show a much smaller degree of hereditary variance (just 2 per cent), but this is suggested to be an artefact of the data not an undermining of twin study findings (2014; Plomin and Deary 2015) and the most recent analysis is returning a higher proportion (6-15 per cent) of variance as hereditary (Selzam *et al* 2016).

In education research there has also been some engagement with genetics in relation to learning difficulties and 'disorders'. Autism, ADHD (attention deficit hyperactivity disorder), and reading and language learning difficulties have all been bound up in the hunt for genetic causes, in particular the search for 'candidate genes'. Figure 1, for instance, offers a schematic of a genetic variation suspected to be involved in reading and language learning difficulty:

<insert Figure 1. the candidate gene image>

Work of this sort raises objections from sociology of education as it takes as given the very diagnoses that disability studies and inclusive education research demonstrate to be both constitutive and damaging. And it pays no attention to the nuances of biography, social context, and the everyday of school and classroom life – all of which have been shown to have major influence on the presence and effects of these sorts of diagnosis (Allan 2010; Graham 2007; Harwood 2006; Youdell 2011). These criticisms do not necessarily refute the possibility of genetic influence, but they do question the effects (political, pedagogic, personal) of elevating ‘candidate genes’ to primary cause. While sociology has tended towards critique, all genetic and neuroscience research is not the same, and policy makers’ and media uses and abuses of work in these fields is not the same as the work itself. For instance, there is a growing body of neuroscience research in education into the relationship between variability in brain function and reading, including reading difficulties, that is also demonstrating significant results for children from neuroscience-informed pedagogic interventions (Goswami 2006, 2015).

More fundamentally, developments in the new biological sciences are moving away from hard heredity, candidate genes, and GWAS towards *epigenetics* – a broad set of sub-fields of bioscience that engage the interface of the biological and the social and so have particular potential to be articulated with social sciences. In the rest of this paper I will offer an account of epigenetics

and detail two strands of epigenetic research: the effects of care and stress in rats and the effects of Omega-3 in our diets.

Epigenetics

Epigenetics is concerned with the interplay between the events and experiences of a life and the way the body's genetic code is put to work (Moore 2015). These effects occur inside the lifetime of the creature and may have enduring intra-generational effects but do not change the genetic code (genome) of a body. Rather, epigenetic changes regulate genes through a series of mechanism, primary of which are: 'methylation' (the adding of methyl molecules) of genes, of the chromatin in which genes are located, or of the histones on which chromosomes are stored, and 'acetylation' (the adding of acetyl molecules) of histones. These regulatory changes effect how genes are expressed and so what genes make a body do – they 'exponentially extend the computational power of the genome' (Molfese 2011: 2). These relationships and processes are helpfully illustrated in Figure 2.

<insert Figure 2. Molfese histone diagram here>

The genome itself, then, does not determine how a creature will be and behave – the genome provides a resource that, in interaction with other influences, is embroiled in the action of molecules, cells, and the creatures these make up. The potentialities of a body are vastly greater than the genome.

Some accounts of epigenetic effects make reference to 'gene silencing' or turning genes 'off' and 'on', but growing research evidence suggests a subtler array of effects, and the persistence and potential for reversal of methylation is an open research question, with some suggestion that methylation can be transient and variable in response to environment. Research in rats has shown varying methylation over the hours and days post-fear exposure (Molfese 2011) and DNA methylation in specific genes in monozygotic (single egg) twins at age 5 and age 10 has been shown to vary across twins at age 5 and to be unstable within individuals between the ages of 5 and 10 (van Ijzendoorn *et al* 2011). It is important to keep in mind that epigenetic regulation of gene expression is not inherently good or bad – 'it is an environmentally primed adaptation that may or may not be adaptive to future environments (van Ijzendoorn *et al* 2011: 307).

Under the wider umbrella of epigenetics, are the emerging fields of nutrigenomics and metabolomics. This work is concerned with the within-generation interaction between diet and the body's genetic code (nutrigenomics), and the intermediate chemical processes involved in metabolism through which nutrition and physical activity influence the body at a molecular level (metabolomics) (Mickelborough and Lindley 2013).

Neuroscience might also be engaged alongside epigenetics. Despite the 'hard wired' brains and genetic intelligence of popular and policy discourse, as well as some ongoing research, neuroscience tends towards the 'plasticity' of the brain (Rose and Abi-Rached 2013). The brain undergoes changes to its structures, networks within and across regions, and inside individual neuronal

and glial cells over the life course, and many of these changes occur in interaction with environmental factors. The extent, particularity and effects of brain plasticity continue to be explored within the field, but the fact of plasticity is well established and opens up a broad field of potential interface between the brain and the social world.

Environment and the social world

While the environment is recognised as highly important in epigenetic research, particular accounts of environment are common: maternal antenatal nutrition, stress, and experience of being parented; infant/child experience of being parented; parent-infant/child attachment; nutrition; stress; fear; and environmental toxins. Meloni (2016) highlights the preponderance of the traumatic and pathological in epigenetics research noting that ‘the prevailing research design looks at the link between social deprivation and abnormal or hypomethylation; epigenetics therefore becomes the signature of poverty.’ (Meloni, 2016: 219).

As Meloni underscores, this approach to environment suggests certain sorts of research hypotheses and sets up certain sorts of answers. Yet this does not need to be the case – social science could extend these environmental factors (Chung *et al* 2016) to include the processes and practices of the social world. That is, nuanced sociological understandings of relationships; interactions; feelings; subjectivities; social, institutional, and pedagogic practices; politics; inequalities; ideas; discourses; and objects could be brought to epigenetic analyses. Some scientists are aware of the limited way

that environment has been operationalised in bioscience: ‘many correlational G X E [gene x environment] studies assess genes in a very precise way but fail to measure the environmental component in an equally precise manner.’ (Belsky & van Ijzendoorn 2015: 3). There is then, at least some openness to an extended and more nuanced understanding of environment and, as I have already noted, distinct conceptual framing and methods do not preclude a biosocial approach.

Animal models and other strange practices

As I move on to detail research on care and stress in rats and the effects of Omega-3 in our diets we encounter another key tension to be navigated in biosocial work: methods. Epigenetic research requires biological samples in which potentially tissue-specific epigenetic changes can be measured – sometimes blood, saliva or cheek cells are adequate but sometimes specific tissues, e.g. muscle or brain, are required demanding biopsies or post-mortem samples. Some epigenetic research uses model animals – rats, mice, flies, fish and primates, from controlled breeding lines, kept in often purposefully unpleasant environments, and ultimately killed for tissue examination – from which approximations to humans are drawn. And neuroscience research draws heavily on putting subjects in fMRI (functional magnetic resonance imaging) brain scanning machines or wearing EEG (electroencephalography) or MEG (magnetoencephalography) caps covered in pick-ups while carrying out experimental tasks in the lab. These methods are a long way from collaborative or ethnographic research generating rich accounts of everyday lives, and may well clash with ethical concerns over

how animals and humans should be used in research. Again, as sociologists of education we may find ourselves degrounded when engaging, as I do below, with research findings generated in these ways.

Care and stress – epigenetics of rat lick and groom

<insert figure 3. Image of rat lick groom>

The image in Figure 3. asserts the epigenetic effects in rats of maternal care. This field of research takes the variability in rat mothers' (dams) licking and grooming of offspring (and less centrally arch-back i.e. protective nursing) and examines the impact these practices have on the brain and so behavior of offspring, including on the offsprings' subsequent rearing of their own young. In these studies maternal rat behavior is classified as Low, Medium and High lick groom (Low-LG, Medium-LG, High-LG) and comparisons are made across the offspring of these.

One key effect on offspring of Low-LG is on what is known as the 'HPA axis', or 'stress axis'. This axis refers to the confluence of hypothalamic, pituitary, and adrenal activity, hence HPA. Rat offspring are subjected to restraint tests intended to provoke stress and so allow controlled analysis of reactions in the HPA, as measured by blood or brain tissue analysis. Rats reared by Low-LG dams are found to have higher and longer lasting levels of adrenocorticotropin (ACTH) (a pituitary hormone acting on the adrenal cortex) and corticosterone (an adrenal steroid hormone provoked by ACTH) than offspring of other rats.

The suggestion here is that Low-LG leads to changes in the functioning of the HPA axis which mean Low-LG offspring having elevated ACTH and CRH because they are less able to 'down-regulate' their release (Champagne 2009). Down-regulation, in this instance, means there are fewer receptors for the molecule so it has less effect (up-regulation here would mean there are more receptors for the molecule so it has greater effect). Licking and grooming behaviour is also shown to have an effect on particular mRNA, which is crucial to the functioning of cells. In order for DNA to have effects, it has to undergo 'transcription'. Transcription is the process of taking the information from a gene – an enzyme RNA polymerase does this – and making a copy of it in the form of messenger RNA, or mRNA, so that it can go elsewhere in the cell to produce protein. Low-LG offspring have lower hippocampal glucocorticoid receptor (GR) mRNA levels (glucocorticoids are a class of steroid hormones involved in metabolism of carbohydrates, fat, and protein) so lower levels of receptors means these are less well down-regulated. Low LG offspring also have higher levels of mRNA for hypothalamic corticotrophin releasing hormone (CRH) (which is a neurotransmitter involved in stress response), which means there will be more of this hormone. So, because there is less GR (glucocorticoid receptors) mRNA in the hippocampus, and more corticosterone, once the stressful event is over it is harder to down-regulate the corticosterone that has been released with HPA activation (Champagne 2009; van Ijzendoorn *et al* 2011).

Recent work by Beery *et al* (2016) notes the effect of LG on social behaviours, with High-LG offspring identified as more social. This is

associated with variability in oxytocin receptor levels and distribution across areas of the brain's limbic system ('social behaviour network' Beery *et al* 2016: 43). They note that oxytocin receptor gene (OXTr) methylation associated with Low-LG in rats has been associated with anxiety and depression in humans, however, OXTr methylation is variable over time and over tissue, and they highlight that human studies rely on blood tissue which may or may not reflect brain tissue.

Care, stress and schooling – from rats to humans?

Critical sociologists may find somewhat discomfoting (even preposterous) the idea that rat dam behaviour and its effects in rat offspring might have some relevance for the education of human children. Yet researchers in the field suggest that the relational and environmental stressors that are introduced to rats under controlled laboratory conditions are indeed reflective of the sort of amalgam of factors that coalesce to create conditions of profound disadvantage for children: '[f]or humans, conditions of chronic poverty may, in fact, be a close approximation of the constant manipulation of the environment used in research with rats or rhesus monkeys' (Ijzendoorn *et al* 2011: 308).

Of great importance in thinking about the implications or practical relevance of this research to humans, is the fact that these epigenetic changes in the brain are not fixed. Tognini *et al* (2015) emphasize the significance of the scope of plasticity in the human brain:

The brain has an exceptional and unique epigenetic feature with respect to all other tissues in our body, both referring to the abundance of epigenetic marks [...] and to extremely plastic epigenetic landscape due to the continuous stimulation from the environment.' (Tognini *et al* 2015).

In rat studies this is borne out by the effects of positive intervention – where infant and adolescent offspring of Low-LG dams are fostered to High-LG dams, the HPA-axis effects are reversed (Champagne 2009).

As noted, sociology has approached policy predicated on the claim to the effects of mothering on children with extreme caution, rightly noting the tendency for such policy and its enactments to dislocate families from the structural and material conditions that pattern their lives and so make mothers singly responsible for their child's poor relative outcomes (Gillies 2008). But this policy inflection does not follow necessarily from the epigenetic research I have explored here.

In thinking about humans, relatively straightforward lick groom behaviour must be translated. An obvious comparison, and one made in the literature (e.g in van Ijzendoorn *et al* 2011), is with attachment theory and the sensitive-responsive mothering that is popular in the early intervention literature. Yet the plasticity that is demonstrated across infancy and adolescence suggests a concern with a whole range of modes of relationality and relationships spanning childhood into adulthood. This suggests biosocial research look

outside the mother-child dyad and the family to include relationships in classrooms with teachers and other adults as well as with peers. This plasticity and the variability of the HPA axis should guard against these research findings being taken-up as evidence of organic, albeit epigenetic, causes for diagnosed disorders. Changes to the HPA axis prove to be adaptive for some (Ijzendoorn *et al* 2011, Beery *et al* 2016). Furthermore, such epigenetic adaptations may well be susceptible to the everyday processes, practices and feelings of the classroom and school, just as they are to early experiences of nurture. This highlights the potential significance of this research for understanding and facilitating learning. There is longstanding psychoanalytic work in education that emphasizes psychic processes in the classroom and the profound importance of the teacher's relational capacities – to love, after Bion, and to hold the child in mind, after Winnicott (Bibby 2012; Britzman 2006; Teague 2015). Developing biosocial research into relationality and learning, then, has the perhaps counter intuitive potential to move difficulties in the classroom *out* of the child, pursuing instead an array of interacting influences in the environment, including the classroom, and the ways in which these become embodied.

Food – metabolomics and polyunsaturated fatty acids

What we eat is another environmental factor that is investigated for epigenetic or metabolomic effects. Polyunsaturated fatty acids (PUFAs) and specifically Omega-3 fish oil have been a key focus of research. Omega-3 metabolites docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) are found in cell membranes throughout the body, in various types of tissue (including

neurons and muscle tissue), and in blood and contribute to complex processes that change cells at the molecular level, including anti-inflammatory and respiratory functions (Groeger 2010; Mickleborough and Lindley 2014, Shei *et al* 2014). DHA is a major component of neurons and speeds up neuronal membrane fluidity and EPA is involved in neural connectivity and reduced stress reactions (Kirby 2010a; Tammam 2015).

Omega-3 has become a research focus because EPA and DHA have important cellular functions and Omega-3 appears to be in short supply in cells fed on contemporary developed world diets in which Omega-3 competes for cellular uptake with overly abundant Omega-6. To give a sense of the extent of the contest for uptake between Omega-6 and Omega-3, it is estimated that the ratio of Omega-6 to Omega-3 in the cells of bodies fed on contemporary Western diets has risen from a ratio of between 1 and 2:1 in the pre-industrial period, to between 15 and 25:1 today (Kirby *et al* 2010a, 2010b; Mickleborough & Lindley 2013). Like the epigenetic neuronal effects of nurture, the neuronal effects of Omega-3 deficiency are examined in animals. The contrasting neuronal activity of tadpoles with expected and deficient Omega-3 (Figure 4.) suggests strongly the role of EPA and DHA in neuronal activity (Kirby 2010b, Tammam 2015) and highlights why researchers concerned with brain function in humans look to the effects of Omega-3.

<Insert figure 4. Tadpole Neurons>

Food and schooling – what can fish oil do here?

The potential effects of Omega-3 on education has undergone some investigation, in particular in relation to general cognitive performance, reading and language learning difficulties, Autism and ADHD. In the main, this research involves randomised control trials in which children are supplemented with Omega-3 and pre- and post- supplementation tests, observations and questionnaires measure associated effects. In some studies baseline ratios of Omega-6 to Omega-3 are measured, and cheek-cell samples are used to measure uptake of Omega-3 during supplementation.

In relation to general cognitive performance, the research to date is equivocal. A high ratio of Omega-6 to Omega-3 in the central nervous system has been shown to have negative effect on neurotransmission (Tammam 2015).

Omega-3 supplementation appears to have a beneficial effect, but this does not show association with cognitive performance when Omega-3 levels are measured in both red blood cells and plasma (Kirby 2010a, 2010b). Clearer results have been offered in relation to reading and language difficulties, where an association has been shown with deficiency of Omega-3 and with phospholipid metabolism disorder (which inhibits uptake/synthesis of Omega-3) (Kirby 2010a). Higher levels of Omega-3 have also been associated with higher literacy performance (Kirby 2009). Similarly, diagnoses of ADHD have been associated with deficiency in Omega-3, as measured through blood plasma (Kirby 2010b), and supplementation resulting in higher Omega-3 levels, as measured through red blood and plasma cells, are associated with improved parent and teacher scores for attention, hyperactivity, and anti-social behavior (Kirby 2010b). Omega-3 supplementation has been

associated with reduced 'behavioural transgression' across student groups (Tamman 2015). Supplementation has not been shown to be beneficial for students with Autism diagnoses (Mankad 2015).

The Omega-3 research in education to date has been conducted within a scientific paradigm in which RCTs and quantifiable outcomes are foregrounded and has suggested associations, not molecular mechanisms or pathways. It has also proceeded from an acceptance of underpinning concepts such as cognitive ability and diagnosed learning and other disorders. A whole range of forces making up the flows of everyday life and of central interest to sociologists remain to be integrated with research into the effects of Omega-6:Omega-3 ratios and their involvement in learning. While education has long been intervening into the bodies of children through diet (school meals, school milk), at present only children whose families are in the know and can afford the cost are receiving Omega-3 supplements. This suggests that not attending to Omega-6 intakes and offering Omega-3 to all children may have real social justice implications.

Biosocial Education

Social science needs to engage with bioscience – new biosciences have significant reach and influence; environment is now understood to play an important part in the regulation and expression of genes and on metabolic mechanisms; and there is scope to greatly extend the way that environment is understood. This engagement should be more than critique – we should engage with the possibility that biological sciences, like social science, has something important to say, and that we have something important to say to

each other. In order to allow this to happen, we should develop new ways of working across the social and biological.

I am not suggesting that we try to become bioscientists, or that we simply lend our expertise to bioscience. Certainly, our accounts of the social, cultural, institutional, discursive, pedagogic, political, relational, affective and subjective have the potential to augment richly the life sciences' tightly delineated accounts of environment, e.g. parent-child attachment, the uterus. But I suggest we do more than this. Our conceptual tools and research accounts have the potential to transform life science's understanding of environment and its potential influences and, therefore, the questions it asks or the hypotheses it moves from. And life sciences' emerging knowledges and research techniques have the potential to shift radically sociological accounts of embodiment and the relationship between the body and the social. Indeed,.

I suggest degrounded collaborative trans-disciplinary working across social and biological sciences to interrogate conceptual underpinnings ('environment' might prove is a good starting point for trans-disciplinary concept studies); develop hybrid conceptual frames; pose new types of questions and develop new forms of hypotheses; and envisage research methodologies and methods in new ways. Biosocial education research in this vein would take epigenetics and metabolomics out of the laboratory and into schools, adapting its methods to capture bodies' molecular activities in real time and as they are enfolded in the nuances of everyday life in school, and as this is captured in its fine grain by sociological methods of ethnography and

in-depth case study. It would fold these analyses of the molecular and metabolic together with analyses of everyday life in school as this is manifest and produced through curriculum, institutional and pedagogic practices, relationality, affectivity, identification and recognition. As a result it would offer biosocial analyses of the ways that these factors are folded together in the making of learners, and it would offer unique insights into how we might change schooling to accommodate and respond to both the biological and social mechanisms and functions of children's bodies.

Sociology of education may remain nervous about the uses of epigenetics and skeptical about the potential of biosocial education research. In particular, it may be concerned that nuanced biosocial research might be translated into easy-fixes and/or more determinism in both policy and over-stretched classrooms dominated by the demands of high stakes tests. It is important that biosocial education research is mindful of these possibilities. But, if gene regulation and expression is subject to ongoing environmental influence then there is a continuing possibility of change. While how we might intervene in these biosocial processes is only now beginning to be imagined e.g through foregrounding relationality in the classroom or providing key dietary supplements to all children, it is important that we begin to consider how best we might intervene in policy, biosocial research domains, and schools in ways that are socially beneficial and fair (or even equalising). Gabrielle Ivinson has suggested in relation to the body and pedagogy that:

[a] greater awareness of somatic regulation within official pedagogic

practice might help to illuminate how and why some young people are excluded from academic learning even before lessons properly begin because they cannot conform to the degree of docile posturing required'. (Ivinson 2012 p492).

The intra-action of the social and biological in the production of emergent phenomena such as learning means that our nuanced understandings of institutional, social, pedagogic, psychic and affective processes should be integrated with biosciences to generating important new biosocial understandings for education. As noted by van Ijzendoorn, '[f]rom an epigenetic perspective, divisions between genes, brain, and behavior are artificial, as the environment becomes embodied in the epigenome.' (Ijzendoorn 2011: 309). We need to engage biosocial education because we are biosocial.

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