

Natural Justice

Submission to Rethinking Crime and Punishment

Inquiry into Alternatives to Prisons chaired by Lord Coolsfield

This submission is made on behalf of Natural Justice a research charity based at the University of Oxford. Our primary activity is the multidisciplinary investigation of the causes of antisocial and criminal behaviour with a view to seeking more humane and effective interventions. We argue that any rethink of Crime and Punishment has to address the paucity of evidence that underpins assumption about what ‘causes’ people to offend. That a stratum of evidence about the causes of crime or antisocial behaviour needs to be in place before we can talk about ‘prevention’ or ‘risk factors’ in any meaningful sense. In addition, findings from studies with appropriate methodology to examine possible causal factors in antisocial behaviour give good reasons to question assumptions about culpability by highlighting factors that affect behaviour without our knowledge. Rethinking crime and punishment is therefore both timely and important but may need to start at a much more fundamental level to create the proposed basis for ‘evidence based policy-making.’

Natural Justice is investigating the possibility that antisocial behaviour may be influenced by physiological factors that are not addressed in the criminal justice system. Our research into nutrition as a modifiable causal factor in antisocial behaviour was presented at a Reception the House of Lords co-hosted by the Rt. Hon. Lord Waddington and the Rt. Hon. Paul Boateng at in 2000 to explain the relevance to the Government’s determination to address the causes of crime. Following the publication of positive findings in the British Journal of Psychiatry¹, we established collaborations with the Medical Research Council-Human Nutrition Research and the Institute of Psychiatry and internationally with the US National Institute for Health and the Dutch Ministry of Justice among others.

Rethinking ‘Cause’

Determining what are causal factors that lead to criminal or antisocial behaviour raises many complex issues: What is crime, theories to explain such behaviour, the causal pathways to crime, how much crime there is and finally how do we best respond to it? It also raises methodological issues because in science causation must be demonstrated through rigorous experimental designs, and it is noteworthy that such precise methodology is rarely seen in criminal justice. Thus, there is a need to start by questioning what is understood by “causes of crime” and consider the possibility that a complete tier of research is missing to underpin our approaches to criminal justice.

The Governments strategy is to be “tough on crime, tough on the causes of crime.” It is an excellent strategy but a possible weakness lies in the lack of evidence about what these “causes” are. One has to ask when any of the factors commonly referred to as a cause of crime or antisocial behaviour have ever been demonstrated experimentally as science requires? Frequently the term cause is used incorrectly because what is referred to is actually a correlation. A correlation simply means that A is related to B, it tells us nothing about the nature of that relationship. Such correlations are also frequently presented as “risk factors” suggesting we can predict who will offend and thus involve them in preventative

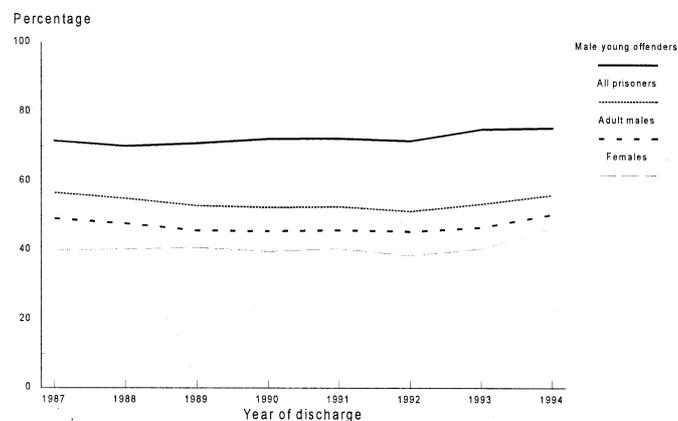
interventions but what exactly can a correlation predict when it tells us nothing about the nature of a relationship between a given factor and offending? Thus, interventions based on such correlations can at best be described as amelioration and concerns that such preventative interventions are labelling are fully justified. In a nutshell, how can we prevent offending if we do not understand what causes it? Yet such propositions are commonplace in criminal justice and underpin many forms of intervention.

Rethinking Efficacy

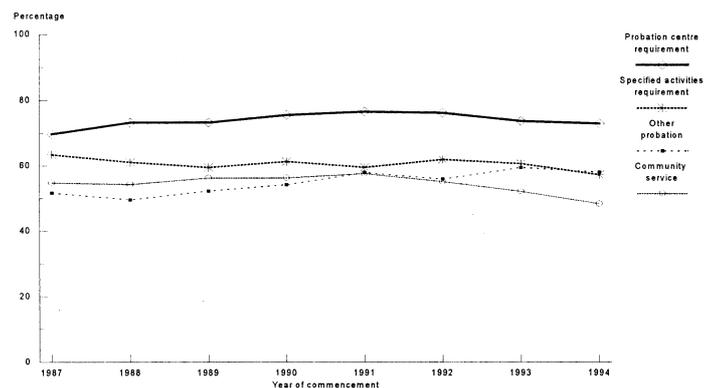
There is an urgent need for evidence based policy but policy has to be based on something better than correlations. There are two additional proofs to establish a cause. Namely that A precedes B and that the relationship of A and B is not due to C. To achieve these two additional controls you need to use rigorous experimental designs. We may hope that an intervention has helped reduce offending but without adequate controls to test the approach, scientific rigour dictates that remains a hope. It is not just semantics. According to a Former Director of the US National Institute for Mental Health on offender treatment programmes ² “It’s easy to fool yourselves about efficacy if you haven’t done a proper clinical trial.” An intervention programme for offenders might appear to be effective but if you do not control for other explanations when developing an intervention how do you know that any changes you attribute to your intervention are not actually due to something else? Simply put, you don’t! Information is after all only as good as the means used to obtain it. The purpose of this is not to disparage existing approaches or question the sincerity of intentions but to highlight the need to raise the bar when it comes to research intended to inform criminal justice policy.

This leads one to question how safe are the assumptions that underpin the efficacy of current practice in criminal justice?

Re-offending two years after a custodial sentence



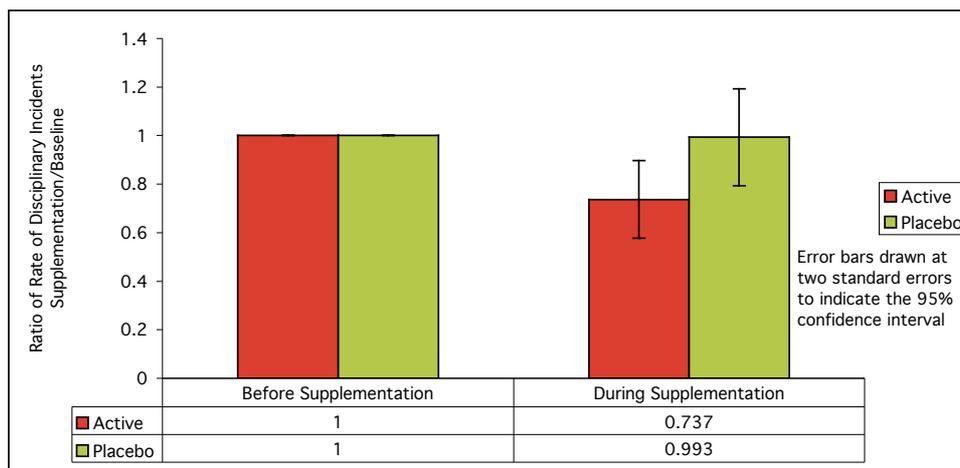
Re-offending two years after a community sentence



For instance, Home Office Stats Bulletin 5/99 1999 reported to take into account “all possible relevant factors” that might influence the comparison of custodial or community sentences. It reported that the average reconviction rates two years after sentence was 56% for custodial sentences and 54% for community sentences. Thus, the Home Office report concluded “there is no discernable difference between reconviction rates of community penalties and custody.” A surprising conclusion if crime is entirely socially mediated. More recent independent estimates reported that difference as 8% but the remarkable aspect of this is that the difference is so small, given that custody removes the offender from the social context of their offending. Such small effects need to be treated with caution, as typically standard error is not reported so we cannot compare the reported effect size of an intervention with error. We understand from discussions with the Home Office that it is common for efficacy of an intervention to be smaller than standard error, which strictly is not evidence of any effect. The Inquiry may wish to note that if the effect of a treatment is greater than two standard errors it does indicate real (statistically significant) change but all too frequently standard error is not reported. Crucially, when experimental designs have been used to test factors that may cause antisocial behaviour we get results that are rather surprising and question existing approaches.

Below are the findings of placebo controlled double blind stratified experimental trial of the type that is required to attribute causation. In this case what is being tested is the effect of nutrition on offending within a prison establishment.¹

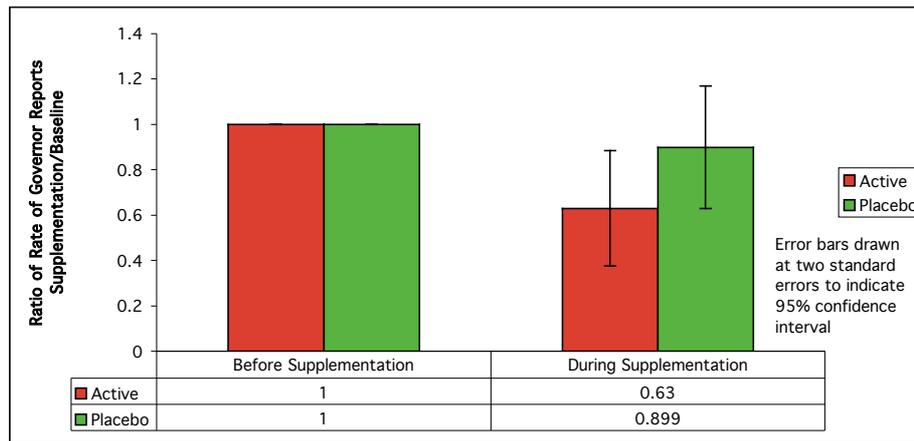
Efficacy: Rate of all Disciplinary Incidents. Intent to treat 1133 offences



Difference between Active and Placebo Groups -26.3 (± 18%, 95% CI) p < 0.027, two tailed

The charity Natural Justice obtained the co-operation of the Home Office to conduct an empirical study to test if poor nutrition is a cause of antisocial behaviour. This required a rigorous experimental design and was undertaken in a maximum-security establishment. On a random basis, where neither the volunteers, prison staff or researchers in the prison knew who was getting which type, 231 volunteers were given either placebo or real capsules containing broadly our daily requirements of vitamins, minerals and essential fatty acids. The number of proven offences committed by each participant was monitored and the result was that for those who received the extra nutrients they committed an average of 26.3 % fewer offences compared to placebos, which was statistically significant. For those consuming real supplements for a minimum of two weeks, they committed 37% fewer (statistically significant) of the most serious offences, such as violence, whereas those taking placebos remained within standard error and hence showed no real evidence of change in their propensity to offend. The statistical power for the study was 92%, which broadly means the chances of drawing a correct conclusion.

Rate of Governor Reports: Based on 338 offences



Placebo -10.1%. $p > 0.1$, two tailed (95% CI $\pm 35\%$). Active -37.0%. $p < 0.005$, two tailed (95% CI $\pm 25.4\%$)

The difference in the rate of offending between the active and placebo groups was remarkable and comfortably outside two standard errors, yet could not be explained by ethnic or social factors, or variations in the administration of Governor reports etc, as they were controlled for by the randomised design: Since no one in the prison knew who was getting real or placebo capsules, it had to be the nutrients in the capsules that *caused* the change in behaviour. The importance of establishing efficacy with rigour becomes clear as the Institution had a high staffing level and the latest “incentives” strategy but the placebo group did not alter their propensity to offend over time. Yet at the first attempt, something that is not even addressed in criminal justice yielded a significant effect. If these findings are replicated we may have finally demonstrated a causal factor in antisocial behaviour. These findings should also have relevance to crime in the community, as essential nutrients are essential irrespective of where you live. We have already conducted a pilot of this approach as an alternative to custody.³ Subject to funding we hope to repeat these double blind studies in the community to test the relationship between nutrition and crime directly.

Culpability

Central to any form of criminal justice is the notion that culpability can be attributed. Culpability is distinct from simply establishing guilt as the degree of individual liability is judged in relation to an action. The classical form of justice assumes that man is an agent of free will, can choose to commit an offence; hence culpability can be fully attributed. Crime is judged in relation to a body of criminal law, which sets out offences, namely acts for which a legal penalty will apply. Straightforwardly, a crime is deemed to have been committed when one of these laws is judged to have been broken. Given the diversity of social behaviour, it is immediately evident that complexity of these laws and the scope of consequent legal sanctions will themselves be complex. The nature of the contingency between a law and an act so specified has been long debated in law and can be set out as broadly those that are based *in mala se* on moral wrongs and those that are based on *mala prohibita* i.e. *you shall or shall not do the following*, to ensure consistent or perhaps normative social boundaries. Thus, these laws are principally concerned to balance actions against consequences and are designed to encourage compliance with community norms of behaviour. They assume that offending is a matter of free will. But what happens if there are factors that affect behaviour without even the offender’s knowledge?

Rethinking Culpability

Evidence from the Aylesbury study above showed exactly that because the participants did not guess accurately what sort of capsules they had been given: here we have a potent effect on behaviour that (unlike alcohol) *acts without our knowledge*. Therefore, if an individual is

unwittingly undermined by poor nutrition, those around them are unlikely to know about it either and would tend to attribute any inappropriate behaviour to deficits in the person's personality etc. This lays the foundation for a real rethink about the nature of volition and culpability. One has to ask what would the future have held for these 231 young men if they had grown up with better nourishment? Sadly, we don't know but it bears thinking about. Indeed, evidence from a Mauritian longitudinal study provides an indication where eighty-three children given an enriched nutritional and social environment at age 3 to 5 years were significantly less likely to be involved in antisocial behaviour at age 17 years or criminal behaviour at age 23 years compared with 355 matched controls.⁴ The beneficial effects of the intervention were greatest for children who showed signs of malnutrition at age 3 years. Add to this evidence linking poor nutrition to many areas of mental illness such as schizophrenia, depression self-harm, suicides, drug use, dyslexia; all of which are considered to be over represented in custody.

Rethinking Crime

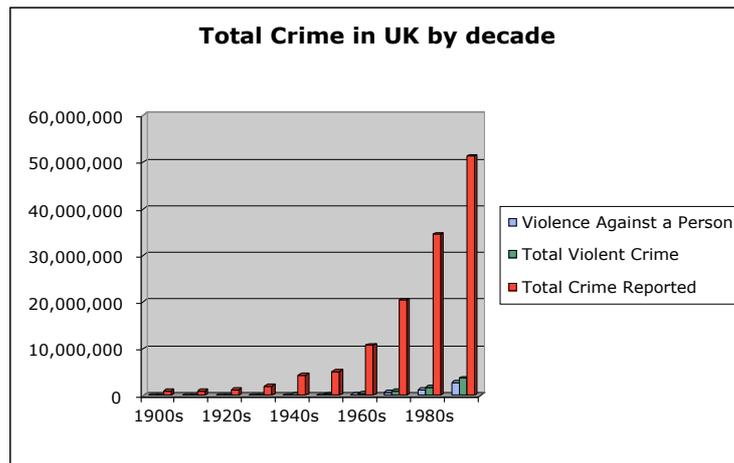
The findings have potentially far reaching consequences as vitamins, minerals and fatty acids are essential irrespective of location, so you would expect to see this effect in the community where poor diets are consumed: Hence it is not where you eat that is important but what you eat. One of the most scientifically intriguing aspects of this study is that the prisoners received three meals a day and despite making poor food choices, their diets were possibly better than those consumed by many young men of the same age in the community, yet the improvement in behaviour from boosting prisoners diets was huge. We have limited knowledge of what the optimum ranges of nutrients are from a behavioural perspective but an implication is that a great number of young people could be undermined by what they eat. Couple this with the estimate that we may have 2 million children living in food poverty in the UK and dietary standards that currently do not take behaviour into account and a potential social time-bomb is apparent. Because nutrition is fundamental for life, its effects are pervasive and in this context behavioural problems we think are due to social influences such as parenting style may partly be down to what we eat.

It is apparent that on a societal scale, these problems are liable to be greatly amplified as greater numbers of social interactions are subject to these hitherto unnoticed influences on our behaviour, that may even shift the socially acceptable norms of behaviour without our knowledge. It may sound farfetched but few would have predicted the potency of effect shown in the prison study and more evidence is emerging. Nutrition will also interact with important social factors such as poverty, stress, the fragmentation of family but we will interpret these events entirely in terms of what we can see. Such physiological factors may turn out be important in understanding tragic and irrational acts which defy a rational explanation. It is not suggested that nutrition is the only explanation of antisocial behaviour only that it might form a significant part. Awareness offers hope because if this scenario is correct, this process can be reversed if we choose to nourish our children rather than sentencing them for influences on their behaviour that we have not taken into account.

Rethinking Crime Trends

Human beings are part of the food chain, not independent from it. Thus, we eat what we are and if we can finally accept that mind and body are not separate, a simple explanation why food may affect behaviour is found in the existence of the human brain, which like any other part of the body requires nourishment to function normally. The brain is a metabolic powerhouse, which despite being only 2% of our body mass consumes around 20% of available energy and to metabolise this energy requires a range of nutrients, vitamins, minerals and essential fatty acids. These nutrients are classed as *essential* for the normal functioning of the brain, which means there may be consequences if we do not obtain sufficient nutrients from our diet. Nutrition is a meeting point of the physical and social

worlds: the hardware and software of life so to speak, where both are required for social behaviour. Nutrition thus contains aspects of both nature and nurture. If nutrition plays a causal role in our behaviour, then effects from nutrition would not only have to be in force within individuals as has been demonstrated experimentally but presumably should be capable of helping shape patterns of social behaviour. In the case of antisocial behaviour these changes are considerable: *“The overall rate of crime has risen severalfold over the last fifty years, a rise so rapid that it can only be due to some impact in the environment. Clearly if society has been so spectacularly successful in causing the levels of crime to increase there must be the potential for the right sort of interventions to be equally effective in causing it to decrease!”*⁵

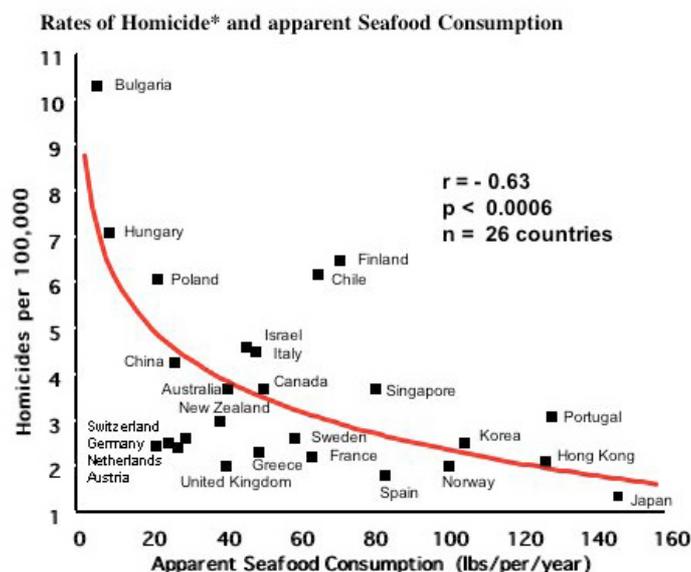


Source: National Statistics Office 2002

What is being suggested is that even after a scholarly examination of the available evidence, such large changes above are hard to convincingly explain in terms of genetics or simply changes of reporting or recording crime. In view of the Aylesbury findings above, a plausible candidate to explain some of the rapid rise in crime could be changes in our brain’s ‘environment’ and the right sort of intervention may turn out to be something as simple as paying a great deal more attention to what passes through our mouths on its way to our brains! For this to be the case you would expect there to have been changes in our diet over the past 50 years and there is evidence for this.

According to the recently revised World Health Organisation’s technical report *Diet, Nutrition and the Prevention of Chronic Disease*: *“The increasing westernization, urbanisation and mechanisation in most countries around the World is associated with changes in diets towards one of high fat, high energy foods and sedentary lifestyles.”* A UK study comparing diets consumed in 1950 by 4 year-old children with those in 1992/93⁶ concluded that the post war diet with its reliance on staple foodstuffs such as bread and vegetables might well have been beneficial to the health of young people. Thus, the increase of choice and processed foods nowadays is not necessarily beneficial from a nutritional perspective. The nutritional qualities of staple foods may have also have altered. The nutritional values of fruit and vegetables are significantly lower in many cases in the updated fifth edition of 1991⁷ than was first published in 1936 in the seminal McCance and Widdowson’s *The Nutritive Value of Fruits, Vegetables and Nuts*⁸ apparently because “the nutritional value of many of the more traditional foods has changed.” In addition, the balance of nutrients consumed may also have shifted over time with reductions in omega-3 fish oil consumption and concomitant increase in intakes of omega-6 fatty acids⁹; a trend that is now considered to have serious implications for mental health and of particular interest here, violence: see below. It has to be recognised however, that such epidemiological and historical data have limitations and the connection with changing social patterns over the past 50 years is speculative, but nevertheless these

studies do raise the possibility that such nutritional influences could have increased their grip at a time when social behaviour has deteriorated.



*World Health Statistics Annual 1995, WHO, Geneva Switzerland
 Source: Hibbeln, J.R. World Rev. Nutr. Diet, 2001; 88; 41-46

Curiously, there is a relatively stable feature in patterns of crime where the peak ages of offending are consistently found, across different cultures, in boys in late adolescence. We know that boys have greatly accelerated growth in late adolescence while girls' growth is more linear. It is speculation but perhaps this is the only time when the developed brain is in such competition with the rest of the body for precious nutrients so their behavioural influences may conceivably reach a peak during the growth spurt then tail off. If correct, this group would show the largest improvement in behaviour from improved nutrition.

Conclusion

Humans are both social and physical beings: not one, not the other but *both*. Hence, the brain needs to be nourished in two ways: the love, nurturing and education we all need but also the nutrition to sustain our physical being. Some of these factors will act in ways that we can see, some of them *will not*, so we need a broader interpretation of the causes of antisocial behaviour in criminal justice, where physical and social functioning are both considered relevant to culpability. Interventions targeted at proven causes of crime or antisocial behaviour should be highly resource efficient and result in less victims of crime. Emerging clinical evidence suggests that nutrition is cheap, humane and highly effective at reducing anti-social behaviour. The Economist magazine of June 29 2002 reported that this approach costs 0.2% of the cost of custody. This nutritional approach needs to be widely replicated but since essential nutrients have been shown to *cause* reductions in antisocial behaviour we may be able to genuinely *prevent* offending by taking positive steps to ensure that members of our society are properly nourished. Future crime reduction strategies could be as simple as broadening the provision of school meals with reinstated nutritional standards or providing enhanced nutrition as part of our intervention strategy with offenders. Indeed we are in discussions with the Dutch Ministry of Justice who are considering just such a strategy.

“New thinking is needed in understanding ways of helping young offenders control their violence. Physical treatments might well complement psychological approaches. If changes in

diet can be as helpful as this research suggests, the public health importance would be great.”
Quote from Professor Eric Taylor, Department of Child and Adolescent Psychiatry, Institute of Psychiatry, for Natural Justice press conference, the Royal College of Psychiatry, June 2002.

There is a myriad of evidence linking physiological factors and behaviour that is largely ignored in criminal justice: see Further Reading. It seems we ignore them at our peril. Suffice to say any offender who might respond to a social intervention also has to eat, so it makes sense to combine social and physiological approaches. Most importantly, people’s positive potential might be realised if such an approach is taken at a time when criminal justice resources are under stress. Physiological approaches have the advantage that they are more amenable for objective evaluation and may be an easier target for change than socio-economic factors. Since food is a meeting place of the social and physical worlds it may provide a constructive platform for social interventions to be much more effective. To make an analogy, no amount of energy spent on software will resolve a hardware problem. If this physiological approach works, it should work irrespective of racial, legislative or geographical boundaries, as human metabolism unites us all. Given the possible benefits, more research is urgently needed. It may contribute to a healthy and peaceful society.

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References:

1. Gesch, C.B., Hammond, S.M., Hampson, S.E., Eves A., Crowder, M.J. (2002) Influence of supplementary vitamins, minerals and essential fatty acids on the antisocial behaviour of young adult prisoners. *Br J Psychiatry*. 181, 22-28.
2. Marshall, E. (2000) The shots heard 'round the world'. *Science*, 289, 570-574. *Science*. 2000, 289, 5479. 573-574.
3. Gesch, C.B. (1990) Natural Justice: A pilot study in evaluating and responding to criminal behaviour as an environmental phenomenon; The South Cumbria (England) Alternative Sentencing Options (SCASO) Project. *Int J Biosocial Med Res* 12(1), 41-68.
4. Raine, A et al. Effects of Environmental Enrichment at Ages 3–5 Years on Schizotypal Personality and Antisocial Behavior at Ages 17 and 23 Years. *Am J Psychiatry* 2003; 160:1627–1635
5. Rutter, M., Giller, H., Hagell, A. Prevention and Intervention I. In: *Antisocial Behaviour by Young People*. Blackwell. 1998: 309.
6. Prynne C.J., Paul A.A., Price, G.M., Day K.C., Hilder, W.S., Wadsworth, M.E. Food and nutrient intake of a national sample of 4-year-old children in 1950: comparison with the 1990s. *Public Health Nutr*. 1999; 2(4): 537-47
7. Holland, B., Welch A.A., Unwin, I.D., et al. McCance and Widdowson’s *The Composition of Foods*. 5th Edition. Cambridge: Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. 1991
8. McCance, R.A., Widdowson, E.M., Shackleton, L.R.B. *The Nutritive Value of Fruits, Vegetables and Nuts*, Medical Research Council Special Report Series No. 213, HMSO, London, 1936.
9. Eaton, S.B., Eaton, S.B., Sinclair, A, Cordain, L, Mann, N.J., Dietary intake of long-chain polyunsaturated fatty acids during the paleolithic. In: Simopoulos AP, ed. *The Return of Ω -3 Fatty Acids to the Food Supply I: Land-Based Animal Food Products and Their Health Effects*. *World Review of Nutrition and Dietetics* Vol. 83. Karger. Basal. 1998: 12–23.

Further Reading

1. Bryce-Smith, D. Lead pollution and mental health. *Biologist*. 1971; 18(2):52-58.
2. Bryce-Smith, D., Waldron, H. A. Lead, behaviour and criminality. *Ecologist*. 1974; 4(10): 367 -377
3. Bryce-Smith, D. Environmental chemical influences on behaviour, personality, and mentation. *Int J Biosocial Research*. 1986; 8 (2): 115-150
4. Schauss, A.G. Differential outcomes among probationers comparing orthomolecular approaches to conventional casework/counselling. *J Orthomolecular Psychiatry*. 1978; 8(3): 158-168.
5. Schoenthaler, S. J. The Northern California diet and Behaviour program: An empirical examination of 3000 incarcerated juveniles in Stanislaus County Juvenile Hall. *Int J Biosocial Research*. 1983; 5(2): 99-106.
6. Schoenthaler, S.J., Amos, S., Doraz, W., et al. The effect of randomised vitamin-mineral supplementation on violent and non-violent antisocial behavior among incarcerated juveniles. *J Nutritional and Environmental Medicine*. 1997; 7: 343-352.
7. Hamazaki, T., Sawazaki, S., Itomura, M., et al. The effect of docosahexaenoic acid on aggression in young adults. *J Clinical Investigation*. 1996; 97: 1129-1133.
8. Zanarini, M.C., Frankenburg, F.R. Omega-3 Fatty Acid Treatment of Women With Borderline Personality Disorder: A Double-Blind, Placebo-Controlled Pilot Study. *Am J Psychiatry* 2003. 160:1.167-169.
9. Corrigan, F.M. Gray, R., Strathdee, A., et al. Fatty acid analysis of blood from violent offenders. *Journal of Forensic Psychiatry*. 1994; 5(1): 83-92.
10. Walsh, W. J., Isaacson, H. R., Rehman, F., et al Elevated blood copper/zinc ratios in assaultive young males. *Physiology and Behavior*. 1997: 62; 327-329.
11. Stevens, L. J., Zentall, S. S., Abate, M. L., et al. Omega-3 fatty acids in boys with behavior, learning, and health problems. *Physiology & Behavior*. 1996; 59: 915-920.
12. Virkkunen, M. E., D. F. Horrobin, et al. Plasma phospholipids, essential fatty acids and prostaglandins in alcoholic, habitually violent and impulsive offenders. *Biol Psychiatry* 1987; 22: 1087-1096.
13. Hibbeln, J. R., Umhau, J. C., Linnoila, M., et al. A replication study of violent and nonviolent subjects: Cerebrospinal fluid metabolites of serotonin and dopamine are predicted by plasma essential fatty acids. *Biological Psychiatry*. 1998; 44: 243-249.
14. Stoney C.M., Engebretson T.O., Plasma Homocysteine Concentrations are Positively Associated with Hostility and Anger. *Life Sciences*. 2000; 66(23): 2267-2275

15. Bottiglieri T., Laundry M., Crellin R., Toone BK., Carney M.W., Reynolds E.H. Homocysteine, folate, methylation and monoamine metabolism in depression. *J Neurol Neurosurg Psychiatry*. 2001; 70(3): 419.
16. Wadsworth M.E.J. Delinquency, Pulse Rates and Early Emotional Deprivation. *Br J Criminology*. 1976; 16(3): 245-256.
17. Christensen, J. H., Christensen, M. S. et al. Heart rate variability and fatty acid content of blood cell membranes: a dose-response study with n-3 fatty acids. *Am J Clin Nutr*. 1999; 70: 331-337.
18. Raine, A., Venables, P. H. et al. High autonomic arousal and electrodermal orienting at age 15 years as protective factors against criminal behavior at age 29 years. *Am J Psychiatry*. 1995; 152(11): 1595-1600.
19. Pine, D. S., Wasserman, G. A. et al. Heart period variability and psychopathology in urban boys at risk for delinquency. *Psychophysiology*. 1998; 35(5): 521-529.
20. Brennan, P., Raine, A. Schulsinger, F., Kirkegaard-Sorensen, L., Knop, J., Hutchings, B., Rosenberg, R., Mednick, S. Psychophysiological Protective Factors for Male Subjects at High Risk for Criminal Behavior. *Am J Psychiatry*. 1997; 154: 853-855.
21. Linnoila, M. V., M. Virkkunen, et al. Low cerebrospinal fluid 5-hydroxyindoleacetic acid concentration differentiates impulsive from nonimpulsive violent behavior. *Life Sci*. (1983). 33: 2609-2214.
22. Stanley, B., Molcho, A. et al. Association of aggressive behavior with altered serotonergic function in patients who are not suicidal. *Am J Psychiatry*. 2000; 157(4): 609-614.
23. Virkkunen, M., Goldman, D. et al. Low brain serotonin turnover rate (low CSF 5-HIAA) and impulsive violence. *J Psychiatry Neurosci*. 1995; 20: 271-275.
24. de la Presa Owens, S. Innis S. M. "Docosahexaenoic and arachidonic acid prevent a decrease in dopaminergic and serotonergic neurotransmitters in frontal cortex caused by a linoleic and alpha-linolenic acid deficient diet in formula-fed piglets." *J Nutr*. 1999; 129: 2088-2093.
25. Rapoport, S.I, Bosetti, F. Do lithium and anticonvulsants target the brain arachidonic acid cascade in bipolar disorder? *Arch Gen Psychiatry* 2002; 59(7): 592-6.
26. Castano, A., Herrera, AJ., Cano, J., Machado, A. Effects of a short period of vitamin E-deficient diet in the turnover of different neurotransmitters in substantia nigra and striatum of the rat. *Neuroscience* 1993; 53(1): 179-85.
27. Hubbard, P.C, Lummis, S.C. Zn(2+) enhancement of the recombinant 5-HT(3) receptor is modulated by divalent cations. *Eur J Pharmacol* 2000; 394(2-3):189-97
28. Hartvig, P., Lindner, .KJ., Bjurling, P., Laengstrom, B., Tedroff, J. Pyridoxine effect on synthesis rate of serotonin in the monkey brain measured with positron emission tomography. *J Neural Transm Gen Sect*. 1995; 102(2): 91-7.
29. Department of Health. Dietary Reference Values for food energy and nutrients for the United Kingdom. Report on Health and Social Subjects 41. 1991: London: HMSO.

30. Hibbeln, J. R. Seafood consumption and homicide mortality. *World Rev Nutr Diet* 2000; 85: 41-41.
31. Benton, D., Cook, R. The impact of selenium supplementation on mood. *Biol Psychiatry*. 1991; 29(11): 1092-1098.
32. Schrauzer, G. N., Shrestha, K. P. Lithium in drinking water and the incidences of crimes, suicides, and arrests related to drug addictions. *Biol Trace Elem Res*. 1990; 25: 105-113.
33. Masters R.D., Coplan, M.J., Hone, B.T. Dykes. J.E. Association of Silicoflouride treated water with elevated lead. *Neurotoxicology* 2000; 21.6:1091-1100
34. Hall R.W. A study of a mass murder: Evidence of underlying cadmium and lead poisoning and brain involved immunoreactivity. *International Journal of Biosocial Medical Research*. 1989; 11(2):144 – 152.
35. Needleman H.L., Riess, J.A., Tobin, M.J. Biesecker, G.E. et al. Bone Lead and Delinquent Behavior. *JAMA* 1996; 275(5): 363-369.
36. Criminal statistics for England and Wales. 1996. Home Office, HMSO 1997: 20.
37. Criminal statistics for England and Wales. 1997. Home Office, HMSO 1998: 20.
38. Prynne C.J., Paul A.A., Price, G.M., Day K.C., Hilder, W.S., Wadsworth, M.E. Food and nutrient intake of a national sample of 4-year-old children in 1950: comparison with the 1990s. *Public Health Nutr*. 1999; 2(4): 537-47
39. Mayer, A.M. Historical changes in the mineral content of fruits and vegetables. *British Food Journal*. 1997; 99(6): 207-211
40. McCance, R.A., Widdowson, E.M., Shackleton, L.R.B. The Nutritive Value of Fruits, Vegetables and Nuts, Medical Research Council Special Report Series No. 213, HMSO, London, 1936.
41. Holland, B., Welch A. A., Unwin, I. D., et al. McCance and Widdowson's The Composition of Foods. 5th Edition. Cambridge: Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food. 1991.
42. Hibbeln J.R., Salem Jr. N. Omega--3 Fatty Acids in Psychiatric Disorders, Current Status of the Field. In: Mostofsky D.I., Yehuda, S. and Salem Jr. N. (eds) *Fatty acids: Physiological and Behavioral Functions*. Humana Press. 2001: 18: 4-5.
43. Marshall, W. Senate considers lead gasoline ban. *Science*. 1984. 225. 34-35.