

Chapter 1

Biological Interventions for Crime Prevention

Christopher Chew, Thomas Douglas and Nadira Faber

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1. Introduction

Attempts to prevent criminal conduct have typically involved social or environmental manipulations, with incarceration, probation regimens, and psychological rehabilitation programmes being perhaps the most prominent examples. However, biological interventions have also at times been used for this purpose, and one of the presuppositions of this volume is that a wider range of biological interventions capable of preventing crime may be available in the future.

This chapter sets the scene for the subsequent philosophical discussions by surveying a number of biological interventions that have been used, or might in the future be used, for the purposes of crime prevention. These interventions are pharmaceutical interventions intended to suppress libido, treat substance abuse or attention deficit-hyperactivity disorder (ADHD), or modulate serotonin activity; nutritional interventions; and electrical and magnetic brain stimulation. Where applicable, we briefly comment on the historical

use of these interventions, and in each case we discuss the evidence that they are effective, or might become so with further refinement.

The list of interventions that we review is not exhaustive. For example, we have nothing to say about the frontal leucotomy and other forms of psychosurgery that were used for crime prevention (among other purposes) in the Twentieth Century. We will also not comment on the lethal injection, though it is a biological intervention that has arguably been used at least in part with the purpose of preventing crime. Our aim is to survey the kinds of biological intervention that are most likely to be justifiably and widely deployed as part of attempts to prevent crime in the future. As such, we focus on interventions that are relatively safe and/or non-invasive and for which there is some evidence of effectiveness or potential future effectiveness.

We do not limit ourselves to particular types of crime, but as it happens, the interventions we survey are most likely to be effective in combating certain forms of either sexual crime, or non-sexual violent crime. It should be noted that the psychological, sociological and biological mechanisms underlying these two types of crime are thought to be different;¹ our inclusion of interventions relevant to both types of crime should not be

¹ David Thornton, Ruth Mann, Steve Webster, Linda Blud, Rosie Travers, Caroline Friendship, and Matt Erikson, 'Distinguishing and Combining Risks for Sexual and Violent Recidivism', *Annals of the New York Academy of Sciences* 989 (2003), pp. 225–35; R. Karl Hanson, Heather Scott, and Richard A. Steffy, 'A Comparison of Child Molesters and Nonsexual Criminals: Risk Predictors and Long-Term Recidivism', *Journal of Research in Crime and Delinquency* 32 (1995), pp. 325–37; Anton van Wijk, Robert Vermeiren, Rolf Loeber, Lisette't Hart-Kerkhoffs, Theo Doreleijers, Ruud Bullens, 'Juvenile Sex Offenders Compared to Non-Sex Offenders', *Trauma, Violence, & Abuse* 7 (2006), pp. 227–43; Leam A. Craig, Kevin D. Browne, Anthony Beech, and Ian Stringer, 'Differences in Personality and Risk Characteristics in Sex, Violent and General Offenders', *Criminal Behaviour and Mental Health* 16 (2006), pp. 183–94.

taken to suggest otherwise, nor do we mean to suggest that these broad categories of crime are homogenous with respect to the underlying causal mechanisms.

2. Pharmacological interventions

2.1 Anti-libidinal agents

Pharmacological agents that seek to lower sexual drive are arguably the most established example of biological interventions used for crime prevention, though they are associated with significant controversy, and are still utilized relatively infrequently. The motivation for using such agents to prevent sexual re-offending is the thought that some sex crimes, especially those committed by paedophiles, are motivated in part by a misdirected sex drive. By diminishing sex drive, anti-libidinal agents may thus, in some classes of offender, diminish motivation to offend.

The precursor to the use of such agents is *surgical castration* or *orchidectomy*, the surgical removal of both male testes. One of the earliest surgical procedures, surgical castration has been employed for a variety of reasons ranging from religious to musical to corrective. In the Middle Ages, it was applied as a retributive punishment for sex-related crimes such as rape or adultery.² In the 20th Century, the procedure was re-introduced as a treatment and rehabilitative measure for sex offenders in a number of European countries, including Denmark, Germany, Norway, Finland, Estonia, Iceland, Latvia, and Sweden,

² Nikolaus Heim, Carolyn J. Hirsch, 'Castration for Sex Offenders: Treatment or Punishment? A Review and Critique of Recent European Literature', *Archives of Sexual Behavior* 8 (1979), pp. 281–304.

where it was used under a range of legal provisions.³ Infamously, court-ordered castration for sex offenders was used widely in Nazi Germany, with more than 2800 orchidectomies carried out between 1934 and the abolition of the practice in 1944.⁴ Following World War II, the use of surgical castration decreased significantly worldwide, and it has been only rarely carried out, almost entirely on a voluntary basis, since the 1970's.⁵ Currently, voluntary surgical castration for sex offenders is still offered in two European countries (the Czech Republic and Germany) and five U.S. states (California, Florida, Iowa, Louisiana and Texas).⁶

The decline in the use of surgical castration was due in large part to ethical concerns. Surgical castration results in marked and irreversible psychological and physical changes including sterility, and it makes sexual activity difficult, if not impossible.⁷ Many commentators have criticised the practice as a “cruel and unusual” punishment and an affront to human rights.⁸ The historical association of the practice with the totalitarian

³ Emma D. Stone, George L. Thurston, ‘Castration for Sexual Offenders. A Commentary on a Recent Case’, *The Medico-Legal Journal* 27 (1959), pp. 136–9.

⁴ Michael Burleigh, *Ethics and Extermination: Reflections on Nazi Genocide* (Cambridge: Cambridge University Press, 1997).

⁵ Kimberly A. Peters, ‘Chemical Castration: An Alternative to Incarceration’, *Duquesne Law Review* 31 (1992), pp. 307-328.

⁶ Charles L. Scott, Trent Holmberg, ‘Castration of Sex Offenders: Prisoners’ Rights Versus Public Safety’, *Journal of the American Academy of Psychiatry and Law* 31 (2003), pp. 502–9; Laura S. Chism, ‘Case for Castration: A Shot towards Rehabilitation of Sexual Offenders’, *Law and Psychology Review* 37 (2013), pp. 193–209.

⁷ Heim and Hirsch, ‘Castration for Sex Offenders’; Peters, ‘Chemical Castration’.

⁸ Council of Europe: Committee for the Prevention of Torture. Report to the German Government on the visit to Germany carried out by the European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT), 2012; Council of Europe: Committee for the Prevention of Torture. Report to the Czech Government on the visit to the Czech Republic carried out by the European Committee for the Prevention of Torture and Inhuman or Degrading Treatment or Punishment (CPT), 2009.

regimes of Nazi Germany⁹ and the USSR,¹⁰ and in response to activities that were wrongly criminalised such as homosexuality,¹¹ may also have contributed to its fall in popularity. There is, in addition, uncertainty regarding the actual efficacy of the practice in preventing re-offending, due to unavoidable methodological limitations and a sparse body of research, though there are suggestions that it was effective.¹²

Anti-libidinal pharmacological agents aim to provide similar reductions in sexual drive and recidivism, but with the option of reversibility on discontinuation, and without the need for an invasive surgical procedure (the agents are normally administered by injection). They have typically been used to treat paraphilias, such as paedophilia, or to prevent sexual re-offending, with the two goals often being combined and, in some cases, conflated.

Several pharmacological agents have been identified in the literature as potential anti-libidinal agents. The two best established of these are *cyproterone acetate* (CPA), used widely in Europe, and *medroxyprogesterone acetate* (MPA), used widely in the United States.¹³ Recently, *gonadotrophin-releasing hormone* (GnRH) *agonists* have been

⁹ Burleigh, *Ethics and Extermination*.

¹⁰ Sidney Bloch, Paul Chodoff, Stephen A. Green, *Psychiatric Ethics* (Oxford: Oxford University Press, 1999).

¹¹ Geoffrey J. Giles, ‘The Most Unkindest Cut of All’: Castration, Homosexuality and Nazi Justice’, *Journal of Contemporary History* 27 (1992), pp. 41–61; Nikolaus Heim, ‘Sexual Behavior of Castrated Sex Offenders’, *Archives of Sexual Behavior* 10 (1981), pp. 11–9.

¹² Heim and Hursch, ‘Castration for Sex Offenders’; Friedrich Lösel and Martin Schmucker, ‘The Effectiveness of Treatment for Sexual Offenders: A Comprehensive Meta-Analysis’, *Journal of Experimental Criminology* 1 (2005), pp. 117–46; Linda E. Weinberger, Shoba Sreenivasan, Thomas Garrick, Hadley Osran, ‘The Impact of Surgical Castration on Sexual Recidivism Risk Among Sexually Violent Predatory Offenders’, *Journal of the American Academy of Psychiatry and the Law* 33 (2005), pp. 16–36.

¹³ Harvey Gordon and Don Grubin, ‘Psychiatric Aspects of the Assessment and Treatment of Sex

employed for this purpose.¹⁴ All of these agents are posited to act by lowering testosterone levels in the long-term, though GnRH agonists achieve this reduction through a less direct mechanism than CPA and MPA.¹⁵ When they are used with the goal of reducing testosterone activity to pre-pubescent levels they are frequently referred to as ‘chemical castration’. They can produce significant and not uncommon medical side-effects, including osteoporosis, weight gain, male breast enlargement, and hot flushes,¹⁶ and CPA and MPA are also associated with deep venous blood clots and subsequent complications. Additionally, their use in the context of criminal justice has also provoked ethical debate regarding autonomy, consent, and coercion.¹⁷

A fourth class of anti-libidinal agents, *selective serotonin reuptake inhibitors* (SSRIs), are psychotropic medications commonly used to treat depression and anxiety disorders, which have long been associated with a decrease in libido through poorly-understood

Offenders’, *Advances in Psychiatric Treatment* 10 (2004), pp. 73-80; Florence Thibaut, Flora De La Barra, Harvey Gordon, Paul Cosyns, John M. W. Bradford & the WFSBP Task Force on Sexual Disorders, ‘The World Federation of Societies of Biological Psychiatry (WFSBP) Guidelines for the Biological Treatment of Paraphilias’, *The World Journal of Biological Psychiatry* 11 (2010), pp. 604–55.

¹⁴ Ariel Rösler, Eliezer Witztum, ‘Treatment of Men with Paraphilia with a Long-Acting Analogue of Gonadotropin-Releasing Hormone’, *The New England Journal of Medicine* 338 (1998), pp. 416–22.

¹⁵ Andreas Hill, Peer Briken, Christian Kraus, Kerstin Strohm, Wolfgang Berner, ‘Differential Pharmacological Treatment of Paraphilias and Sex Offenders’, *International Journal of Offender Therapy and Comparative Criminology* 47 (2003), pp. 407–21.

¹⁶ Frederico D. Garcia and Florence Thibaut, ‘Current Concepts in the Pharmacotherapy of Paraphilias’, *Drugs* 71 (2011), pp. 771–90; Peer Briken and Martin P. Kafka, ‘Pharmacological Treatments for Paraphilic Patients and Sexual Offenders’, *Current Opinion in Psychiatry* 20 (2007), pp. 609–13.

¹⁷ John McMillan, ‘The Kindest Cut? Surgical Castration, Sex Offenders and Coercive Offers’, *Journal of Medical Ethics* 40 (2014), pp. 583-90; Thomas Douglas, Pieter Bonte, Farah Focquaert, Katrien Devolder, and Sigrid Sterckx, ‘Coercion, Incarceration, and Chemical Castration: An Argument from Autonomy’, *Journal of Bioethical Inquiry* 10 (2013), pp. 393–405; Jesper Ryberg, ‘Is Coercive Treatment of Offenders Morally Acceptable? On the Deficiency of the Debate’, *Criminal Law and Philosophy* 9 (2015), pp. 619-631.

pathways.¹⁸ These medications are sometimes used *for* their anti-libidinal effects in sex offenders.

The effectiveness of anti-libidinal agents in preventing sexual crimes is controversial. There are numerous methodological problems with the existing literature, stemming in part from the practical and ethical difficulties in conducting research on individuals with a history of sex offending. Aside from the ethical issues with the delivery of anti-libidinal agents themselves, there are significant research ethics concerns in allowing high-risk sexual offenders to remain untreated, as a randomised controlled trial might require, and in ensuring that research projects are fully voluntary and non-exploitative, given the vulnerable position of many offenders. Most researchers investigating anti-libidinal agents have also had to work within the practical constraints of the prison system, and many have been plagued by disruption from early release or transfers, and difficulties in adequately controlling for environmental conditions and demographics.

A recent Cochrane systematic review of anti-libidinal agents for persons at risk for sexual offending highlights some of these difficulties with the evidence base.¹⁹ Despite an exhaustive search of the literature, the authors were only able to identify seven randomised controlled trials that met their strict inclusion criteria. All of these studies were published prior to 1993, with samples sizes ranging from 9 to 37 participants; only

¹⁸ Deepak Prabhakar and Richard Balon, 'How Do SSRIs Cause Sexual Dysfunction?', *Current Psychiatry* 9 (2010), pp. 30–4.

¹⁹ Omer Khan, Michael Ferriter, Nick Huband, Melanie J. Powney, Jane A. Dennis, and Conor Duggan, 'Pharmacological Interventions for Those Who Have Sexually Offended or Are at Risk of Offending', *Cochrane Database of Systematic Reviews* 2 (2015), DOI: 10.1002/14651858.CD007989.pub2.

two formally measured rates of sexual recidivism; and none were conducted in a prison setting. Furthermore, considerable heterogeneity between study comparisons and outcome measures meant that quantitative meta-analysis was not considered possible by the authors. Given these significant limitations, the authors concluded that the existing high-quality literature was insufficient to draw firm conclusions on the effectiveness of anti-libidinal agents in preventing sexual recidivism.

Although randomised controlled trials are considered the ‘gold-standard’ level of evidence, non-randomised trials can still provide useful data. Several non-systematic reviews including a broader range of study designs have also examined the literature surrounding anti-libidinal interventions. They have arrived at varying conclusions,²⁰ depending on which trials were included and how their results were interpreted.

Given these limitations, we have settled for commenting on three important papers on this topic: the Oregon Depo-Provera Trial, the largest single study on anti-libidinal interventions in a prison population;²¹ a meta-analysis by Lösel and Schmucker which constitutes the most inclusive quantitative review of interventions in sexual offenders to

²⁰ Garcia and Thibaut, ‘Current Concepts in the Pharmacotherapy of Paraphilias’; Briken and Kafka, ‘Pharmacological Treatments for Paraphilic Patients and Sexual Offenders’; Marnie E. Rice and Grant T. Harris, ‘Is Androgen Deprivation Therapy Effective in the Treatment of Sex Offenders?’, *Psychology, Public Policy, & Law* 17 (2011), pp. 315-332; Frederico D. Garcia, Heloise G. Delavenne, Alessandra dFA Assumpção, and Florence Thibaut, ‘Pharmacologic Treatment of Sex Offenders with Paraphilic Disorder’, *Current Psychiatry Reports* 15 (2013), p. 356; John M. W. Bradford, Paul Fedoroff, Sanjiv Gulati, ‘Can Sexual Offenders Be Treated?’, *International Journal of Law and Psychiatry* 36 (2013), pp. 235–40; Fabian M. Saleh and Fred S. Berlin, ‘Sex Hormones, Neurotransmitters, and Psychopharmacological Treatments in Men with Paraphilic Disorders’, *Journal of Child Sexual Abuse* 12 (2003), pp. 233–53.

²¹ Barry M. Maletzky, Arthur Tolan, and Bentson McFarland, ‘The Oregon depo-Provera Program: A Five-Year Follow-Up’, *Sex Abuse* 18 (2006), pp. 303-16.

date;²² and a review completed by the World Federation of Societies of Biological Psychiatry in developing their Guidelines for the Biological Treatment of Paraphilias, which constitutes the current expert opinion on the topic.²³

The Oregon Depo-Provera trial came about as a result of legislative changes in the US state of Oregon that required compulsory treatment with MPA on release in a selected population of sexual offenders, and was intended to evaluate the efficacy of the program.²⁴ The study retrospectively followed the first cohort of men (n=275) inducted into the program between 2000 and 2004, separating the men into three groups: those prescribed MPA who indeed underwent treatment (n=79); those prescribed MPA but who for various reasons did not ultimately undergo treatment (n=55); and those judged to not require MPA (n=141). A number of methodological limitations were present. For example, detailed data concerning doses, timing and length of MPA administration were unavailable, as was information about serum testosterone levels and length of follow-up. In addition, decisions about which participants required anti-libidinal agents were based on an unvalidated risk scoring scale developed by the investigators, and no attempt was made to ensure equal baseline recidivism risk across the three groups. Nevertheless, the study arguably constitutes the strongest evidence on this topic available from a single piece of research, and the results were striking – only 5% of the group who actually received MPA committed new offences ($p < 0.0001$), none of which were sexual in nature,

²² Lösel and Schmucker, ‘The Effectiveness of Treatment for Sexual Offenders’.

²³ Thibaut et al., ‘The World Federation of Societies of Biological Psychiatry (WFSBP) Guidelines’.

²⁴ Barry M. Maletzky, Gary Field, ‘The Biological Treatment of Dangerous Sexual Offenders: A Review and Preliminary Report of the Oregon Pilot depo-Provera Program’, *Aggression and Violent Behavior* 8 (2003), pp. 391–412.

compared with a 26-30% re-offense rate in the other two groups, with just over half of these offences being sexual in nature. None of the MPA treated group returned to prison, compared to 15-20% of the other two groups ($p < 0.0001$ for recommended and did not receive, $p < 0.002$ for not recommended). As has been noted elsewhere,²⁵ that the recidivism rates for the two non-treated groups correlates well with reported sexual offender recidivism rates from other studies, providing some weak support for the reliability of the study's results.²⁶

Lösel and Schmucker's meta-analysis is, to date, the most comprehensive quantitative review undertaken of the efficacy of surgical and chemical castration in preventing sexual re-offending.²⁷ The authors examined 69 studies from multiple countries that met their inclusion criteria, with 80 separate comparisons totalling over 22,000 individuals. Of these, 6 studies assessed the efficacy of anti-libidinal agents, and 8 studies examined surgical castration. Both interventions, but especially surgical castration, were found to have large, statistically significant effects in reducing recidivism, more so than any other intervention examined. The authors do, however, strike a cautionary tone, noting that many of the studies do not reach 'gold-standard' levels of design quality, and are still subject to methodological limitations even after passing inclusion criteria. Subjects often receive these therapies in conjunction with other cognitive-behavioural interventions, introducing potential confounders, and are furthermore (particularly with surgical

²⁵ Briken and Kafka, 'Pharmacological Treatments for Paraphilic Patients and Sexual Offenders'.

²⁶ R. Karl Hanson and Kelly E. Morton-Bourgon, 'The Characteristics of Persistent Sexual Offenders: A Meta-Analysis of Recidivism Studies', *Journal of Consulting and Clinical Psychology* 73 (2005), pp. 1154–63.

²⁷ Lösel and Schmucker, 'The Effectiveness of Treatment for Sexual Offenders'.

castration) often voluntary and thus administered only to a highly selected population. Despite these issues, the authors nevertheless conclude that there is an overall significant and positive effect with these interventions, and that they should be considered for use, in combination with other modes of treatment, in sexual offenders.

The World Federation of Societies of Biological Psychiatry (WFSBP) Guidelines for the Biological Treatment of Paraphilias were the result of a specially appointed Task Force on Sexual Disorders aiming to provide expert clinical guidelines for the treatment of paraphilias and sexual disorders.²⁸ The Task Force undertook an extensive review of the literature, evaluated the efficacy of a range of anti-libidinal agents in the treatment of sexual disorders, and produced a graded treatment algorithm for a range of paraphilias. There was, however, no quantitative analysis of treatment effects; in contrast to the Lösel and Schmucker study, the WFSBP review aimed to arrive at an agreed expert opinion, rather than undertaking a detailed meta-analysis. The existing evidence was not found to support the use of SSRIs due to a lack of sufficient research, with a possible exception being patients that exhibit obsessive-compulsive elements in their paraphilia. MPA and CPA were both thought to be effective, though conclusions were limited by the moderately poor quality of the existing evidence due to methodological limitations. More importantly, they had multiple significant side effects that were of substantial concern and would limit their use. The newer class of GnRH antagonists (including triptorelin, leuprolin, and goserelin) also suffered from the limited quality of existing research, but appeared to be more potent than CPA and MPA, with fewer side effects reported. The

²⁸ Thibaut et al., ‘The World Federation of Societies of Biological Psychiatry (WFSBP) Guidelines’.

Task Force concluded that, overall, there was some evidence that anti-libidinal agents can have an anti-recidivist effect and that they should be utilised in conjunction with other modes of treatment, and regular medical follow-up.

Overall, this body of evidence could be taken to suggest that the use of hormonal anti-libidinal agents is likely to be effective in reducing sexual recidivism in selected groups of sexual offenders, but has medically significant side-effects. However, any firm conclusion is precluded by the issues with the existing research literature noted above.

2.2 Pharmacological treatments for substance abuse and addiction

Substance abuse and addiction (SA/A) are linked rather directly to criminal behaviour – in most jurisdictions around the world, the possession, sale, and use of so-called illicit drugs, not including alcohol, is a criminal offence.²⁹ In the United States, a significant fraction of the dramatic increase in the prison population since the 1970's can be attributed to a rising number of inmates arrested on drug-related charges as part of the 'war on drugs'.³⁰

There is also evidence for a relationship between SA/A and other criminal offenses, particularly violent crimes, with strong associations present in many surveys of offenders and inmates. Among the general prison population in the US, nearly 70% of State

²⁹ Marcus Roberts, Axel Klein, and Mike Trace, 'Towards A Review of Global Policies on Illegal Drugs', *The Beckley Foundation Drug Policy Programme* (2004). Available at http://reformdrugpolicy.com/wp-content/uploads/2011/09/report_1globalpolicy.pdf.

³⁰ Philip J. Cook and Jens Ludwig, 'Economical Crime Control', *The National Bureau of Economic Research* No. 16513 (2010). Available at <http://www.nber.org/papers/w16513>; David Bewley-Taylor, 'Getting High on the Policy Agenda: Europe, the US and the Future of the Global Drug Prohibition Regime', *Journal of Transatlantic Studies* 4 (2006), pp. 27-53.

prisoners reported regular use of illicit drugs, 56% in the month prior to, and 33% at the time of offence.³¹ In comparison, 7.9% of the general American population over the age of 12 reported being current users of illicit drugs (use during the immediate month prior) in the same year.³² A large systematic review found estimates of between 10-60% for the prevalence of drug and alcohol SA/A in prison populations.³³ Australian data indicates that as many as two in three people detained by police for offenses tested positive for illicit drugs (not including alcohol), and complementary survey data have suggested that up to 45% of offenses are self-attributed to either alcohol or illicit drug use.³⁴

Of course, these associations between use of illicit drugs and criminal offending mask a more complex and multifactorial picture. None of the commonly-used substances have direct biological effects that are *sufficient* to, in and of themselves, produce violent behaviour or offending. Rather, they constitute risk factors interacting within a miscellaneous milieu of social, cultural, institutional, and (underlying) biological factors.³⁵ One schematic framework suggests three basic means via which SA/A can promote violence: *systemic violence* (turf wars and conflicts resulting from procurement and distribution); *economic-compulsive violence* (economically-oriented crimes committed to support the acquisition of addictive substances); and

³¹ Christopher J. Mumola and Jennifer C. Karberg, 'Drug Use and Dependence, State and Federal Prisoners, 2004', US Department of Justice, Office of Justice Programs, Bureau of Justice Statistics (2006). Available at <https://www.bjs.gov/content/pub/pdf/dudsfp04.pdf>.

³² 'Results from the 2004 National Survey on Drug Use and Health: National Findings', NSDUH Series H-28. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2005. Available at <http://medicalmarijuana.procon.org/sourcefiles/2k4results.pdf>.

³³ Seena Fazel, Parveen Bains, and Helen Doll, 'Substance Abuse and Dependence in Prisoners: A Systematic Review', *Addiction* 101 (2006), pp. 181-91.

³⁴ Adam Tomison, 'How Much Crime Is Drug or Alcohol Related? Self-Reported Attributions of Police Detainees', *Trends & Issues in Crime and Criminal Justice* 439 (2009), pp. 421-40.

³⁵ Tomison, 'How Much Crime Is Drug or Alcohol Related?'

psychopharmacological violence (aggressive behaviour attributable in part to biological side-effects of substance use).³⁶ Surveys suggest that *systemic violence* is most prevalent, with *economic-compulsive* and *psychopharmacological violence* constituting small but still significant categories.³⁷ Of course, most violence associated with SA/A likely involves a mixture of these factors, rather than one in isolation.

The latter two, *economic-compulsive* and *psychopharmacological violence* are most relevant to this discussion, being most directly related to direct biological effects of SA/A. Presumably, the addictive properties of many illicit (and licit) drugs are an important driver of *economic-compulsive violence*, and thus treatment of SA/A would be expected to prevent or reduce this sort of offending. *Psychopharmacological violence* provoked by the short- and long-term cognitive, psychological, and behavioural changes induced by abuse or withdrawal from certain drugs – including irritability, anxiety, psychomotor agitation, physical aggression and even psychosis – is also likely amenable to treatment of SA/A.

Traditionally, behavioural and psychosocial interventions such as cognitive behavioural therapy (CBT) and twelve-step programs form the backbone of community SA/A treatment programs.³⁸ There are, however, a number of pharmacological therapies have

³⁶ Bruce D. Johnson, Paul J. Goldstein, Edward Preble, James Schmeidler, Douglas S. Lipton, Barry Spunt, and Thomas Miller, *Taking Care of Business: The Economics of Crime by Heroin Abusers* (Lexington, MA: Lexington Books, 1985).

³⁷ Paul J. Goldstein, Henry H. Brownstein, Patrick J. Ryan, and Patricia A. Bellucci, 'Crack and Homicide in New York City, 1988: A Conceptually Based Event Analysis', *Contemporary Drug Problems* 16 (1989), pp. 651-88.

³⁸ Benjamin R. Nordstrom and Frances R. Levin, 'Treatment of Cannabis Use Disorders: A Review of the Literature', *American Journal on Addictions* 16 (2007), pp. 331-42; Molly Magill

also recently been found to be effective in treating SA/A in the outpatient setting, especially in combination with the above interventions. These include topiramate, an anti-epileptic, and buprenorphine, a weak opioid agonist, but the strongest evidence is for the use of opioid antagonists and methadone maintenance therapy (MMT). High-quality systematic reviews find that opioid antagonists significantly reduce the risk of heavy drinking, as well as the overall amount and frequency of alcohol consumption in alcoholics,³⁹ and that MMT significantly reduces the use of heroin and improves treatment program retention in narcotic addicts.⁴⁰

Evidence on the effectiveness of these interventions in the criminal justice system specifically is much sparser, and suffers from methodological limitations. The most widely-studied and promising intervention in this particular setting is MMT,⁴¹ though the literature is still limited and the actual availability of these interventions in prisons is poor.⁴² A wide array of observational and higher-quality randomised controlled trials agree that MMT is effective in reducing drug relapse rates and improving treatment program retention and uptake.⁴³

and Lara A. Ray, 'Cognitive-Behavioral Treatment with Adult Alcohol and Illicit Drug Users: A Meta-Analysis of Randomized Controlled Trials', *Journal of Studies on Alcohol and Drugs* 70 (2009), pp. 516–27.

³⁹ S. Rosner, A. Hackl-Herrwerth, S. Leucht, S. Vecchi, M. Srisurapanont, and M. Soyka, 'Opioid Antagonists for Alcohol Dependence', *Cochrane Database of Systematic Reviews* 12 (2010), DOI: 10.1002/14651858.CD001867.pub2.

⁴⁰ Rosner et al., 'Opioid Antagonists for Alcohol Dependence'.

⁴¹ Redonna K. Chandler, Bennett W. Fletcher, and Nora D. Volkow, 'Treating Drug Abuse and Addiction in the Criminal Justice System: Improving Public Health and Safety', *JAMA* 301 (2009), pp. 183–90; Stephen J. Bahr, Amber L. Masters, and Bryan M. Taylor, 'What Works in Substance Abuse Treatment Programs for Offenders?', *The Prison Journal* 92 (2012), pp. 155–74.

⁴² Steven Belenko, Matthew Hiller, and Leah Hamilton, 'Treating Substance Use Disorders in the Criminal Justice System', *Current Psychiatry Reports* 15 (2013), pp. 1-11.

⁴³ Bahr, Masters, and Taylor, 'What Works In Substance Abuse Treatment Programs for

Whether there is a similarly substantial effect in reducing criminal activity, recidivism, and re-incarceration is still uncertain, with conflicting conclusions from high-quality reviews of the evidence. A recent systematic review of opioid maintenance therapy in prison settings,⁴⁴ and a meta-analysis of a range of incarceration-based drug treatment programs⁴⁵ concluded that the evidence from trials with MMT painted a mixed but

Offenders?'; Martin Killias, Marcelo Aebi, Miriam Pina, Nicole Egli, and Pernille S. Christensen, 'Effects of Drug Substitution Programs on Offending Among Drug-Addicts', *Campbell Systematic Reviews* 3 (2009); Kate A. Dolan, James Shearer, Bethany White, Jialun Zhou, John Kaldor, and Alex D. Wodak, 'Four-Year Follow-Up of Imprisoned Male Heroin Users and Methadone Treatment: Mortality, Re-Incarceration and Hepatitis C Infection' *Addiction* 100 (2005), pp. 820-8; Sara L. Johnson, Jennifer T. C. van de Ven, and Brian Grant, 'Institutional Methadone Treatment: Impact on Release Outcome and Institutional Behaviour', *Research Report* 119 (2001); Wayne Hall, Jeff Ward, and Richard Mattick, 'Methadone Maintenance Treatment in Prisons: The New South Wales Experience' *Drug and Alcohol Review* 12 (1993), pp. 193-203; Vincent P. Dole, J. Waymond Robinson, John Orraca, Edward Towns, Paul Searcy, and Eric Caine, 'Methadone Treatment of Randomly Selected Criminal Addicts', *The New England Journal of Medicine* 280 (1969), pp. 1372-5; Dagmar Hedrich, Paula Alves, Michael Farrell, Heino Stöver, Lars Møller, and Soraya Mayet, 'The Effectiveness of Opioid Maintenance Treatment in Prison Settings: A Systematic Review', *Addiction* 107 (2012), pp. 501-17; Anke Stallwitz and Heino Stöver, 'The Impact of Substitution Treatment in Prisons – A Literature Review', *International Journal of Drug Policy* 18 (2007), pp. 464-74; Lars M. Gunne and Leif Grönbladh, 'The Swedish Methadone Maintenance Program: A Controlled Study', *Drug and Alcohol Dependence* 7 (1981), pp. 249-56; Johann A. Koehler, David K. Humphreys, Thomas D. Akoensi, Olga Sánchez de Ribera, and Friedrich Lösel, 'A Systematic Review and Meta-Analysis on the Effects of European Drug Treatment Programmes on Reoffending', *Psychology, Crime & Law* 20 (2014), pp. 584-602; Timothy W. Kinlock, Michael S. Gordon, Robert P. Schwartz, Terrence T. Fitzgerald, and Kevin E. O'Grady, 'A Randomized Clinical Trial of Methadone Maintenance for Prisoners: Results at 12 Months Postrelease', *Journal of Substance Abuse Treatment* 37 (2009), pp. 277-85; Michael S. Gordon, Timothy W. Kinlock, Robert P. Schwartz, and Kevin E. O'Grady, 'A Randomized Clinical Trial of Methadone Maintenance for Prisoners: Findings at 6 Months Post-Release', *Addiction* 103 (2008), pp. 1333-42; Timothy W. Kinlock, Michael S. Gordon, Robert P. Schwartz, Kevin O'Grady, Terrence T. Fitzgerald, and Monique Wilson M, 'A Randomized Clinical Trial of Methadone Maintenance for Prisoners: Results at One-Month Post-Release', *Drug and Alcohol Dependence* 91 (2007), pp. 220-7; Timothy W. Kinlock, Michael S. Gordon, Robert P. Schwartz, and Kevin E. O'Grady, 'A Study of Methadone Maintenance for Male Prisoners 3-Month Postrelease Outcomes', *Criminal Justice and Behavior* 35 (2008), pp. 34-47.

⁴⁴ Hedrich et al., 'The Effectiveness of Opioid Maintenance Treatment in Prison Settings'.

⁴⁵ Ojmarrh Mitchell, David B. Wilson, and Doris L. MacKenzie, 'Does Incarceration-Based Drug Treatment Reduce Recidivism? A Meta-Analytic Synthesis of the Research', *Journal of Experimental Criminology* 3 (2007), pp. 353-75.

overall neutral picture, with varying results reported. In contrast, a recent systematic review and meta-analysis of drug treatment programs for offenders in Europe⁴⁶ and a systematic review of a variety of pharmacological substitution-based programmes⁴⁷ suggest that such interventions are indeed effective in facilitating a significant reduction in criminal behaviour. In the light of such conflicts, it is suggested that further high-quality research with larger sample populations are required to confirm the benefits of MMT.

2.3 Pharmaceutical treatments for ADHD

ADHD is a neurodevelopmental disorder that typically begins in childhood, and is characterized by high-for-age levels of inattention and/or hyperactivity and impulsivity. It is commonly associated with poor academic performance in school, and difficulties with social interaction, and can persist into adulthood.⁴⁸

ADHD is significantly associated with criminal offending. In corrective institutions worldwide, numerous studies have consistently found a disproportionately high prevalence of ADHD. Although some of these studies suffered from significant methodological weaknesses, the results indicated that between 24 and 67% of adolescent prisoners met the criteria for childhood ADHD, and between 23-45% of adult prisoners met the criteria for adult ADHD.⁴⁹ For comparison, a large pooled meta-analysis of

⁴⁶ Koehler et al., 'A Systematic Review and Meta-Analysis on the Effects of European Drug Treatment Programmes on Reoffending'.

⁴⁷ Killias et al., 'Effects of Drug Substitution Programs on Offending Among Drug-Addicts'.

⁴⁸ Benjamin J. Sadock and Virginia A. Sadock, *Kaplan & Sadock's Synopsis of Psychiatry: Behavioral Sciences/Clinical Psychiatry* (Philadelphia, PA: Lippincott Williams & Wilkins, 2007).

⁴⁹ Toshihiko Matsumoto, Akiko Yamaguchi, Takeshi Asami, Atsushi Kamijo, Eizo Iseki, Yoshio

global studies on the prevalence of ADHD suggested the worldwide pooled rate was 5.29%.⁵⁰

It is more difficult to establish the exact causal link between ADHD and criminality, as there is significant co-morbidity with multiple psychiatric conditions that are themselves risk factors for criminal behaviour, particularly *substance abuse and addiction*, *oppositional defiant disorder* (ODD) and *conduct disorder* (CD).⁵¹ Multiple longitudinal and retrospective cohort studies, however, have supported a significant increase in risk for criminal offending with ADHD, even after controlling for OD and CDD co-morbidity.⁵² One particularly prominent theory regarding the association between ADHD

Hirayasu, and Kiyoshi Wada, 'Drug Preferences in Illicit Drug Abusers with a Childhood Tendency of Attention Deficit/Hyperactivity Disorder: A Study Using the Wender Utah Rating Scale in a Japanese Prison', *Psychiatry and Clinical Neurosciences* 59 (2005), pp. 311–8; Susan Young, Gisli Gudjonsson, Sarah Ball, and Jenny Lam, 'Attention Deficit Hyperactivity Disorder (ADHD) in Personality Disordered Offenders and the Association with Disruptive Behavioural Problems', *The Journal of Forensic Psychiatry & Psychology* 14 (2003), pp. 491–505; Gisli H. Gudjonsson, Jon F. Sigurdsson, Susan Young, Anna K. Newton, Marius Peersen, 'Attention Deficit Hyperactivity Disorder (ADHD). How Do ADHD Symptoms Relate to Personality Among Prisoners?', *Personality and Individual Differences* 47 (2009), pp. 64–8; M. Rosler, W. Retz, P. Retz-Junginger, G. Henges, M. Schneider, T. Supprian, P. Schwitzgebel, K. Pinhard, N. Dovi-Akue, P. Wender, and J. Thome, 'Prevalence of Attention Deficit-/Hyperactivity Disorder (ADHD) and Comorbid Disorders in Young Male Prison Inmates', *European Archives of Psychiatry and Clinical Neuroscience* 254 (2004), pp. 365–71.

⁵⁰ Guilherme Polanczyk, Maurício S. de Lima, Bernardo L. Horta, Joseph Biederman, and Luis A. Rohde, 'The Worldwide Prevalence of ADHD: A Systematic Review and Meta-regression Analysis', *The American Journal of Psychiatry* 164 (2007), pp. 942–8.

⁵¹ Catrina M. Schilling, Anthony Walsh, Ilhong Yun, 'ADHD and Criminality: A Primer on the Genetic, Neurobiological, Evolutionary, and Treatment Literature for Criminologists', *Journal of Criminal Justice* 39 (2011), pp. 3-11.

⁵² Leslie M. Babinski, Carolyn S. Hartsough, Nadine M. Lambert, 'Childhood Conduct Problems, Hyperactivity-impulsivity, and Inattention as Predictors of Adult Criminal Activity', *The Journal of Child Psychology and Psychiatry* 40 (1999), pp. 347-55; Terrie E. Moffitt, 'Juvenile Delinquency and Attention Deficit Disorder: Boys' Developmental Trajectories from Age 3 to Age 15', *Child Development* 61 (1990), pp. 893–910; Travis C. Pratt, Francis T. Cullen, Kristie R. Blevins, Leah Daigle, James D. Unnever, 'The Relationship of Attention Deficit Hyperactivity Disorder to Crime and Delinquency: a Meta-Analysis', *International Journal of Police Science & Management* 4 (2002), pp. 344–60; James H. Satterfield, Katherine J. Faller, Francis M. Crinella, Anne M. Schell, James M. Swanson, Louis D. Homer, 'A 30-Year Prospective Follow-Up Study

and criminality in the criminology literature is that it results from the poor impulse control often seen in ADHD.⁵³

Fortunately, ADHD is also one of the most successfully treatable psychiatric conditions.⁵⁴

Stimulant medications, such as methylphenidate, have been found effective in treating the disorder in numerous large and well-designed randomized controlled trials.⁵⁵ A review of the literature by the American Academy of Paediatrics strongly supported the effectiveness of stimulant medications in treating symptoms of ADHD.⁵⁶

of Hyperactive Boys with Conduct Problems: Adult Criminality', *Journal of the American Academy of Child & Adolescent Psychiatry* 46 (2007), pp. 601–10; J. Biederman, C. R. Petty, C. Dolan, S. Hughes, E. Mick, M. C. Monuteaux, S. V. Faraone, 'The Long-Term Longitudinal Course of Oppositional Defiant Disorder and Conduct Disorder in ADHD Boys: Findings from a Controlled 10-Year Prospective Longitudinal Follow-Up Study', *Psychological Medicine* 38 (2008), pp. 1027–36; Salvatore Mannuzza, Rachel G. Klein, John L. Moulton III, 'Lifetime Criminality Among Boys with Attention Deficit Hyperactivity Disorder: A Prospective Follow-Up Study into Adulthood Using Official Arrest Records', *Psychiatry Research* 160 (2008), pp. 237–46; Margaret H. Sibley, William E. Pelham, Brooke S. G. Molina, Elizabeth M. Gnagy, Daniel A. Waschbusch, Aparajita Biswas, Michael G. MacLean, Dara E. Babinski, Kathryn M. Karch, 'The Delinquency Outcomes of Boys with ADHD with and Without Comorbidity', *Journal of Abnormal Child Psychology* 39 (2011), pp. 21–32.

⁵³ Schilling, Walsh, Yun, 'ADHD and Criminality'.

⁵⁴ Russell A. Barkley, Kevin R. Murphy, Mariellen Fischer, *ADHD in Adults: What the Science Says* (New York: Guilford Press, 2010).

⁵⁵ The MTA Cooperative Group, 'A 14-Month Randomized Clinical Trial of Treatment Strategies for Attention-Deficit/Hyperactivity Disorder', *Archives of General Psychiatry* 56 (1999), pp. 1073–86; Joseph Biederman, Suma Krishnan, Yuxin Zhang, James J. McGough, Robert L. Findling, 'Efficacy and Tolerability of Lisdexamfetamine Dimesylate (NRP-104) in Children with Attention-Deficit/Hyperactivity Disorder: A Phase III, Multicenter, Randomized, Double-Blind, Forced-Dose, Parallel-Group Study', *Clinical Therapeutics* 29 (2007), pp. 450–463; Howard M. Schachter, Ba' Pham, Jim King, Stephanie Langford, David Moher, 'How Efficacious and Safe Is Short-Acting Methylphenidate for the Treatment of Attention-Deficit Disorder in Children and Adolescents? A Meta-Analysis', *Canadian Medical Association Journal* 165 (2001), pp. 1475–88; A. R. Jadad, M. Boyle, C. Cunningham, M. Kim, R. Schachar, 'Treatment of Attention-Deficit/Hyperactivity Disorder: Summary', in *AHRQ Evidence Report Summaries* (Rockville, MD: Agency for Healthcare Research and Quality, 1999).

⁵⁶ Ronald T. Brown, Robert W. Amler, Wendy S. Freeman W, James M. Perrin, Martin T. Stein, Heidi M. Feldman, Karen Pierce, Mark L. Wolraich, 'Treatment of Attention-Deficit/Hyperactivity Disorder: Overview of the Evidence', *Pediatrics* 115 (2005), pp. e749–57.

As ADHD is strongly associated with criminal offending, the effective treatment of this condition might be expected to reduce the risk of criminal behaviour. A recent large Swedish retrospective cohort study has reported findings that support this conclusion⁵⁷ – in 25,565 adult subjects diagnosed with ADHD, the untreated control group had an overall 12% increased risk of criminal conviction during the follow-up period compared to the treated group. Despite the open-label design and reliance on registry data, the results were statistically significant and robust under multiple sensitivity analyses.

2.4 Modulating serotonin levels to attenuate aggression

Another promising area of recent interest has been the role that different neurotransmitter systems play in mediating social behaviour. This has included work examining the effects of oxytocin on trust,⁵⁸ adrenaline on racial bias,⁵⁹ and serotonin on various aspects of social behaviour. In what follows we briefly exemplify this research by setting out some of the relevant findings regarding serotonin.

⁵⁷ Paul Lichtenstein, Linda Halldner, Johan Zetterqvist, Arvid Sjolander, Eva Serlachius E, Seena Fazel, Niklas Långström, Henrik Larsson, ‘Medication for Attention Deficit-Hyperactivity Disorder and Criminality’, *The New England Journal of Medicine* 367 (2012), pp. 2006–14.

⁵⁸ Michael Kosfeld, Markus Heinrichs, Paul J. Zak, Urs Fischbacher, Ernst Fehr, ‘Oxytocin Increases Trust in Humans’, *Nature* 435 (2005), pp. 673–6; Paul J. Zak, Robert Kurzban, William T. Matzner, ‘Oxytocin Is Associated with Human Trustworthiness’, *Hormones and Behavior* 48 (2005), pp. 522–7; Carsten K. W. De Dreu, Lindred L. Greer, Michael J. J. Handgraaf, Shaul Shalvi, Gerben A. Van Kleef, Matthijs Baas, Femke S. Ten Velden, Eric Van Dijk, ‘The Neuropeptide Oxytocin Regulates Parochial Altruism in Intergroup Conflict Among Humans’, *Science* 328 (2010), pp. 1408–11; Carsten K. W. De Dreu, ‘Oxytocin Modulates Cooperation Within and Competition Between Groups: An Integrative Review and Research Agenda’, *Hormones and Behavior* 61 (2012), pp. 419–28; Thomas Baumgartner, Markus Heinrichs, Aline Vonlanthen, Urs Fischbacher, Ernst Fehr, ‘Oxytocin Shapes the Neural Circuitry of Trust and Trust Adaptation in Humans’, *Neuron* 58 (2008), pp. 639–50.

⁵⁹ Sylvia Terbeck, Guy Kahane, Sarah McTavish, Julian Savulescu, Philip J. Cowen, Miles Hewstone, ‘Propranolol Reduces Implicit Negative Racial Bias’, *Psychopharmacology* 222 (2012), pp. 419–24.

There is an enormous body of animal research literature concerning the relationship between the neurotransmitter serotonin and social behaviour, implicating it in behaviours ranging from parental attachment and mating, to co-operation and aggression. In particular, lower central serotonin levels were associated with increased *proactive*⁶⁰ aggression in mice, and a number of genes involved in the synthesis and metabolism of serotonin have been associated with aggressive behaviours.⁶¹

In humans, the serotonergic neurotransmitter system has been implicated in aggression and antisocial behaviour, though its role has not been fully elucidated.⁶² Levels of a serotonin metabolite in cerebrospinal fluid, for example, are significantly lower in antisocial subjects compared to healthy controls.⁶³ Variations in the gene coding for MAOA, an enzyme in the brain that breaks down serotonin, have also been strongly associated with aggressive behaviour in certain social contexts.⁶⁴ A mutation in the gene

⁶⁰ That is, goal-directed aggression to achieve a final purpose other than physical violence (e.g. robbery). This is in contrast to *reactive* aggression, in response to perceived hostility.

⁶¹ Dominik Kiser, Ben Steemer, Igor Branchi, Judith R. Homberg, 'The Reciprocal Interaction Between Serotonin and Social Behaviour', *Neuroscience & Behavioral Reviews* 36 (2012), pp. 786–98.

⁶² G. L. Brown, M. H. Ebert, P. F. Goyer, D. C. Jimerson, W. J. Klein, W. E. Bunney, F. K. Goodwin, 'Aggression, Suicide, and Serotonin: Relationships to CSF Amine Metabolites', *The American Journal of Psychiatry* 139 (1982), pp. 741–6.

⁶³ Todd M. Moore, Angela Scarpa, Adrian Raine, 'A Meta-Analysis of Serotonin Metabolite 5-HIAA and Antisocial Behavior', *Aggressive Behavior* 28 (2002), pp. 299–316.

⁶⁴ Yung-yu Huang, Sarah P. Cate, Cristina Battistuzzi, Maria A. Oquendo, David Brent, J. John Mann, 'An Association Between a Functional Polymorphism in the Monoamine Oxidase a Gene Promoter, Impulsive Traits and Early Abuse Experiences', *Neuropsychopharmacology* 29 (2004), pp. 1498–505; Avshalom Caspi, Joseph McClay, Terrie E. Moffitt, Jonathan Mill, Judy Martin, Ian W. Craig, Alan Taylor, Richie Poulton, 'Role of Genotype in the Cycle of Violence in Maltreated Children', *Science* 297 (2002), pp. 851–4; Debra L. Foley, Lindon J. Eaves, Brandon Wormley, Judy Silberg, Hermine H. Maes, Jonathan Kuhn, Brien Patrick Riley, 'Childhood Adversity, Monoamine Oxidase A Genotype, and Risk for Conduct Disorder', *Archives of General Psychiatry* 61 (2004), pp. 738–44; Kent W. Nilsson, Rickard L. Sjöberg, Mattias Damberg, Jerzy Leppert, John Öhrvik, Per Olof Alm, Leif Lindström, Lars Oreland, 'Role of Monoamine Oxidase A Genotype and Psychosocial Factors in Male Adolescent Criminal

coding for the 5-HT_{2B} serotonin receptor has also been identified in a series of violent Finnish offenders, and subsequent experiments in mice suggest it is associated with increased levels of impulsivity and aggressive behaviours.⁶⁵

The *serotonin deficiency hypothesis* – that levels of brain serotonin are inversely correlated with aggressive behaviour – is currently the most popular explanation of the relationship. Some support for this hypothesis can be derived from a series of studies which assessed the effects of acute tryptophan depletion on aggressive behaviours. Tryptophan is an amino acid that is a metabolic precursor to serotonin, and reduction in circulating blood plasma levels is a validated experimental method to indirectly reduce brain serotonin levels.⁶⁶ The studies found that depletion of tryptophan, and thus of neural serotonin, significantly increased behavioural and self-reported measures of aggression, with greater effects in those with aggressive tendencies.⁶⁷ Conversely, a randomised,

Activity’, *Biological Psychiatry* 59 (2006), pp. 121–7.

⁶⁵ Laura Bevilacqua, Stéphane Doly, Jaakko Kaprio, Qiaoping Yuan, Roope Tikkanen, Tiina Paunio, et al., ‘A Population-Specific HTR_{2B} Stop Codon Predisposes to Severe Impulsivity’, *Nature* 468 (2010), pp. 1061–6.

⁶⁶ Sean D. Hood, Caroline J. Bell, David J. Nutt, ‘Acute Tryptophan Depletion. Part I: Rationale and Methodology’, *Australian and New Zealand Journal of Psychiatry* 39 (2005), pp. 558–64; Molly J. Crockett, Luke Clark, Jonathan Roiser, Oliver J. Robinson, Roshan Cools, Henry W. Chase, et al., ‘Converging Evidence for Central 5-HT Effects in Acute Tryptophan Depletion’, *Molecular Psychiatry* 17 (2012), pp. 121–3.

⁶⁷ Donald M. Dougherty, James M. Bjork, Dawn M. Marsh, F. Gerard Moeller, ‘Influence of Trait Hostility on Tryptophan Depletion-Induced Laboratory Aggression’, *Psychiatry Research* 88 (1999), pp. 227–32; James M. Bjork, ‘Behavioral Effects of Plasma Tryptophan Depletion in Aggressive and Nonaggressive Men’, *Texas Medical Center Dissertations (via ProQuest)* (1999). Available at http://search.proquest.com/docview/304576742?accountid=14553%5Cnhttp://openurl.library.uiuc.edu/sfxlcl3?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&genre=dissertations+%26+theses&sid=ProQ:ProQuest+Dissertations+%26+Theses+Full+Text&ati; F. Gerard Moeller, Donald M. Dougherty, Alan C. Swann, Diana Collins, Chester M. Davis, Don R. Cherek, ‘Tryptophan Depletion and Aggressive Responding in Healthy Males’, *Psychopharmacology* 126 (1996), pp. 97–103; James M. Bjork, Donald M. Dougherty, F. Gerard Moeller, Don R. Cherek, Alan C.

controlled double-blind study found that augmentation of central serotonin levels by administration of SSRIs⁶⁸ attenuated aggressive responses, particularly in participants with a history of aggression.⁶⁹

A recent comprehensive meta-analysis of over 6,500 total participants in 175 studies and across four different experimental methods tested the validity of this *serotonin deficiency hypothesis*, and found a small, but reliable inverse relationship between serotonin levels and aggression.⁷⁰ The investigators noted, however, that there was significant heterogeneity in results of studies within similar experimental methods.

More specifically, a number of recent reviews have also suggested that serotonin deficiency may be more closely related to *impulsive* (as opposed to instrumental) aggression.⁷¹ Impulsive aggression is usually characterised as a reactive, emotional

Swann, 'The Effects of Tryptophan Depletion and Loading on Laboratory Aggression in Men: Time Course and a Food-Restricted Control', *Psychopharmacology* 142 (1999), pp. 24–30; A. J. Cleare, A. J. Bond, 'The Effect of Tryptophan Depletion and Enhancement on Subjective and Behavioural Aggression in Normal Male Subjects', *Psychopharmacology* 118 (1995), pp. 72–81.

⁶⁸ Selective Serotonin Reuptake Inhibitors are agents that reduce the reuptake of serotonin at the synapse, and thus increase synaptic serotonin levels.

⁶⁹ Mitchell E. Berman, Michael S. McCloskey, Jennifer R. Fanning, Julie A. Schumacher, Emil F. Coccaro, 'Serotonin Augmentation Reduces Response to Attack in Aggressive Individuals', *Psychol Science* 20 (2009), pp. 714–20.

⁷⁰ Aaron A. Duke, Laurent Bègue, Rob Bell, Tory Eisenlohr-Moul, 'Revisiting the Serotonin-Aggression Relation in Humans: A Meta-Analysis', *Psychological Bulletin* 139 (2013), pp. 1148–72.

⁷¹ Dongju Seo, Christopher J. Patrick, Patrick J. Kennealy, 'Role of Serotonin and Dopamine System Interactions in the Neurobiology of Impulsive Aggression and its Comorbidity with Other Clinical Disorders', *Aggression and Violent Behavior* 13 (2008), pp. 383–95; Estrella R. Montoya, David Terburg, Peter A. Bos, Jack van Honk, 'Testosterone, Cortisol, and Serotonin as Key Regulators of Social Aggression: A Review and Theoretical Perspective', *Motivation and Emotion* 36 (2012), pp. 65–73; Emil F. Coccaro, Jennifer R. Fanning, K. Luan Phan, Royce Lee, 'Serotonin and Impulsive Aggression', *CNS Spectrums* 20 (2015), pp. 295–302; Daniel R. Rosell, Larry J. Siever, 'The Neurobiology of Aggression and Violence', *CNS Spectrums* 20 (2015), pp. 254–79.

response to a provocative stimulus, and is associated with antisocial personality disorder. Instrumental aggression, on the other hand, is described as pre-meditated, less emotionally motivated, and carried out with the intent of achieving a particular goal or reward, and is associated with psychopathy.

If serotonin deficiency increases aggression, it might be expected also to contribute to the occurrence of certain kinds of violent and sexual crime. Further, we might speculate that drugs which increase serotonin levels will tend to diminish the likelihood that an individual will commit such crimes. These thoughts remain highly speculative, however; we are not aware of any high quality studies directly investigating the effect of serotonin levels or SSRIs on criminality.

There is also a further mechanism via which serotonin neurobiology might influence criminality. Recent work by Crockett et al. suggests that depletion of tryptophan tends to increase the degree to which individuals will sacrifice their own interests in order to punish those who have treated them unfairly; that is, it seems to strengthen the disposition to engage in costly retaliation.⁷²

How might this be useful in developing future interventions to reduce criminality? It has been suggested that retaliatory dispositions are, in at least some instances, implicated in violent or criminal behaviour. The psychologist Stephen Pinker argues that one contributor to violent behaviour is a combination of retaliatory dispositions and positive

⁷² Molly J. Crockett, Annemieke Apergis-Schoute, Benedikt Herrmann, Matthew D. Lieberman, Ulrich Müller, Trevor W. Robbins, Luke Clark, 'Serotonin Modulates Striatal Responses to Fairness and Retaliation in Humans', *The Journal of Neuroscience* 33 (2013), pp. 3505–13.

self-evaluation.⁷³ That is, certain criminal behaviour (e.g. blood feuds, retaliatory violence, and code-of-honour retribution) is the result of a desire to mete out ‘justice’, as well as an unfortunate tendency to think that we are, more often than not, on the aggrieved side. It is not implausible that dampening this drive for retaliation might be a means of reducing criminal or violent behaviour.⁷⁴

3. Nutritional interventions

Adequate nutrition, particularly at critical stages in early life, is important for normal neurodevelopment, and poor nutrition increases the risk of developmental and psychiatric disorders later in life. Severe malnutrition in the first and second trimesters,⁷⁵ for example, has been associated with a significantly greater rate of antisocial personality

⁷³ Steven Pinker, *The Better Angels of Our Nature: The Decline of Violence in History and Its Causes* (London: Penguin UK, 2011).

⁷⁴ Of note, highly-publicised concerns that have emerged in the last decade that SSRIs instead *increase* the risk of violent and aggressive behaviour (David Healy, ‘Lines of Evidence on the Risks of Suicide with Selective Serotonin Reuptake Inhibitors’, *Psychotherapy and Psychosomatics* 72 (2003), pp. 71-9). Such claims remain controversial (Marie-Thérèse Walsh, Timothy G. Dinan, ‘Selective Serotonin Reuptake Inhibitors and Violence: A Review of the Available Evidence’, *Acta Psychiatrica Scandinavica* 104 (2001), pp. 84-91; Paul F. Bouvy, Marieke Liem, ‘Antidepressants and Lethal Violence in the Netherlands 1994-2008’, *Psychopharmacology* 222 (2012), pp. 499-506) as they rely largely on support from anecdotal case reports and contentious re-analysis of incomplete, unpublished internal pharmaceutical company data (David Healy, Andrew Herxheimer, David B. Menkes, ‘Antidepressants and Violence: Problems at the Interface of Medicine and Law’, *PLOS Medicine* 3 (2006), pp. 1478-1486; Tarang Sharma, Louise S. Guski, Nanna Freund, Peter C. Gøtzsche, ‘Suicidality and Aggression During Antidepressant Treatment: Systematic Review and Meta-Analyses Based on Clinical Study Reports’, *BMJ* 352 (2016), i65; Andreas Ø Bielefeldt, Pia B. Danborg, Peter C. Gøtzsche, ‘Precursors to Suicidality and Violence on Antidepressants: Systematic Review of Trials in Adult Healthy Volunteers’, *Journal of the Royal Society of Medicine* 109 (2016), pp. 381-92). It is the authors’ view that such claims are currently unsupported by the existing literature (Bernadka Dubicka, Alys Cole-King, Shirley Reynolds, Paul Ramchadani, ‘Paper on Suicidality and Aggression During Antidepressant Treatment Was Flawed and the Press Release Was Misleading’, *BMJ* 352 (2016), i911), but interested readers should refer to the citations above.

⁷⁵ Richard Neugebauer, Hans W. Hoek, Ezra Susser, ‘Prenatal Exposure to Wartime Famine and Development of Antisocial Personality Disorder in Early Adulthood’, *JAMA* 282 (1999), pp. 455–62.

disorder in later life. This is a psychiatric condition characterized by impulsivity, aggression, disregard for others, and criminal behaviour.⁷⁶

Postnatally, early childhood malnutrition is also associated with an increased risk of externalising behaviours – aggression, hyperactivity, attention problems and delinquency – in later childhood and teenage years. Such behaviours are themselves a significant risk factor for juvenile delinquency, and criminal offending and violence in adulthood.⁷⁷ A large prospective longitudinal study of 1795 Mauritian children⁷⁸ found that malnourishment at age 3 was associated with significantly higher overall rating for externalising behaviours at ages 8, 11 and 17 years. This relationship was independent of gender, ethnicity, and psychosocial adversity (captured by adverse parental, family, or housing factors), but controlling for cognitive ability (IQ) abolished the main effects of malnutrition in the statistical analysis. This suggests that poor neurodevelopment may be the causal link between malnourishment and subsequent externalising behaviour. A smaller prospective cohort study of 213 Jamaican children⁷⁹ assessed the effect of early childhood stunting on psychosocial functioning and behaviour in later childhood and adolescence. Stunting (growth retardation) is associated with under-nutrition and

⁷⁶ American Psychiatric Association, ‘Personality Disorders’, in *Diagnostic and Statistical Manual of Mental Disorders: DSM-5* (Washington, D.C: American Psychiatric Association, 2013), p. 991.

⁷⁷ Jianghong Liu, ‘Childhood Externalizing Behavior: Theory and Implications’, *Journal of Child and Adolescent Psychiatric Nursing* 17 (2001), pp. 93–103.

⁷⁸ Jianghong Liu, Adrian Raine, Peter H. Venables, Sarnoff A. Mednick, ‘Malnutrition at Age 3 Years and Externalizing Behavior Problems at Ages 8, 11, and 17 Years’, *The American Journal of Psychiatry* 161 (2004), pp. 2005–13.

⁷⁹ Susan P. Walker, Christine A. Powell, Sally M. Grantham-McGregor, John H. Himes, Susan M. Chang, ‘Nutritional Supplementation, Psychosocial Stimulation, and Growth of Stunted Children: The Jamaican Study’, *The American Journal of Clinical Nutrition* 54 (1991), pp. 642–8.

infectious diseases, and is particularly common in areas of low socioeconomic status. Children who experienced early stunting had increased prevalence of antisocial and oppositional behaviours in late adolescence⁸⁰ in comparison to their non-stunted peers. A report on a cohort of Barbadian children⁸¹ who experienced a limited episode of protein-energy malnutrition also suggested that they were more likely, in comparison to healthy controls, to display aggressive behaviour towards their peers, oppositional-defiant behaviours towards adults, and attention-deficit issues in later childhood (ages 5-11). These behaviours persisted through to late adolescence (ages 11-17) but were somewhat attenuated.⁸²

More reassuringly, however, there is some evidence to suggest that early malnutrition is at least partially amenable to mitigation through early intervention programs including nutritional supplementation.⁸³ Individuals who have not experienced malnutrition may also benefit from nutritional supplementation, with a number of studies showing behavioural improvements in ‘healthy’ cohorts. There have been, to date, three well-designed, randomised controlled trials of nutritional supplementation in young adult

⁸⁰ Susan M. Chang, Susan P. Walker, Sally M. Grantham-McGregor, Christine A. Powell, ‘Early Childhood Stunting and Later Behaviour and School Achievement’, *Journal of Child Psychology and Psychiatry* 43 (2002), pp. 775-83.

⁸¹ Janina R. Galler, Cyralene P. Bryce, Deborah P. Waber, Rebecca S. Hock, Robert Harrison, G. David Eaglesfield, GarretT Fitzmaurice, ‘Infant Malnutrition Predicts Conduct Problems in Adolescents’, *Nutritional Neuroscience* 15 (2012), pp. 186–92.

⁸² Janina R. Galler, Cyralene P. Bryce, Deborah P. Waber, Gayle Medford, G. David Eaglesfield, Garrett Fitzmaurice, ‘Early Malnutrition Predicts Parent Reports of Externalizing Behaviors at Ages 9-17’, *Nutritional Neuroscience* 14 (2011), pp. 138–44.

⁸³ Adrian Raine, Kjetil Mellingen, Jianghong Liu, Peter H. Venables, Sarnoff A. Mednick, ‘Effects of Environmental Enrichment at Ages 3-5 Years on Schizotypal Personality and Antisocial Behavior at Ages 17 and 23 Years’, *The American Journal of Psychiatry* 160 (2003), pp. 1627–35.

prisoners, all of which have suggested that they produce a robust and significant improvement in behaviour.

The earliest, by Schoenthaler et al, was a double-blinded randomised controlled trial in 62 inmates of a maximum-security psychiatric facility aged between 13 and 17.⁸⁴ The subjects were given supplements containing high-dose minerals and vitamins over an experimental period of 13 weeks. Nutritional status assessment and dietary advice was also given to all subjects, regardless of whether they were in the active or placebo group. Voluntary blood samples before, and after, the experiment were also collected for about half the study group. Compared to the 13-week initial baseline period, violent infractions fell 80% in the active group (56% in the placebo group); non-violent infractions fell 83% (49% with placebo); and total infractions fell 83% (55% with placebo). The treatment effect for supplementation was 4.236 (p=0.044) for violent infractions; 7.646 (p=0.008) for non-violent rule infractions; and 8.517 (p=0.005) for total rule infractions. There were also some indications that this decrease in rule-breaking was mediated by underlying changes in nutrient levels, with improvements in behaviour correlating with correction of pre-experimental nutrient deficiencies.

A second double-blinded, randomised controlled trial of 231 young inmates in the United Kingdom also strongly suggested that nutritional supplementation (including omega fatty

⁸⁴ Stephen J. Schoenthaler, Stephen Amos, Walter Doraz, Mary-Ann Kelly, George Muedeking, James Wakefield Jr, 'The Effect of Randomised Vitamin-Mineral Supplementation on Violent and Non-Violent Antisocial Behavior Among Incarcerated Juveniles', *Journal of Nutritional & Environmental Medicine* 7 (1997), pp. 343–52.

acids) was effective in reducing antisocial behaviour in the prison system.⁸⁵ An intention-to-treat analysis found that inmates on supplementation committed, overall, 26.3% fewer disciplinary offenses compared to those on placebo ($p < 0.03$). A more specific analysis excluding drop-outs and subjects who showed poor compliance or were started on psychotropic medication found a more pronounced decrease in disciplinary incidents of 35.1% (compared to 6.7% for placebo), which was particularly pronounced for serious (including violent) offenses.

Zaalberg et al. attempted to reproduce these results, conducting a similar study in a Dutch cohort of young prisoners, enlisting 326 subjects.⁸⁶ 105 (32%) did not complete the trial, mainly for practical reasons including early release or transfer, and no significant differences in a variety of characteristics were found between completers and drop-outs. The results of the trial replicated a significant reduction in rule-breaking incidents with supplementation, as well as non-significant improvements in scores of aggression and psychological wellbeing. One note of caution, however, is that there were indications that participants managed, in one way or another, to identify whether they were treatment or placebo group, with a significant increase in correct guesses of group assignments throughout the trial. Thus, it is possible that differences between the groups were due to differences in expectations rather than the treatment itself.

⁸⁵ C. Bernard Gesch, Sean M. Hammond, Sarah E. Hampson, Anita Eves, Martin J. Crowder, 'Influence of Supplementary Vitamins, Minerals and Essential Fatty Acids on the Antisocial Behaviour of Young Adult Prisoners. Randomised, Placebo-Controlled Trial', *British Journal of Psychiatry* 181 (2002), pp. 22–8.

⁸⁶ Ap Zaalberg, Henk Nijman, Erik Bulten, Luwe Stroosma, Cees van der Staak, 'Effects of Nutritional Supplements on Aggression, Rule-Breaking, and Psychopathology Among Young Adult Prisoners', *Aggressive Behavior* 36 (2010), pp. 117–26.

Overall, there is a substantial body of evidence suggesting that adequate nutrition in the pre-natal, post-natal, and childhood periods is essential to normal behavioural development, and that, conversely, malnutrition increases the risk of antisocial and delinquent behaviour later in life. These behavioural sequelae of early childhood malnutrition appear to be at least partially reversible by appropriate programs of enrichment and nutrition. This would seem to indicate a simple and promising means of intervening to reduce future risk of criminality in at-risk populations and young delinquents. Even more intriguing is the aforementioned small but high-quality body of evidence suggesting that nutritional supplementation can rapidly and substantially reduce antisocial and rule-breaking behaviour in prisoners, perhaps through the correction of underlying micronutrient deficiencies. Whatever the mechanism, and pending further investigation and replication in the post-release setting, this may present a cheap, effective, and readily available means of reducing recidivism and criminal behaviour.

4. Brain stimulation techniques

One further mode of intervention that may, speculatively, be capable of modulating dispositions to violently offend is the family of interventions that can be loosely referred to as *electromagnetic brain stimulation* (EBS): deep brain stimulation (DBS), transcranial magnetic stimulation (TMS) and transcranial direct-current stimulation (tDCS). Each of these involves the application of magnetic fields or electrical currents, via different methods, to specific areas of the brain, with the aim of modulating brain activity. DBS involves the invasive neurosurgical placement of metal electrodes within the brain to

transmit electrical impulses.⁸⁷ TMS and tDCS, on the other hand, non-invasively induce changes in brain activity through the use of superficial magnets⁸⁸ and electrodes⁸⁹ respectively. These two modes have a shallow depth of effective penetration relative to DBS and are thus only able to affect relatively superficial brain regions.⁹⁰ Recent developments in TMS technology, though, suggest it may be possible to extend this range.⁹¹ Both DBS and TMS already have FDA-approved medical indications: the former for essential tremor and Parkinson's disease,⁹² dystonia⁹³ and obsessive-compulsive disorder;⁹⁴ and the latter for migraine⁹⁵ and treatment-resistant depression.⁹⁶

⁸⁷ Joel S. Perlmutter, Jonathan W. Mink, 'Deep Brain Stimulation', *Annual Review of Neuroscience* 29 (2006), pp. 229–57.

⁸⁸ Mark Hallett, 'Transcranial Magnetic Stimulation and the Human Brain', *Nature* 406 (2000), pp. 147–50.

⁸⁹ Michael A. Nitsche, Leonardo G. Cohen, Eric M. Wassermann, Alberto Priori, Nicolas Lang, Andrea Antal, et al., 'Transcranial Direct Current Stimulation: State of the Art 2008', *Brain Stimulation* 1 (2008), pp. 206–23.

⁹⁰ Dylan Edwards, Mar Cortes, Abhishek Datta, Preet Minhas, Eric M. Wassermann, Marom Bikson, 'Physiological and Modeling Evidence for Focal Transcranial Electrical Brain Stimulation in Humans: A Basis for High-Definition tDCS', *NeuroImage* 74 (2013), pp. 266–75; Zhi-De Deng, Sarah H. Lisanby, Angel V. Peterchev, 'Electric Field Depth-Focality Tradeoff in Transcranial Magnetic Stimulation: Simulation Comparison of 50 Coil Designs', *Brain Stimulation* 6 (2013), pp. 1–13.

⁹¹ Yiftach Roth, Alon Amir, Yechiel Levkovitz, Abraham Zangen, 'Three-Dimensional Distribution of the Electric Field Induced in the Brain by Transcranial Magnetic Stimulation Using Figure-8 and Deep H-Coils', *Journal of Clinical Neurophysiology* 24 (2007), pp. 31–8.

⁹² FDA, 'FDA Approves Brain Implant to Help Reduce Parkinson's Disease and Essential Tremor Symptoms'. Available at <http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm451152.htm>.

⁹³ FDA Pediatric Advisory Committee, 'FDA Executive Summary: Medtronic Activa Neurostimulator for Dystonia Treatment'.

⁹⁴ FDA, 'FDA Approves Humanitarian Device Exemption for Deep Brain Stimulator for Severe Obsessive-Compulsive Disorder'. Available at <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm149529.htm>.

⁹⁵ FDA, 'Treating Migraines: More Ways to Fight the Pain', *FDA's Consumer Health Information*. Available at <http://www.fda.gov/downloads/forconsumers/consumerupdates/ucm414816.pdf>.

⁹⁶ FDA, 'Neurostar TMS System Evaluation of Automatic Class III Designation'. Available at http://www.accessdata.fda.gov/cdrh_docs/pdf6/k061053.pdf.

More recently, the use of EBS interventions to therapeutically alter cognitive, psychological and behavioural outcomes has been explored, although this possibility remains largely speculative. This has not, however, dampened enthusiasm, and the resulting popularity and proliferation of mass-market “DIY brain stimulation kits” have necessitated serious considerations about the appropriate way to regulate such devices.⁹⁷

How might EBS interventions be useful in preventing or reducing criminal conduct? The basic thought is that it could be used to up- or down-regulate brain activity in the brain regions responsible for modulating (anti-)social behaviour.

It is important to recognise that there are a variety of interventions already in use, aside from EBS, that alter both brain structure and functional activity and human behaviour—including psychotherapies⁹⁸ such as cognitive behavioural therapy⁹⁹ and mindfulness

⁹⁷ Hannah Maslen, Thomas Douglas, Roi Cohen Kadosh, Neil Levy, Julian Savulescu, ‘The Regulation of Cognitive Enhancement Devices: Extending the Medical Model’, *Journal of Law and the Biosciences* 1 (2014), pp. 68-93.

⁹⁸ Amit Etkin, Christopher Pittenger, H. Jonathan Polan, Eric R. Kandel, ‘Toward a Neurobiology of Psychotherapy: Basic Science and Clinical Applications’, *The Journal of Neuropsychiatry and clinical neurosciences* 17 (2005), pp. 145–58.

⁹⁹ Vincent Paquette, Johanne Lévesque, Boualem Mensour, Jean-Maxime Leroux, Gilles Beaudoin, Pierre Bourgouin, Mario Beaugard, ““Change the Mind and You Change the Brain”: Effects of Cognitive-Behavioral Therapy on the Neural Correlates of Spider Phobia’, *NeuroImage* 18 (2003), pp. 401–9; Richard A. Bryant, Kim Felmingham, Andrew Haddon Kemp, Pritha Das, G. Hughes, Anthony Peduto, Leanne M. Williams, ‘Amygdala and Ventral Anterior Cingulate Activation Predicts Treatment Response to Cognitive Behaviour Therapy for Post-Traumatic Stress Disorder’, *Psychological Medicine* 38 (2008), pp. 555–61; Greg J. Siegle, Cameron S. Carter, Michael E. Thase, ‘Use of fMRI to Predict Recovery from Unipolar Depression with Cognitive Behavior Therapy’, *The American Journal of Psychiatry* 163 (2006), pp. 735–8; Maureen Ritchey, Florin Dolcos, Kari M. Eddington, Timothy J. Strauman, Roberto Cabeza, ‘Neural Correlates of Emotional Processing in Depression: Changes with Cognitive Behavioral Therapy and Predictors of Treatment Response’, *Journal of Psychiatric Research* 45 (2011), pp. 577–87.

meditation.¹⁰⁰ EBS interventions aim to produce similar outcomes, but improve specificity and reliability through targeting brain activity as a means to behavioural outcomes. To illustrate this, consider *neurofeedback*, a novel technique that is arguably midway between traditional therapies and EBS. Neurofeedback utilises real-time functional magnetic resonance imaging (rtfMRI) and biofeedback methods to train subjects to consciously modulate levels of brain activity in specific regions of interest.¹⁰¹ In other words, neurofeedback arguably constitutes a form of non-electrical brain stimulation; and already studies suggest that it can produce corresponding behavioural changes associated with stimulation of these brain areas, including emotional processing,¹⁰² linguistic ability,¹⁰³ and even reductions in chronic pain.¹⁰⁴

¹⁰⁰ Richard J. Davidson, Jon Kabat-Zinn, Jessica Schumacher, Melissa Rosenkranz, Daniel Muller, Saki Santorelli, et al., 'Alterations in Brain and Immune Function Produced by Mindfulness Meditation', *Psychosomatic Medicine* 65 (2003), pp. 564-70; Britta K. Hölzel, James Carmody, Mark Vangel, Christina Congleton, Sita M. Yerramsetti, Tim Gard T, Sara W. Lazar, 'Mindfulness Practice Leads to Increases in Regional Brain Gray Matter Density', *Psychiatry Research: Neuroimaging* 191 (2011), pp. 36-43.

¹⁰¹ Nikolaus Weiskopf, Frank Scharnowski, Ralf Veit, Rainer Goebel, Niels Birbaumer, Klaus Mathiak, 'Self-Regulation of Local Brain Activity Using Real-Time Functional Magnetic Resonance Imaging (fMRI)', *Journal of Physiology-Paris* 98 (2004), pp. 357-73; Andrea Caria, Ralf Veit, Ranganatha Sitaram, Martin Lotze, Nikolaus Weiskopf, Wolfgang Grodd, Niels Birbaumer, 'Regulation of Anterior Insular Cortex Activity Using Real-Time fMRI', *NeuroImage* 35 (2007), pp. 1238-46.

¹⁰² Andrea Caria, Ranganatha Sitaram, Ralf Veit, Chiara Begliomini, Niels Birbaumer, 'Volitional Control of Anterior Insula Activity Modulates the Response to Aversive Stimuli. A Real-Time Functional Magnetic Resonance Imaging Study', *Biological Psychiatry* 68 (2010), pp. 425-32.

¹⁰³ Giuseppina Rota, Ranganatha Sitaram, Ralf Veit, Michael Erb, Nikolaus Weiskopf, Grzegorz Dogil, Niels Birbaumer, 'Self-Regulation of Regional Cortical Activity Using Real-Time fMRI: The Right Inferior Frontal Gyrus and Linguistic Processing', *Human Brain Mapping* 30 (2009), pp. 1605-14.

¹⁰⁴ R. Christopher deCharms, Fumiko Maeda, Gary H. Glover, David Ludlow, John M. Pauly, Deepak Soneji, et al., 'Control over Brain Activation and Pain Learned by Using Real-Time Functional MRI', *Proceedings of the National Academy of Sciences of the United States of America* 102 (2005), pp. 18626-31.

Currently, there are three main crime-relevant psychological dispositions or processes that the literature suggests may be modifiable by EBS: moral cognition, aggression, and impulsivity.

Many criminal activities, particularly violent crimes such as rape, murder, and bodily assault, are almost universally recognised as immoral. Deficits or abnormalities in moral cognition may, then, increase the likelihood of criminal offending, with psychopathy and antisocial personality disorder (APD) as extreme examples of such cases. De Ridder et al. detail evidence from functional imaging studies for abnormal brain functioning in two conditions associated with criminal offending – APD and paedophilia.¹⁰⁵ They argue that it would theoretically be possible to remedy these abnormalities through the use of electrical brain stimulation, with the use of TMS for initial therapeutic trials, and the later implantation of DBS electrodes to maintain a permanent therapeutic effect. There are also some early indications that tDCS may be able to modulate moral decision-making and behaviour,¹⁰⁶ but these studies are preliminary, utilise small sample sizes, and require replication. There are, to our knowledge, as yet no studies assessing directly for

¹⁰⁵ Dirk De Ridder, Berthold Langguth, Mark Plazier, Tomas Menovsky, ‘Moral Dysfunction: Theoretical Model and Potential Neurosurgical Treatments’, in J. Verplaetse, J. Schrijver, S. Vanneste, J. Braeckman (eds.), *The Moral Brain: Essays on the Evolutionary and Neuroscientific Aspects of Morality* (London: Springer, 2009).

¹⁰⁶ Sébastien Tassy, Olivier Oullier, Yann Duclos, Olivier Coulon, Julien Mancini, Christine Deruelle, et al., ‘Disrupting the Right Prefrontal Cortex Alters Moral Judgement’, *Social Cognitive and Affective Neuroscience* 7 (2011), pp. 282–8; Daria Knoch, Michael A. Nitsche, Urs Fischbacher, Christopher Eisenegger, Alvaro Pascual-Leone, Ernst Fehr, ‘Studying the Neurobiology of Social Interaction with Transcranial Direct Current Stimulation – The Example of Punishing Unfairness’, *Cerebral Cortex* 18 (2008), pp. 1987–90; Daria Knoch, Alvaro Pascual-Leone, Kaspar Meyer, Valerie Treyer, Ernst Fehr, ‘Diminishing Reciprocal Fairness by Disrupting the Right Prefrontal Cortex’, *Science* 314 (2006), pp. 829–32; Liane Young, Joan Albert Camprodon, Marc Hauser, Alvaro Pascual-Leone, Rebecca Saxe, ‘Disruption of the Right Temporoparietal Junction with Transcranial Magnetic Stimulation Reduces the Role of Beliefs in Moral Judgments’, *Proceedings of the National Academy of Sciences* 107 (2010), pp. 6753–8.

therapeutic effects of any EBS modality on the conditions mentioned above, or indeed measures of criminal offending.

Aggression and impulsivity are two dispositions that are often thought to increase the risk of antisocial and criminal behaviour,¹⁰⁷ and have been linked with altered brain activity in the prefrontal cortex and amygdala.¹⁰⁸ Modifying these through EBS may be a possible means to prevent criminal behaviour. There are some indications in the sparse literature that this may indeed be possible – Dambacher et al., for example, found that receiving tDCS to the right dorsolateral prefrontal cortex (DLPFC) significantly decreased measures of proactive aggression in men.¹⁰⁹ Even more interestingly, a trial by Riva et al. found that tDCS potentially mitigates the increase in aggression associated with social exclusion.¹¹⁰ Participants experiencing simulated social exclusion who also received

¹⁰⁷ David Magnusson, Håkan Stattin, Anders Dunér, ‘Aggression and Criminality in a Longitudinal Perspective’, in K. Teilmann Van Dusen, S. A. Mednick (eds.), *Prospective Studies of Crime and Delinquency* (Hingham, MA: Kluwer-Nijhoff Publishing, 1983); Joan McCord, ‘A Longitudinal Study of Aggression and Antisocial Behavior’, in K. Teilmann Van Dusen, S. A. Mednick (eds.), *Prospective Studies of Crime and Delinquency* (Hingham, MA: Kluwer-Nijhoff Publishing, 1983); Donald R. Lynam, Avshalom Caspi, Terrie E. Moffit, Per-Olof Wikström, Rolf Loeber, Scott Novak, ‘The Interaction Between Impulsivity and Neighborhood Context on Offending: The Effects of Impulsivity Are Stronger in Poorer Neighborhoods’, *Journal of Abnormal Psychology* 109 (2000), pp. 563–74; Madeline H. Meier, Wendy S. Slutske, Stephan Arndt, Remi J. Cadoret, ‘Impulsive and Callous Traits Are More Strongly Associated with Delinquent Behavior in Higher Risk Neighborhoods Among Boys and Girls’, *Journal of Abnormal Psychology* 117 (2008), pp. 377–85; Robert A. Prentky, Raymond A. Knight, ‘Impulsivity in the Lifestyle and Criminal Behavior of Sexual Offenders’, *Criminal Justice and Behavior* 13 (1986), pp. 141–64.

¹⁰⁸ R. J. R. Blair, ‘Neuroimaging of Psychopathy and Antisocial Behavior: A Targeted Review’, *Current Psychiatry Reports* 12 (2010), pp. 76–82; M. C. Brower, B. H. Price, ‘Neuropsychiatry of Frontal Lobe Dysfunction in Violent and Criminal Behaviour: A Critical Review’, *Journal of Neurology, Neurosurgery, and Psychiatry* 71 (2001), pp. 720–6.

¹⁰⁹ Franziska Dambacher, Teresa Schuhmann, Jill Lobbestael, Arnoud Arntz, Suzanne Brugman, Alexander T. Sack, ‘Reducing Proactive Aggression Through Non-Invasive Brain Stimulation’, *Social Cognitive and Affective Neuroscience* 10 (2015), pp. 1303-9.

¹¹⁰ Paolo Riva, Leonor J. Romero Lauro, C. Nathan DeWall, David S. Chester, Brad J. Bushman BJ, ‘Reducing Aggressive Responses to Social Exclusion Using Transcranial Direct Current

stimulation of the right ventrolateral prefrontal cortex (VLPFC) were significantly less aggressive than those who did not, and were indistinguishable from those who experience simulated social inclusion. Aggressive behaviour resulting from social exclusion, the authors note, may place a role in certain criminal behaviours, including domestic violence and school shootings. In addition to these, a number of small experimental studies similarly suggest that modulation of regions in the pre-frontal cortex through tDCS and TMS has an effect on propensities for risk-taking behaviour¹¹¹ and higher-order cognitive inhibitory control.¹¹²

As will be evident, currently much of the support for the use of EBS to reduce or prevent criminal behaviour is highly speculative, consisting mainly of small-scale, as-yet unreproduced cognitive science experiments. Two highly critical quantitative reviews of tDCS have recently been published (by the same author) arguing that the existing evidence, in aggregate, indicates that tDCS is almost completely ineffective;¹¹³ these

Stimulation', *Social Cognitive and Affective Neuroscience* 10 (2015), pp. 352-6.

¹¹¹ Shirley Fecteau, Daria Knoch, Felipe Fregni, Natasha Sultani, Paulo Boggio, Alvaro Pascual-Leone, 'Diminishing Risk-Taking Behavior by Modulating Activity in the Prefrontal Cortex: A Direct Current Stimulation Study', *The Journal of Neuroscience* 27 (2007), pp. 12500-5; Shirley Fecteau, Alvaro Pascual-Leone, David H. Zald, Paola Liguori, Hugo Theoret, Paulo S. Boggio, Felipe Fregni, 'Activation of Prefrontal Cortex by Transcranial Direct Current Stimulation Reduces Appetite for Risk during Ambiguous Decision Making', *The Journal of Neuroscience* 27 (2007), pp. 6212-8.

¹¹² Liron Jacobson, Daniel C. Javitt, Michal Lavidor, 'Activation of Inhibition: Diminishing Impulsive Behavior by Direct Current Stimulation over the Inferior Frontal Gyrus', *Journal of Cognitive Neuroscience* 23 (2011), pp. 3380-7; Tzu-Yu Hsu, Lin-Yuan Tseng, Jia-Xin Yu, Wen-Jiu Kuo, Daisy L. Hung, Ovid J. L. Tzeng, et al., 'Modulating Inhibitory Control with Direct Current Stimulation of the Superior Medial Frontal Cortex', *NeuroImage* 56 (2011), pp. 2249-57; Chi-Hung Juan, Neil G. Muggleton, 'Brain Stimulation and Inhibitory Control', *Brain Stimulation* 5 (2012), pp. 63-9.

¹¹³ Jared Cooney Horvath, Jason D. Forte, Olivia Carter, 'Quantitative Review Finds No Evidence of Cognitive Effects in Healthy Populations from Single-Session Transcranial Direct Current Stimulation (tDCS)', *Brain Stimulation* 8 (2015), pp. 535-50; Jared Cooney Horvath, Jason D. Forte, Olivia Carter, 'Evidence That Transcranial Direct Current Stimulation (tDCS) Generates

articles have themselves, however, come under scrutiny for their statistical analyses and methodology.¹¹⁴ As things currently stand, much research and further therapeutic trials will need to be conducted before EBS is even able to be considered as a viable alternative or adjunct in the criminal justice system.

5. Final thoughts

This chapter has reviewed six biological kinds of intervention that one might reasonably expect, in the future, to be deployed, or at least advocated, for the purposes of preventing crime. Four of these have already been used or trialled in this role. The fifth and sixth—modulation of the serotonergic bases of aggression and retaliatory dispositions, and EBS interventions to specifically alter moral cognition, aggression, or impulsivity – are speculative but somewhat promising possibilities for the future.¹¹⁵

Crime is inherently social both in the sense that it affects other people, and in the sense that social context has an influence on the effectiveness of any crime prevention technique. It is therefore important to note that many of the findings we have reviewed in this chapter are based on empirical studies conducted with individuals acting alone in the

Little-To-No Reliable Neurophysiologic Effect Beyond MEP Amplitude Modulation in Healthy Human Subjects: A Systematic Review', *Neuropsychologia* 66 (2015), pp. 213–36.

¹¹⁴ Amy R. Price, Roy H. Hamilton, 'A Re-evaluation of the Cognitive Effects From Single-session Transcranial Direct Current Stimulation', *Brain Stimulation* 8 (2015), pp. 663–5; Andrea Antal, Daniel Keeser, Alberto Priori, Frank Padberg, Michael A. Nitsche, 'Conceptual and Procedural Shortcomings of the Systematic Review "Evidence That Transcranial Direct Current Stimulation (tDCS) Generates Little-To-No Reliable Neurophysiologic Effect Beyond MEP Amplitude Modulation in Healthy Human Subjects: A Systematic Review" by Horvath and Co-workers', *Brain Stimulation* 8 (2015), pp. 846–9; Pratik Y. Chhatbar, Wuwei Feng, 'Data Synthesis in Meta-Analysis may Conclude Differently on Cognitive Effect From Transcranial Direct Current Stimulation', *Brain Stimulation* 8 (2015), pp. 974–6.

¹¹⁵ Although note that serotonin modulators have been used for their anti-libidinal side-effects as part of attempts to prevent sexual recidivism. See 'Anti-Libidinal Agents'.

closed environment of the laboratory. It has, however, been shown that biological factors in principle can affect people differently when they are studied as isolated individuals from when they act in a social group. This has, for example, been empirically shown for stress¹¹⁶ and for alcohol,¹¹⁷ and it has been argued that this is likely to be also the case for other biological factors, including pharmacological substances.¹¹⁸ Future research needs not only to confirm that the techniques we discussed can be effective in individuals in the laboratory, but also in non-laboratory settings.

To conclude our discussion, we would like to note some potentially significant differences between the six kinds of intervention that we have discussed.

One difference relates to the (notoriously problematic) distinction between the natural and the artificial. With one possible exception, all of the interventions we discussed are ‘artificial’ in the sense that they involve the deployment of products produced through complex, human-designed processes. The possible exception is nutrition, which arguably need not involve the use of such products, and might be deemed by some to be a ‘natural’ intervention.

¹¹⁶ Jan Alexander Häusser, Maren Kattenstroth, Rolf van Dick, Andreas Mojzisch, “‘We’ Are Not Stressed: Social Identity in Groups Buffers Neuroendocrine Stress Reactions’, *Journal of Experimental Social Psychology* 48 (2012), pp. 973–7.

¹¹⁷ Daniel Frings, Tim Hopthrow, Dominic Abrams, Lorne Hulbert, Roberto Gutierrez, ‘Groupdrink: The Effects of Alcohol and Group Process on Vigilance Errors’, *Group Dynamics: Theory, Research, and Practice* 12 (2008), pp. 179–90.

¹¹⁸ Nadira S. Faber, Thomas Douglas, Felix Heise, Miles Hewstone, ‘Cognitive Enhancement and Motivation Enhancement: An Empirical Comparison of Intuitive Judgments’, *AJOB Neuroscience* 6 (2015), pp. 18–20.

A second difference pertains to the distinction between therapy and enhancement. Therapies are often understood as interventions that are intended to correct a disease, disorder or disability, whereas enhancements aim to augment human capacities from an already healthy level.¹¹⁹ (There is, of course, much debate about how to draw the boundaries of ‘disease, disorder and disability’, and thus about the correct application of the therapy-enhancement distinction.) Two of the interventions that we discussed are, as we understood them, necessarily therapeutic, for they are defined by the disorders that they treat—namely, substance abuse or addiction and ADHD. However, it is possible that the same pharmaceuticals could be used with similar effects in individuals who possess some tendencies towards substance abuse, addiction, poor attention, or hyperactivity, though they would not qualify for any disorder. The other kinds of intervention that we survey were not characterised such that they are necessarily therapeutic, though in some cases they might be. For instance, nutritional interventions might be used to correct malnutrition and associated behavioural abnormalities (therapeutic) or to improve on already-healthy nutritional states and behavioural tendencies (enhancement), and anti-libidinal agents are typically used partly for the purpose of treating paraphilias.

Of course, it might turn out, in relation to some of these interventions that they are effective in preventing criminal offending only in cases where they constitute therapies. For instance, the best evidence for the preventive effectiveness of anti-libidinal interventions relates to their use in individuals who would qualify for a diagnosis of

¹¹⁹ Thomas Douglas, ‘Enhancement, Biomedical’, *The International Encyclopedia of Ethics* (2013), pp. 1633–43.

paraphilia. It is much less clear whether anti-libidinal interventions could prevent sexual offending in individuals who suffer from no disorder.

It should also be noted that on some ways of drawing the therapy-enhancement distinction, *all* interventions used to prevent crime would constitute therapies. Some would view all interventions that aim to correct or prevent *abnormalities* as therapeutic, and criminal conduct is arguably always abnormal, even if it is not always accompanied by a disease, disorder or disability. Still, there are plausible and standard ways of drawing the therapy-enhancement distinction such that some of the interventions we have discussed are not therapeutic.

There are, then, at least two oft-made distinctions that might be drawn between the kinds of intervention we have discussed: the artificial-natural distinction, and the therapy-enhancement distinction. In identifying these differences, we do not mean to suggest that they are of moral significance; whether they are has been the subject of much recent discussion in the literature on the ethics of biomedical enhancement. We leave this as a topic for further debate.