Criminal minds: The influence of the monoamine oxidase A genotype and environmental stressors on aggressive behaviour

SOPHIE E. TAYLOR

This article was published in December 2013 in Issue 2 of the Burgmann Journal (Taylor, 2013). A synopsis of the article follows.

The notion that genes play an important role in disease susceptibility has been widely accepted, though many people find it difficult to acknowledge a similar link between genetics and predispositions to particular behaviour. Despite this scepticism, current behavioural models suggest that genetic variants influence neurotransmitter pathways in brain regions associated with cognitive function and the encoding of emotional intent (Caspi et al., 2002; Foley et al., 2004; Widom & Brzustowicz, 2006). Biological studies of families of convicted criminals have found that there is a higher rate of criminal behaviour among the relatives of criminals, suggesting a genetic constituent to certain criminal behavioural tendencies (Widom, 1989; Brunner et al., 1993).

Monoamine oxidase A (MAOA) is a gene located on the X chromosome that regulates the release and degradation of dopamine, serotonin and norepinephrine – the neurotransmitters linked to aggressive and impulsive behaviour. Due to the vital role MAOA plays in the inactivation of neurotransmitters, MAOA dysfunction (too much or too little MAOA activity) was proposed as a potential genetic predictor of aggressive behaviour. A series of studies have shown a significant correlation between a deficiency in the MAOA gene and an increased risk of aggressive behaviour (Garpenstrand et al., 2002). However, correlation does not equal causation and thus other mutations or polymorphisms in the gene may alter the expression of a gene or its structure and function. In addition, genes do not operate independently; rather they function against a background in which other factors are crucial.

Further research therefore focused on examining gene by environmental interactions to understand the contributions of individual loci to aggressive criminal behaviour. Childhood maltreatment was an environmental factor which strongly correlated with aggressive criminal behaviour and was therefore suggested as a potential environment trigger. It was hypothesised that at

sensitive stages during development, changes in MAOA balance triggered by severe environmental factors could disrupt MAOA-mediated brain development (Caspi et al., 2002).

Based on molecular genetic findings, Caspi's and colleagues' (2002) pioneering gene by environment MAOA study suggested that differences in MAOA genotype moderate the relationship between childhood maltreatment and later aggressive behaviour. While many subsequent studies replicated these findings, some studies did not find a gene (MAOA) by environment (maltreatment) interaction (Huizinga et al., 2006; Haberstick et al., 2005). These inconsistencies between studies have resulted in particular gaps in the literature pertaining to levels of brain MAOA activity and its potential influence on individual differences in aggressive behaviour. Further studies have aimed at resolving these discrepancies by focusing on a multiple-risk environmental factor hypothesis and determining the sensitive stages in which MAOA affects brain development (Fergusson et al., 2012). Recent studies have also challenged the applicability of earlier studies on the wider, more diverse populations (Widom & Brzustowicz, 2006; McCord et al., 2001).

'Criminal Minds' focuses on these epigenetic studies of MAOA and aggressive behaviour. The paper discusses the strengths and limitations of each study, and the impacts their findings will have on society and the field of neuroscience.

Bibliography

- Brunner, H.G., Nelen, M., Breakefield, X.O., Ropers, H.H. & van Oost, B.A. (1993). Abnormal Behavior Associated with a Point Mutation in the Structural Gene for Monoamine Oxidase A. *Science*, 262(5133), 578–580. doi:10.1126/science.8211186.
- Caspi, A., McClay, J., Moffitt, T.E., Mill, J., Martin, J., Craig, I.W., Taylor, A. & Poulton, R. (2002). Role of Genotype in the Cycle of Violence in Maltreated Children. *Science*, 297, 851–854. doi: 10.1126/science.1072290.
- Fergusson, D.M., Boden, J.M., Horwood, L.J., Miller, A. & Kennedy, M.A. (2012). Moderating role of the MAOA genotype in antisocial behaviour. *The British Journal of Psychiatry*, 200, 116–123. doi: 10.1192/bjp.bp.111.093328.
- Foley, D.L., Eaves, L.J., Wormley, B., Silberg, J.L., Maes, H.H., Kuhn, J. & Riley, B. (2004). Childhood Adversity, Monoamine Oxidase A Genotype, and Risk for Conduct Disorder. *Archives of General Psychiatry*, 1(7), 738–744. doi: 10.1001/archpsyc.61.7.738.

- Garpenstrand, H., Longato-Stadler, E., Klinteberg, B., Grigorenko, E., Damberg, M., Orelund, L. & Hallman, J. (2002). Low platelet monoamine oxidase activity in Swedish imprisoned criminal offenders. *European Neuropsychopharmacology*, 12(2), 135–140. doi: 10.1016/S0924-977X(01)00148-1.
- Haberstick, B.C., Lessem, J.M., Hopfer, C.J., Smolen, A., Timberlake, D. & Hewitt, J.K. (2005). Monoamine oxidase A (MAOA) genotype and antisocial behaviors in childhood and adolescent maltreatment. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, 135, 59–64. doi: 10.1002/ajmg.b.30176.
- Huizinga, D., Haberstick, B.C., Smolen, A., Menard, S., Young, S.E., Corley, R.P., Stallings, M.C., Grotzinger, J. & Hewitt, J.K. (2006). Childhood Maltreatment, Subsequent Antisocial Behaviour, and the Role of Monoamine Oxidase A Genotype. *Biological Psychiatry*, 60(7), 677–683. doi: 10.1016/j.biopsych.2005.12.022.
- McCord, J., Widom, C.S. & Crowell, N.A. (Eds). (2001). *Juvenile Crime, Juvenile Justice*. Washington, D.C.: National Academy Press.
- Taylor, S.E. (2013). Criminal Minds: the Influence of the Monoamine Oxidase A Genotype and Environmental Stressors on Aggressive Behaviour. *Burgmann Journal*, 2, 71–77.
- Widom, C.S. Does violence beget violence? A critical examination of the literature. *Psychological Bulletin*, 106 (1):3–28, Jul 1989.
- Widom, C.S. & Brzustowicz, L.M. (2006). MAOA and the ‘cycle of violence’: childhood abuse and neglect, MAOA genotype, and risk for violent and antisocial behaviour. *Biological Psychiatry*, 60(7), 684–689. doi:10.1016/j.biopsych.2006.03.039.

This text is taken from *The ANU Undergraduate Research Journal*,
Volume Six, 2014, edited by Jonathon Zapasnik and Alexandra Hogan,
published 2015 by ANU eView, The Australian National University,
Canberra, Australia.