2012

An investigation into the neural substrates of virtue to determine the key place of virtues in human moral development

Andrew P.L Mullins
University of Notre Dame Australia

An investigation into the neural substrates of virtue to determine the key place of virtues in human moral development.

Research thesis submitted for the degree of

Doctor of Philosophy.

Andrew P. J. Mullins

School of Philosophy and Theology
University of Notre Dame, Australia.

December 2012.

Table of Contents

Chapter 2
Neural mechanisms and systems.

Chapter 3
Investigating the characteristics of virtue.

Chapter 4
Understanding the cardinal virtues.

4.1.2.6 If in addition to prudence, the speculative intellect plays a role in virtue, the speculative intellect will be perfected by its own proper habits.

4.1.2.7 Rather than of "acts of isolated virtues" it appears more appropriate to think in terms of "moral operations performed with the integral involvement of multiple virtues".

4.1.2.8 As it is the cause of virtue, reason is necessarily external to moral virtue.

4.1.2.9 Analysis of the human act supports the view that various virtues are present in concert in a single human act.

a) Input from the sensitive appetite precedes the rational in the human act.
b) The contribution of emotion to rationality also argues for a "moral-operations view" rather than of a view of actions disposed by isolated virtues.
c) Furthermore, discrete ascription of a particular action to a single virtue is problematic. Actions in real life manifest the constellation of virtues.

4.1.2.10 The "durability" of the individual virtues differs in meaning according to the specific virtue.

4.2 Biological and functional distinctions between the virtues. … 358

4.2.1 The cardinal virtues have distinctive roles in the operation of virtue.

a) The distinction between the virtues properly of the soul and those properly of the body.
b) Prudence and justice, as they are associated more directly with the rationality, are more removed from the material substrate.
c) Fortitude and temperance have a dual dependency: on the soul and on the corporeal organs.
d) Temperance and fortitude are at the heart of a rational response to pain and pleasure and therefore to appetition that is truly human.

4.2.2 Prudence.

4.2.3 Justice.

a) A broad understanding of justice.

4.2.4 An understanding of the biophysical dimensions of prudence and justice.

a) What is the matter?
b) Biological perfections.

4.2.5 Fortitude.

4.2.6 Temperance.

4.2.7 Biophysical aspects of fortitude and temperance.

a) Subordination to reason.
b) Biological perfections.

Chapter 5
The neural bases of virtue.

Chapter 6
Flourishing.

Figures.

Appendices

Tables

Abstract

Virtues, as described by Aristotle and Aquinas, are understood as dispositions of character to behave in habitual, specific, positive ways; virtue is a critical requirement for human flourishing. From the perspective of Aristotelian-Thomistic anthropology which offers an integrated vision of the material and the rational in the human person, I seek to identify the neural bases for the development and exercise of moral virtue. First I review current neuroscientific knowledge of the capacity of the brain to structure according to experience, to facilitate behaviours, to regulate emotional responses and support goal election. Then, having identified characteristics of moral virtue in the light of the distinctions between cardinal virtues, I propose neural substrates by mapping neuroscientific knowledge to these characteristics. I then investigate the relationship between virtue, including its neurobiological features, and human flourishing. This process allows a contemporary and evidence-based corroboration for a model of moral development based on growth in virtue as understood by Aristotle and Aquinas, and a demonstration of a biological aptitude and predisposition for the development of virtue. Conclusions are drawn with respect to science, ethics, and parenting.

Declaration of Authorship

This thesis is my own work and contains no material which has been accepted for the award of any degree or diploma in any other institution. To the best of my knowledge, the thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

Andrew P.J. Mullins

20 December 2012

Acknowledgements

Fresh out of school I was visiting our old retired parish priest, Fr Tosi. When I told him I was thinking of teaching, he boomed, “Blessed are those who instruct others in the paths of virtue, they shall shine like bright stars.” Well, in life I have had many stars that have not given up on me. As for any wanderings from the path, they are of my doing alone!

In this project I have many stars to thank. I am deeply grateful to my supervisor Professor Hayden Ramsay. Hayden took this on despite desperately busy commitments. Without Hayden’s reassurance and belief in this project, it most certainly would not have materialized. To a large degree, any success it may enjoy will be due to his patient, good humoured guidance. I am also greatly endebted to Professor Julie Quinlivan, my neuroscience supervisor, who provided crucial direction in overseeing my neuroscience research, and to Dr Paul Foley of Neuroscience Research Australia, the NeuRA institute. Paul has shown genuine interest in this undertaking and has generously given of his expertise over the past year. His close knowledge of the basal ganglia and dopamine systems in the brain has been invaluably reassuring.

Others must not be forgotten. It was Professor George Mendz who sowed the seeds of further study when it was the last thing on my mind. And the university has been good to me: a grant made possible a short and very productive stay in Oxford this year. My gratitude also to Gay-Louise, Hayden’s secretary, for her untiring, nothing’s-a-problem capacity to run off reams of drafts and cut through Chancellery red tape to schedule appointments with Hayden; and to Adele at the medical library who, magically and with a smile, tracked down countless papers. My employer, the Parents for Education Foundation, allowed me some ongoing time; and Matt Aldous, my deputy at Wollemi College, took on the busiest of terms to allow me leave to tie up the many loose ends for submission. I will long remember the staff and students of the Veech Library in Strathfield for making this home stretch a delightful experience.

Friends have offered feedback on the drafts of chapters and sections of chapters. I thank especially Dr Robin Choong for his generosity and for stretching my thinking time and again, Dr Thomas Lickona and John Poon for psychological insights, and Dr Michael Cook, for the right word at the right time. I thank also the parents and staff of Redfield and Wollemi for their friendship and encouragement.

At this time I remember Mum, whose eyes never lost their sparkle, Dad whose gift of the telescope represented something far more, and St. Josemaria who put the star chart of the virtues in my hand. I thank Michael and Richard, the best sounding boards in the business, and Rosemary who is, now and always, the brightest of stars in the firmament.

Abbreviations

5-HT	5-hydroxytryptamine (serotonin)
ACC	anterior cingulated cortex
ACh	acetylcholine
ADHD	Attention Deficit Hyperactivity Disorder
AMPA	α-amino-3-hydroxyl-5-methyl-4-isoxazole-propionate
AMPAR	AMPA receptor
A-O	action-outcome
aPFC	anterior PFC
aTL	anterior temporal lobes
ATP	adenosine triphosphate
BDNF	brain derived neurotrophic factor
BG	basal ganglia
BLA	basolateral complex of the amygdala
BOLD	blood oxygen level dependent
cAMP	cyclic AMP (AMP is agonist for AMPA channels)
CAT	computerised axial tomography
CEA	central nucleus of the amygdala
CNS	central nervous system
CREB	cAMP response-element binding protein
CRF	corticotrophin releasing factor
DA	dopamine
DLPFC	dorsolateral prefrontal cortex
DLS	deep limbic system, also, dorsolateral striatum in rodents
DMPFC	dorsalmedial PFC
DMS	dorsomedial striatum in rodents
DSCAM	Downs Syndrome cell adhesion molecule
DT-MRI	Diffusion tensor magnetic resonance imaging
EC	endocannabinoid
EEG	electroencephalography
elF2x	a particular translation initiation factor
Epi	epinephrine
EPSP	excitatory postsynaptic potential
ERP	event related potentials
FAPs	fixed action patterns
FGF	fibroblast growth factor
FGF-2	fibroblast growth factor 2

fMRI	functional magnetic resonance imaging
GABA	γ-Aminobutyric Acid
GP	globus pallidus
GPi	internal segment
GPe	external segment
GPCR	G-protein-coupled-receptor
HFS	high frequency afferent stimulation
HSV1	herpes simplex virus type 1
IGF	insulin-like growth factor
ILN	intralaminar nuclei of the thalamus
IMM	medial mesopalium
IT	inferotemporal cortex
ITM	intermediate term memory
LA	lateral amygdala
LC	locus ceruleus
LGG	low grade glioma
LIP	lateral intraparietal cortex
LOFC	lateral OFC
LTD	long term depression
LTM	long term memory
LTP	long term potentiation
M1	primary motor cortex
MA	motor adaptation
MEG	magnetoelectroencephalography
MRI	magnetic resonance imaging
MRS	magnetic resonance spectroscopy
MSL	motor sequence learning
MSN	medium spiny neuron
MTL	medial temporal lobe
mPFC	medial PFC (in some literature, the rodent equivalent to human DLPFC)
NAc	nucleus accumbens
nAChR	nicotinic receptor
NE	norepinephrine
NMDA	N-methyl-D-aspartate
NMJ	neuromuscular junction
NMP	neuromotor prosthesis
NMR-MOUSE	nuclear magnetic resonance mobile universal surface explorer
NOIR	near optical infra red

NTF	nerve growth factor
OCD	obsessive compulsive disorder
OFC	orbitofrontal cortex
PAS	paired associative stimulation
PCD	programmed cell death
PET	positron emission tomography
PKA and PKC	particular protein kinases
PNS	peripheral nervous system
PPC	posterior parietal cortex
preNMDARs	presynaptic NMDARs
PSP	post synaptic potential
pSTS	post central gyrus
rTMS	repetitive transcranial magnetic stimulation
SACD	social and character development programs
SMA	supplementary motor area
S-O	stimulus-outcome
SN	substantia nigra
SNpc	substantia nigra pars compacta
SNr	substantia nigra pars reticulata
STDP	spike timing dependent plasticities
S-R	stimulus response
S-S	stimulus-stimulus
STN	subthalamic nuclei
STS	posterior superior temporal sulcus
TAN	tonically active neuron
tDCS	transcranial direct current stimulation
tLTD	spike timing-dependent LTD
TMS	transcranial magnetic stimulation
VBM	voxel based morphometry
VGCC	voltage gated calcium channel
VL	ventrolateral nucleus of the thalamus
VLPFC	ventrolateral PFC
VMPFC	ventromedial PFC
VP	ventral palladium
VTA	ventral tegmental area