

The Science of Consciousness

Consciousness concerns awareness and how we experience the world. How does awareness, a feature of the mental world, arise from the physical brain? Is a dog conscious, or a jellyfish, and what explains what is conscious and what is not? How is consciousness related to psychological processes such as perception and cognition? *The Science of Consciousness* covers the psychology, philosophy, and neuroscience of consciousness. Written for introductory courses in psychology and philosophy, this text examines consciousness with a special emphasis on current neuroscience research, as well as comparisons of normal and damaged brains. The full range of normal and altered states of consciousness, including sleep and dreams, hypnotic and meditative states, anaesthesia, drug-induced states, and parapsychological phenomena and their importance for the science of consciousness, is covered, as well as the ‘higher’ states and how we can attain them. Throughout, the text attempts to relate consciousness to the brain.

Trevor A. Harley is Emeritus Professor of Psychology at the University of Dundee and a Fellow of the British Psychological Society. He is the author of *The Psychology of Language*, 4th edition (2013), *Talking the Talk*, 2nd edition (2017), and *The Psychology of Weather* (2018). He is very widely published across psychology, including papers on consciousness and dreams, and has kept a detailed dream diary for several years. He is always wondering what his poodle Beau is thinking about.

The Science of Consciousness

Waking, Sleeping and Dreaming

TREVOR A. HARLEY

University of Dundee

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
79 Anson Road, #06–04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107125285

DOI: 10.1017/9781316408889

© Trevor A. Harley 2021

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2021

A catalogue record for this publication is available from the British Library.

Library of Congress Cataloging-in-Publication Data

Names: Harley, Trevor A., author.

Title: The science of consciousness : waking, sleeping and dreaming / Trevor A. Harley, University of Dundee.

Description: New York, NY : Cambridge University Press, 2021. | Includes bibliographical references and index.

Identifiers: LCCN 2020029739 (print) | LCCN 2020029740 (ebook) | ISBN 9781107125285 (hardback) | ISBN 9781316408889 (ebook)

Subjects: LCSH: Consciousness. | Consciousness—Physiological aspects. | Cognitive neuroscience.

Classification: LCC QP411 .H366 2020 (print) | LCC QP411 (ebook) | DDC 612.8/233—dc23

LC record available at <https://lcn.loc.gov/2020029739>

LC ebook record available at <https://lcn.loc.gov/2020029740>

ISBN 978-1-107-12528-5 Hardback

ISBN 978-1-107-56330-8 Paperback

Additional resources for this publication at www.cambridge.org/harley

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

To Allan Hobson, who started it, and to Ruth, who finished it.

CONTENTS

List of Figures	page xiii	Thought Experiments	27
Preface	xix	The Mind and the Brain	28
Acknowledgements	xxvi	The Mind–Brain Problem	28
List of Abbreviations	xxvii	The Mereological Fallacy	29
		Qualia	29
		Dualism and Monism	29
		René Descartes and Substance Dualism	30
		Other Types of Dualism	31
		Monism	32
		Box 2.2 The History of Physics	33
		The Knowledge Argument	34
		The ‘Mary’ Colour Thought Experiment	34
		For and Against Physicalism	35
		The Inverted Colour Spectrum	36
		The Problem of Pain	38
		The Physical Aspect of Pain	39
		The Mental Aspect of Pain	39
		Pain in Babies	40
		P-zombies	41
		Box 2.3 Zombies	41
		Is Consciousness Essential?	42
		Being Conceivable	42
		Materialism	43
		Reductive Materialism	43
		Eliminative Materialism	44
		Functionalism	45
		Silicon Neurons and Silicon Brains	45
		Box 2.4 Neurons	46
		The ‘China Brain’ Thought Experiment	47
		Box 2.5 What is Computation?	48
		Arguments Against Functionalism	49
		Mysterianism	51
		Chapter Summary	53
		Review Questions	54
		Recommended Resources	55
		3 Do We Have Free Will?	57
		People and Objects	57
		Determinism and Free Will	58
1 The Problem of Consciousness	3		
Why Study Consciousness?	3		
Consciousness and Psychology	3		
Consciousness and Neuroscience	4		
Consciousness and Philosophy	4		
Box 1.1 The Homunculus Inside Us	5		
Consciousness and Spirituality	5		
How We Study Consciousness	6		
Scientific Experimentation	7		
Box 1.2 The Role of Falsification in Science	7		
Box 1.3 The History of Neuroscience	8		
Philosophical Thought Experiments	10		
Artificial Intelligence	11		
Defining Consciousness	11		
Definitions of Consciousness	12		
Awareness	12		
The Problem of Other Minds	13		
The Hard and Easy Problems of Consciousness	15		
Intentionality: Are We Always Conscious of Something?	15		
Types of Consciousness	16		
Phenomenal and Access Consciousness	16		
Other Types of Consciousness	17		
Degrees of Consciousness	18		
The History of Consciousness Research	20		
The Problems of Consciousness	21		
Chapter Summary	23		
Review Questions	24		
Recommended Resources	24		
2 The Mind–Body Problem	26		
Box 2.1 Philosophy: Terms and Disciplines	26		

Human Behaviour	59	Constructing an Artificial Brain	99
The Implications of Quantum Mechanics	60	Neuroprosthesis	101
Dualism and Free Will	60	The Future of AI	102
Box 3.1 What Is an Illusion?	61	The Technological Singularity	102
The Homunculus in the Cartesian Theatre	62	Box 4.3 Transhumanism	103
The Benefits of Believing in Free Will	62	Is AI a Threat?	104
Compatibilism	64	Chapter Summary	105
Environmental Effects on Behaviour	64	Review Questions	106
Box 3.2 Toxoplasma	65	Recommended Resources	106
Crime and Punishment	66		
Moral Responsibility	67	5 Animal Consciousness	108
Box 3.3 The Purpose of Punishment	67	Which Non-human Animals might be Conscious?	108
The Role of Psychology in Understanding Crime	68	The Mind of an Animal	109
Deciding to Act	69	Animal Intelligence	110
Libet's Experiments on 'Voluntary' Movement	70	Box 5.1 Learning Without Neurons	113
Box 3.4 Measuring Brain Activity with EEG	71	The Mirror Test of Self-recognition	114
Criticisms of Libet's Experiments	72	Animals and Pain	116
Involuntary Action	73	Box 5.2 Do Plants Feel Pain?	117
Alien Hand Syndrome	73	Theory of Mind	117
Skill and Habit	74	The Importance of Social Interaction	119
Psychological Compulsions	76	The Evolution of Consciousness	120
Chapter Summary	76	Protoconsciousness	121
Review Questions	77	The Importance of Language	121
Recommended Resources	78	Recursion	122
		The Bicameral Mind	123
4 Machine Consciousness	79	Panpsychism	124
Artificial Life	79	Chapter Summary	126
Artificial Intelligence	81	Review Questions	127
The Timeline of Progress in AI	82	Recommended Resources	127
Chess-playing Computers	84		
Box 4.1 Computer Beats Human	86	PART II THE WORKINGS OF CONSCIOUSNESS	
The Turing Test	86	6 Looking at Our Own Minds	131
Early AI Models of Psychology	88	The Contents of Consciousness	131
How Smart Are Computers Now?	89	The Stream of Consciousness	132
The Computational Correlates of Consciousness	91	The Process of Introspection	133
LIDA	92	Phenomenology	135
Could a Disembodied AI Ever Be Conscious?	93	Experience Sampling	136
Robotics	94	The Limits of Introspection	137
Box 4.2 Aliens	96	Your Beliefs	138
Swarm Intelligence	96	The Reliability of Beliefs	139
Evolutionary Robotics	97	Box 6.1 Solipsism, Anti-realism, and Deceiving Devils	140
Robots and Consciousness	98	Delusions	141
Building a Brain	98		

CONTENTS

ix

Box 6.2 Schizophrenia	141	8 Cognition and Consciousness	185
Mass Hysteria	143	Consciousness Is About Limitations	185
Confabulation	144	Language and Consciousness	186
Box 6.3 The Tanganyika Laughter Epidemic of 1962	144	Language and Culture	186
Denial	145	Thinking	188
Box 6.4 Dementia and Alzheimer's Disease	146	Inner Speech	189
Is Anything Unavailable to Consciousness?	147	Mental Imagery	191
Freud and the Unconscious	147	Attention	192
Box 6.5 Satanic Child Abuse	149	Visual Attention	194
Jung and the 'Collective Unconscious'	151	The Default Mode Network	194
Subliminal Processing	152	Box 8.1 The Default Mode Network	196
Chapter Summary	153	Global Workspace Theory	197
Review Questions	154	The Neuronal Workspace Theory	198
Recommended Resources	155	Box 8.2 The Neuroscience of the Neuronal Workspace Model	200
7 Self and Identity	156	The Multiple Drafts Model	201
The Self	156	Modelling the World	202
The 'Self Model'	157	Mental Models	202
Ego and Bundle Theories	159	Mental Time Travel	203
Box 7.1 Face Transplants	161	Metacognition	205
The Knower and the Known	161	Representational Theories	206
Damasio's Three Levels of Self	161	Recursion (Again)	207
Types of Self and the Executive Self	163	Box 8.3 What Is a Complex System?	209
The Continuity of Existence	165	Emergence	209
Amnesia and the Loss of Memories	166	Representation and Consciousness	210
Box 7.2 <i>Herpes simplex</i> Encephalitis	167	Free Energy	211
The Neuroscience of the Self	169	Quantum Consciousness	212
Disorders of the Physical Self	170	Box 8.4 Quantum Mechanics	213
Split-brain Studies	171	Chapter Summary	215
Dissociative States	173	Review Questions	216
Box 7.3 <i>Derealisation: A Case Study</i>	175	Recommended Resources	217
Dissociative Identity Disorders	175	9 Perception and Consciousness	218
The Boundaries of the Self	176	Empiricism	219
Phantom Bodies	176	Are You Dreaming Now?	220
Phantom Limbs and Phantom Pain	177	Box 9.1 The Brain in a Vat	220
The Rubber Hand Illusion	178	Normal Visual Perception	220
Awareness of Motor Control	179	Filling in	221
Is the Self Restricted to the Body?	180	Bistable Figures	221
Is the Self Just Another Illusion?	181	Binocular Rivalry	222
Chapter Summary	182	Change Blindness and Inattentional	
Review Questions	183	Blindness	224
Recommended Resources	184	Visual Illusions	225

CONTENTS

xi

Box 12.4 Sleep Deprivation for Depression	301	Is There a Special Hypnotic State?	330
Why Do We Sleep?	301	Dissociation	330
Evolutionary Functions of Sleep	301	Non-state Theories of Hypnosis	331
Sleep and Learning	302	Effects of Hypnosis	332
Chapter Summary	303	Hypnotic Suggestions	332
Review Questions	304	Hypnosis and Memory	333
Recommended Resources	304	Box 14.4 Is Hypnosis Dangerous?	334
13 Dreams	305	Hypnotic Anaesthesia	335
Are Dreams Real?	305	The Neuroscience of Hypnosis	336
Box 13.1 Zhuangzi's (Chuang-Tzu's) Butterfly Dream	306	Self-hypnosis	337
What Is a Dream?	307	What Hypnosis Tells Us About Cognition	338
How Well Do We Remember Our Dreams?	308	Chapter Summary	338
Lucid Dreams	310	Review Questions	339
Dream Content	312	Recommended Resources	339
Box 13.2 Dream Content	313	15 Drugs and Consciousness	341
Nightmares	313	A Classification of Psychoactive Drugs	342
Box 13.3 Sleep Paralysis	314	Cannabis	343
Recurring Dreams	315	Box 15.1 Medicinal Use of Cannabis	344
Why Do We Dream?	316	Amphetamine and Other Stimulants	345
Dreaming and Creativity	317	Amphetamine	345
Are Dreams a Way of Dealing with Threat?	318	Box 15.2 Amphetamine Psychosis	346
Psychoanalysis and Dreams	319	Cocaine	347
Post-analytic Dream Theories	320	Opiates and Opioids	348
Dreams and Learning	321	Morphine	348
Chapter Summary	321	Heroin	349
Review Questions	322	Hallucinogenic Drugs	350
Recommended Resources	322	Deliriant Drugs	350
14 Hypnosis	323	Dissociative Drugs	351
The History of Hypnosis	323	Psychedelic Drugs	352
Box 14.1 Freud, Charcot, Hysteria, and Hypnosis	324	Peyote	352
The Process of Hypnosis	325	Psilocybin	353
Hypnotic Induction	326	DMT	353
The Hypnotic Trance	327	LSD	355
Individual Differences in Hypnotisability	327	Box 15.3 Urban Myths and LSD Use	356
Box 14.2 Categories of Question in the Tellegen Absorption Scale	328	The History of LSD Use	357
Can We Learn Suggestibility?	329	Box 15.4 The Summer of Love	358
What Makes a Good Hypnotist?	329	Box 15.5 The Good Friday Marsh Chapel Experiment	359
Box 14.3 Snake Charmers and Horse Whisperers	329	The Neuroscience of Hallucinogens	359
		The Social Context of Drug Use	361
		The Dangers of Cannabis	361
		Cultural Diversity in Drug Use	362

Therapeutic Use of Hallucinogens	362	Trait and State Studies	395
Chapter Summary	363	Experimenter Effects in Parapsychological Research	395
Review Questions	364	Psychokinesis	395
Recommended Resources	364	Box 17.5 Poltergeist	396
16 Meditation and Transcendental Experiences	366	What Would Convince a Sceptic?	397
Meditation	366	What Does Parapsychology Tell Us About Consciousness?	398
The Physiological Effects of Meditation	367	Survival	398
Box 16.1 Raising Body Temperature Through Meditation	367	Box 17.6 Ghosts	399
The Neuroscience of Meditation	368	Reincarnation	400
Mindfulness	370	Chapter Summary	401
Transcendental Consciousness	371	Review Questions	402
Box 16.2 The Life of Colin Wilson	372	Recommended Resources	402
Consciousness Raising	373	18 Bringing it all Together	403
Religious Experiences	374	How Do We Define Consciousness?	403
Box 16.3 The Nine Characteristics of Mystical States	374	The ‘Hard Problem’	404
Temporal Lobe Activity and Religion	376	What Are the Neural Correlates of Consciousness?	404
Entheogens	378	What Are the Cognitive Correlates of Consciousness?	405
Buddhism	378	The Timing of Events	405
Zen	380	The Problem of Free Will	406
Chapter Summary	381	What Is the Self?	406
Review Questions	382	Why Are Some Things Unconscious?	407
Recommended Resources	382	Why Are We Conscious?	407
17 Parapsychology	384	Solving the Binding Problem	408
ESP and Psi	385	What Are Altered States of Consciousness?	408
Spontaneous Phenomena	386	Consciousness Around the World	409
Box 17.1 The Versailles Time Travel Incident	387	Can There Be a Science of Consciousness?	410
Box 17.2 Sonic Noise and Sonic Weapons	388	How This Book Will Help Your Life	411
How Spontaneous Phenomena Change with Time	389	Chapter Summary	412
Experimental Findings in Parapsychology	389	Recommended Resources	412
Box 17.3 Psychic Superstars	390	Glossary of General Terms	415
Issues in Experimental Design	391	Glossary of Basic Neuroanatomy Location Terms	422
Psi and Altered States of Consciousness	391	Glossary of the Most Common Neurotransmitters	422
Box 17.4 Hoax Mediums	392	Glossary of the Most Important Neuroanatomical Structures	422
Psi in the Ganzfeld	393	References	426
Remote Viewing	393	Index	464
Bem’s Experiments	394		

FIGURES

1.1	Diffusion tensor image of the living brain.	page 4
1.2	Democritus (c. 460–c. 370 BCE).	4
1.3	Buddhist nuns practising kung fu.	6
1.4	Sir Karl Popper (1902–1994).	8
1.5	Accuracy or resolution of various neuroscience investigatory techniques.	9
1.6	Growing brain cells.	11
1.7	A bat using sonar.	13
1.8	Helen Keller with her teacher Anne Sullivan, in 1888.	14
1.9	Meet my miniature poodle, Beau.	14
1.10	Hofstadter's 'consciousness cone'.	19
1.11	B.F. Skinner (1904–1990) with the Skinner Box.	21
<hr/>		
2.1	A red rose.	29
2.2	René Descartes (1596–1650).	30
2.3	The location of the pineal gland.	31
2.4	A monochrome rose.	34
2.5	A rainbow.	36
2.6	Colour spaces included in a version of a colour circle.	38
2.7	Chocolate.	39
2.8	Voodoo in Port au Prince, Haiti.	42
2.9	Humanoid robot dental therapy simulator 'Simroid'.	44
2.10	Neurons.	47
2.11	The roundworm <i>Caenorhabditis elegans</i> .	51
2.12	Publicity material from the 1957 Japanese science-fiction movie <i>The Mysterians</i> .	52
<hr/>		
3.1	A clockwork solar system.	59
3.2	British stage magician Jasper Maskelyne (1902–1973), at Whitehall Theatre, London, 1948.	61
3.3	The brain's reward circuitry.	63
3.4	<i>Toxoplasma gondii</i> .	66
3.5	Wormwood Scrubs prison in the UK.	67
3.6	Readiness potential.	70
3.7	An EEG cap.	71
3.8	The premotor cortex and surrounding areas.	74
3.9	Brain circuitry involved in obsessive-compulsive disorder	76
<hr/>		
4.1	A flock of starlings (<i>Sturnus vulgaris</i>).	80
4.2	The boids simulation.	81
4.3	Four-colour map of the United States.	83
4.4	Computer-generated algorithmic art, Composition #72 by Patrick Gunderson.	83

4.5	Deep Blue v. Kasparov (1996 match, Game 1).	84
4.6	Alan Turing (1912–1954).	87
4.7	BLOCKSWORLD, the microworld of Winograd (1972).	89
4.8	A plot showing the acceleration of the rate of development of important cultural and technological events.	90
4.9	Elektro the smoking robot.	94
4.10	CRONOS the robot.	95
4.11	The uncanny valley.	96
4.12	Aliens with tentacles.	97
4.13	The Golem Project; this robot form is called Arrow.	98
4.14	A cochlear implant.	101
<hr/>		
5.1	Beau the poodle.	109
5.2	A puffin with fish.	109
5.3	Alex the talking parrot and Irene Pepperberg.	111
5.4	Classical and modern views of a typical bird brain.	112
5.5	A common raven (<i>Corvus corax</i>) performing cognitive experiments.	112
5.6	'The blob'.	113
5.7	A slime mould.	114
5.8	The mirror test of self-recognition.	114
5.9	A forest fire: firefighters work to put out a forest fire on Signal Hill, Cape Town.	117
5.10	A group of chimpanzees at Ngamba Island Chimpanzee Sanctuary, Lake Victoria, Uganda.	119
5.11	Dr Louis Herman researches dolphin sensory abilities.	122
5.12	The first controlled, powered and sustained human flight, 17 December 1903, by the Wright brothers.	125
<hr/>		
6.1	William James (1840–1910).	133
6.2	Types of introspection.	134
6.3	A landscape of rainbow and tree.	136
6.4	A Kanizsa triangle.	139
6.5	Beatles hysteria.	144
6.6	The occipital lobe of the brain.	145
6.7	Freud's iceberg model of the mind.	148
6.8	A Rorschach test item.	148
6.9	Jungian archetypes revealed in the major arcana of the Tarot.	151
6.10	Subliminal advertising in the 1957 movie <i>Picnic</i> .	152
<hr/>		
7.1	David Hume (1711–1776).	159
7.2	Location of the thalamus.	163
7.3	Reconstruction of the wound to Phineas Gage.	164
7.4	The hippocampus, and the seahorse from which it gets its name, and its location in the brain.	167
7.5	The <i>Herpes simplex</i> virus.	168
7.6	Example of lesions to brain following a <i>Herpes simplex</i> encephalitis infection.	168

LIST OF FIGURES

xv

7.7	The insular cortex.	170
7.8	The brainstem.	170
7.9	The corpus callosum.	171
7.10	Split-brain testing setup	172
7.11	The mirror box setup.	178
7.12	The rubber hand setup.	178
7.13	The Petkova and Ehrsson person-swapping setup.	179
<hr/>		
8.1	Members of the Dani people of Papua, New Guinea.	187
8.2	The Müller–Lyer illusion.	188
8.3	Broca’s area.	190
8.4	The default mode network.	197
8.5	The phi illusion.	201
8.6	The brain and metacognition.	205
8.7	The Droste cocoa tin, 1904 design, illustrating recursion.	208
8.8	Microtubules at the edge of a cell.	212
8.9	A wave.	214
8.10	A quantum computer: the IBM Q System One.	214
<hr/>		
9.1	The Necker cube.	221
9.2	A bistable figure: which way up are the stairs?	222
9.3	The young girl–old lady figure.	222
9.4	‘The Slave Market with the Disappearing Bust of Voltaire’, by Salvador Dali (1940).	223
9.5	A concealed figure.	223
9.6	Stimulus used in change blindness experiment.	225
9.7	Stimulus used in inattentional blindness experiment.	226
9.8	Selection of visual illusions.	226
9.9	The dorsal and ventral visual streams in the brain.	228
9.10	How the world appears to people with spatial neglect.	229
9.11	The copying task and spatial neglect.	229
9.12	Representation of colour–letter synaesthesia.	231
<hr/>		
10.1	Examples of EEG output.	243
10.2	The evolving brain (not to scale).	244
10.3	An infant being tested with EEG.	246
10.4	Hydrocephaly scan.	247
10.5	The location of the claustrum.	254
10.6	The location of the anterior cingulate.	255
10.7	Death is not always instantaneous.	257
10.8	Awareness plotted against arousal.	258
<hr/>		
11.1	Normal waking state and some other states as revealed by EEG.	270
11.2	Timothy Leary (1920–1996).	271

11.3	A quiet place: inside an anechoic chamber.	272
11.4	A salt water sensory deprivation tank.	273
11.5	Lesions affecting the sense of self in space leading to OBEs.	276
11.6	Migraine aura.	278
11.7	EEG during an epilepsy seizure.	278
11.8	Encephalitis lethargica sufferer.	282
<hr/>		
12.1	A typical sleep laboratory.	286
12.2	A manatee sleeping on the sea floor.	288
12.3	Melatonin production.	288
12.4	The location of the pineal gland.	289
12.5	Brain activation in sleep.	290
12.6	Brain transections: <i>cerveau isolé</i> and <i>encéphale isolé</i> .	292
12.7	EEG of a cat.	292
12.8	Brainstem structures.	293
12.9	Hobson's AIM model of consciousness.	295
12.10	Non-drug treatments of insomnia.	297
12.11	Randy Gardner.	300
<hr/>		
13.1	Beau asleep.	306
13.2	Zhuangzi's butterfly dream.	307
13.3	Blood flow differences in high and low dream recallers.	309
13.4	Stimulation at 25–40 Hz of the frontal and temporal regions increases lucidity.	310
13.5	Frontal and parietal areas are more involved in lucid dreaming than in non-lucid dreaming.	311
13.6	'The Nightmare' (1802) by Henry Fuseli.	315
13.7	Activation of the default mode network in waking and REM states contrasted with slow-wave sleep as shown by fMRI.	317
13.8	The structure of benzene.	317
13.9	'The round dance of monkeys': six monkeys holding hands and paws.	318
13.10	Dream symbols.	319
<hr/>		
14.1	Franz Mesmer (1734–1815).	324
14.2	Jean-Martin Charcot (1825–1893).	325
14.3	Group hypnosis.	326
14.4	Billy Graham (1918–2018).	329
14.5	A snake charmer.	330
14.6	A group of smokers trying hypnosis to kick the habit.	333
14.7	Betty Hill's star map.	334
14.8	A Caesarean operation carried out under hypnosis in the maternity ward of Saint-Gregoire hospital in Rennes, France.	335
14.9	Neural correlates of hypnotic induction.	337

LIST OF FIGURES

xvii

15.1	A cannabis plant.	344
15.2	Caffeine and adenosine.	345
15.3	Coca plant fields in Yungas, Bolivia.	347
15.4	Morphine opioids activating receptors.	349
15.5	The peyote cactus.	352
15.6	Magic mushrooms.	353
15.7	Plant source of ayahuasca from the Amazonian basin in Peru.	354
15.8	Ayahuasca ceremony in Yarinacocha, in the Peruvian Amazon, 2018.	354
15.9	LSD tabs.	355
15.10	Representation of fractals in a psychedelic LSD experience.	356
15.11	The Summer of Love, 1967.	358
15.12	Imaging the hallucinating brain.	360
15.13	Carlos Castaneda (1925–1998).	362
<hr/>		
16.1	The brains of novice controls (left) and skilled meditators (right) while meditating.	368
16.2	Brain regions involved in mindfulness meditation.	369
16.3	Mindfulness training seems to affect many of the same brain regions as other types of meditation.	370
16.4	George Ivanovitch Gurdjieff (1877–1949).	372
16.5	Colin Wilson (1931–2013).	372
16.6	Women's liberation: an equal rights march.	374
16.7	Whirling dervishes perform the Sema Ritua.	375
16.8	Average additional brain activation of Carmelite nuns in mystical states.	376
16.9	The 'God helmet'.	377
16.10	A representation of the sacred Buddha, Wuxi city, Jiangsu province, China.	379
16.11	A group of westerners practising Zen Buddhism.	380
<hr/>		
17.1	An 'unidentified flying object' (UFO).	385
17.2	Zener cards.	389
17.3	Uri Geller.	390
17.4	Sensory leakage.	391
17.5	Ectoplasm apparently appearing out of the head of the medium Marthe Beraud.	392
17.6	The ganzfeld.	393
17.7	Some targets in the ganzfeld.	393
17.8	Remote viewing.	394
17.9	Psychokinesis?	396
17.10	Poltergeist: pointing at the location of a rapping sound – or is it a portal to another dimension?	397
17.11	Victorian photograph of a ghost.	399
17.12	Reincarnation: the case of the Pollock twins.	400
<hr/>		
18.1	Moon rocks.	403
18.2	Computer cables and power.	405

18.3	Guard on prison security tower.	406
18.4	Mountain (or eastern) gorillas, <i>Gorilla beringei</i> .	408
18.5	What changes in an altered state of consciousness?	409
18.6	Captain James Cook meeting indigenous people in the tropics, circa 1700.	409
18.7	Equations on a blackboard.	411

PREFACE

The late twentieth century saw the emergence of cognitive science as an interdisciplinary approach to studying the mind, a strategy that took what was needed from experimental psychology, computer science, philosophy, linguistics, anthropology, and comparative psychology, and, increasingly, neuroscience. As I have taught the study of consciousness over the past 30 years – first as part of an introductory cognition class, and then as an advanced option – I have seen the ways in which the evidence gleaned from neuroscience in particular has become essential to our understanding of consciousness. Indeed, all of psychology has become substantially intertwined with neuroscience. During this period, consciousness has moved from being a fringe topic to one taking centre stage, unifying different areas of psychology in the process.

Yet many students are surprised by the idea that there might be nothing more to us than our brain and bodies; and if psychology students are troubled by this notion, those without a psychology background are often shocked. This insight – that our brain is all there is, and therefore that neuroscience must play a major role in our discussion of consciousness – is the main reason for the creation of this text. As an instructor, I began to feel the need of a text that could succinctly address consciousness in light of the available scientific information by putting neuroscience front and centre in the discussion, while maintaining philosophical integrity. I want a text that can show that there is still a glorious mystery ever present in our lives, and that science can cast light on that mystery. *The Science of Consciousness* is that text.

Approach

Primarily an undergraduate text, *The Science of Consciousness* is appropriate for psychology and philosophy courses in consciousness and cognitive psychology. I hope, however, that it will reach a broader audience, and consequently have written with the educated lay person in mind. As a comprehensive introduction to the science of consciousness, the text is distinguished by the following characteristics.

A Multidisciplinary Approach. Because of the profound effect on the study of consciousness by discoveries in diverse academic fields, only an interdisciplinary approach can expose students to the broadest and most up-to-date understanding of consciousness. Consequently, the text examines every major subject in terms of the light that can be shed on it by a wide range of disciplines – from social sciences to biological sciences to computer science to philosophy.

Theoretical Framework. This book is a text, not a monograph, or a piece of original research, or a mission statement. I have endeavoured to be as neutral as possible while covering a range of material from many sources, some of which contradict each other.

Psychology is distinguished by a lack of consensus in the way that would not be evident in, say, an undergraduate physics text, where much more is known and certain about the discipline being studied. It is one of the challenges of a psychology or related course that the student has to learn to live with and evaluate the uncertainty.

Although bias has no place in a text, it might occasionally shine through. My views are closer to those of Chalmers than of Dennett. I think enormous progress has been made in understanding consciousness over the last few decades, mainly as a result of sophisticated psychology experiments and advances in neuroscience, while philosophy has sharpened the issues to be debated. There is a core of problems (the ‘hard problem’) where advances have been less rapid, and there may be some problems that are never solved. But progress isn’t achieved by giving up, and nothing would be more depressing to a student than a defeatist text. This book is called *The Science of Consciousness* because I think science is humanity’s greatest invention.

Little Prior Knowledge Assumed. An interdisciplinary approach brings the challenge that few readers have a background in all of the component disciplines. Not all readers of the text will have the same level of knowledge of these diverse fields, particularly when a major contributor to understanding consciousness is neurobiology, often a difficult subject for the nonspecialist under any circumstances. Students may be apprehensive, finding it difficult to remember all the names and acronyms used in the topic. Understanding the subject can seem more like a test of memory rather than a matter of understanding principles.

Consequently, I have tried to assume as little prior knowledge as possible. Explanations take into account the reality that readers are not students of neuroscience. In addition, rather than weigh down the text with background material that not all readers will need, I have put some information in boxes so that it does not interrupt the flow of the text. Also, I have focused on trying to make the text move seamlessly from subject to subject so that concepts build organically regardless of the discipline from which they emerge. The early part of the text contains a lot of philosophy and a few experiments; later, as we examine consciousness-related topics such as attention and sleep, the text focuses less on philosophy and a great deal more on experiments.

Strong Foundation in Neuroscience. Recent rapid advances in the study of the brain have transformed our ideas about consciousness. No serious consideration of consciousness can proceed without substantial input from neuroscience. Consequently, the discussion of discoveries in neuroscience is an essential aspect of the text. As neuroscience informs every aspect of the subject, the material is integrated throughout rather than shunted into one separate chapter. The glossary though provides a resource for students with less background in neuroscience.

Integration Throughout of ‘Atypical’ States of Consciousness. While other texts cover sleep and dream science very briefly, three full chapters are devoted to the recent discoveries

in this field – discoveries that are especially important to psychology students interested in the latest psychotherapeutic interventions. Other chapters are devoted to ‘atypical’ states of consciousness; it is easy to gain the impression from the literature that consciousness is one simple state.

Inclusion of Cross-cultural Aspects of Consciousness. Most psychology experiments might be carried out on western young undergraduate students, but we must remember that they might not always be representative of the world’s population of what is expected to soon be 8 billion. Different cultures have different views of consciousness; for example, contrast western and eastern approaches to consciousness and spirituality. Different religions place different emphases on altered states of consciousness and means of obtaining them (including prayer and drugs). Even differences between languages affect the way we think of the world.

Engaging Pedagogical Features. The text includes many pedagogical features. Students are encouraged to attempt activities, experiments, and thought experiments, labelled ‘Try this’, throughout the text; these exercises prompt them to examine different conceptual problems. No other subject lends itself so well to self-exploration as does consciousness. ‘Try this’ suggestions are clearly marked in the text.

To maintain the flow of the narrative, as well as to break up the text, boxes contain nonessential material that some students might find useful or interesting. In particular, I have provided background information about interdisciplinary approaches that many undergraduates might not know. I have illustrated the book as richly as possible, taking care to use illustrations that really add information or aid understanding, rather than being merely decorative or token. Each figure is captioned so as to aid skimming and remembering the associated material.

Each chapter contains recommendations for exploring further reading and other material. To make the supplemental reading as accessible as possible, I have focused on approachable secondary sources that will prepare the student for the primary sources of peer-reviewed journal articles and books.

Every chapter begins with a roadmap of what that chapter is about. At the end of each chapter is a clear bullet point summary telling the reader what they need to be able to take away from each chapter. The summaries can also act as another form of self-test for readers to be able to evaluate their understanding and knowledge of each topic. There are explicit self-test questions at the end of each chapter.

I think reading the text from Chapter 1 through to Chapter 18 is the best order, but have tried to make each chapter as independent as possible. There is a glossary to assist readers. Items in the glossary are in bold red on first mention (outside the introduction). There is a separate glossary of neuroanatomical location terms, with entries in the text in bold black italic, a glossary of common neurotransmitters with entries in non-bold red, and a glossary of neurotransmitter structures with entries in bold black. Other important technical terms whose scope is usually confined to one chapter are in italics. There is also a list of abbreviations and acronyms.

Online Resources

The field of consciousness research is fast changing and the reader will want a way of keeping up to date with what has happened since the book's publication. There is, of course, also far more material than can be presented in one book. In an attempt to deal with these issues, there is a website for this book at: www.trevorharley.com/consciousness.html.

Under *Consciousness* you will find corrections, additions, comments, news of recent work, informative reviews of other books on consciousness, and frequently asked questions.

One of the most difficult decisions for the writer is how many citations to include. If absolutely everything is referenced, the book will be enormous and the flow disrupted at least once a sentence. On the other hand, every statement must be obviously true or easily verifiable by the reader. If you think a particular assertion needs additional clarification or verification please email me. More generally, an enormous number of resources are available online. The number of blogs on consciousness alone is daunting, but the difficulty with blogs is that unlike journal articles they are not peer-reviewed. I have posted links to some of them on my website.

Some instructors will think this topic should be in and that topic should be out. If you think a particular topic should be covered, please contact me. If you think I should cite particular research, again please just email me. I hope that as time passes new research will overthrow old ideas and give us fresh understanding.

Organisation and Coverage

The early chapters focus on what consciousness is. After giving the matter some thought, I decided to put a chapter on machine and animal consciousness relatively early on. I think students new to the subject matter will find this discussion enhances their understanding of the nature of consciousness. In general, I have made each chapter as independent as possible, so the order of material can be determined by the instructor. I suggest though that the first three chapters be covered first.

The chapters are grouped into three parts.

Part I is on the nature of consciousness. We try to come to grips with what consciousness is.

Chapter 1 surveys the field of consciousness, explaining why it is such a difficult subject to study. The chapter summarises the whole book. The conclusion is that the 'problem' of consciousness is really several related problems.

Chapter 2 discusses the relationship between the mind and brain – a relationship that some have viewed as between hardware and software. This chapter is mainly a philosophical one. It is essential reading if you want to appreciate what the problems are, and how they might be solved. The focus is mainly on what has been called the 'hard problem' of consciousness: why does it feel like something to be me? This chapter summarises the main philosophical approaches to consciousness in the philosophy of mind.

Chapter 3 addresses the problem of free will. It asks who is making decisions about when to do something. It also examines the legal implications of this discussion; if we don't have free will, can we really be held responsible for our actions? Can we ever really be guilty

of a crime? The chapter covers philosophical, psychological, and neuroscientific approaches to deciding to act.

Chapter 4 is the first of two about other types of consciousness. Could a computer or robot ever be conscious? How would we tell? Are there any ethical issues or fears associated with machine consciousness?

Chapter 5 talks about awareness in animals, asking this time how we might tell that an animal is self-aware. What are the ethical issues concerning possible consciousness in some animals? A related issue to animal consciousness concerns the evolution of consciousness. Why are some animals conscious (presumably) but not others, and why did consciousness evolve in humans? How is the development of consciousness related to the development of human consciousness and of social groups and organisation?

Part II is about the workings of consciousness. How does consciousness arise from the brain, and how is it related to cognitive and perceptual processing?

Chapter 6 examines introspection and what we can learn about consciousness. What do we think about? What are the contents of consciousness? We think we know all about our own consciousness because it is so immediate, but psychologists understand that appearances are deceptive. Our behaviour is prone to all sorts of bias and self-deception. Some illnesses and damages to the brain have interesting and revealing effects on our abilities to access information about ourselves. This chapter also examines Freud's conception of an actively repressed unconscious and his theory about the structure of the mind. The chapter concludes with an examination of subliminal processing and priming.

Chapter 7 is about the self and our views of our own identity. Do we have a stable identity that persists over time? Is there a core 'me'? The chapter focuses on the contrast between ego and bundle theories of the sense. The text examines various illusions that show how the self can be misled about what it is, which leads into a discussion of how brain damage can disrupt our identities. In particular, the chapter explores the extent to which we derive our sense of self from our memories and what happens when our autobiographical memories are extremely disrupted by brain damage. Again, we focus on the neuroscientific basis of our sense of self.

Chapter 8 focuses more on the cognitive psychology of consciousness. We are 'thinking' all the time we are awake, but what is thought? Many of us experience an inner voice commenting on our experience. Where does this inner voice come from, and how is it related to other language systems? We examine whether the form of our language affects the way in which we think and perceive the world. 'Attention' is an important topic in cognitive psychology and is clearly related to consciousness, but as the chapter shows, attention and consciousness are not the same thing. The text discusses the neuroscience of attention and particularly the idea that there is a 'default mode' network busy when we are doing nothing else – a system that generates daydreaming. The chapter presents several models of consciousness that emphasise cognition. Finally, we look at accounts of consciousness involving quantum mechanics.

Chapter 9 takes a look at the closely related topics of the relationships between visual perception, visual awareness, the brain, and consciousness. A great deal of research has been done on visual awareness. What have we learned from all this research?

Chapter 10 examines in detail the key question of how consciousness is related to the brain. At first sight we might need look no further than how anaesthetics function, but as we shall see, although the workings of anaesthetics are instructive, they provide no definitive answers. We can learn a great deal by examining how damage to the brain affects consciousness. We can also learn something with new techniques of imaging the brain, although some caution is needed in drawing conclusions from these results. Several models of consciousness and the brain are discussed in this chapter. It looks at death, the end of consciousness. Or is it? Is there any continuation of consciousness after death? And how should we define death in the first place? Is death a sudden or lingering process, and what affects the duration of any transition from consciousness to death? Is it possible to avoid death?

Part III is about states of consciousness other than normal waking consciousness – what are called ‘altered states of consciousness’, including sleep, dreams, hypnosis, and drug-induced states.

Chapter 11 introduces the notion of an altered state of consciousness, a state of consciousness that is in some way different from our normal waking consciousness. We consider what happens to make the state of consciousness seem altered: how do changes in the brain lead to changes in phenomenology? This chapter looks at a range of altered states with different origins, such as sensory deprivation and out-of-body experiences.

Chapter 12 looks at that most familiar altered state, sleep, in which consciousness is largely absent. The mechanisms that control the sleep–wake cycle are likely to reveal much about what maintains wakefulness and consciousness. We look at brain structures, the connectivity of the brain, and neurotransmitters. The chapter also examines the effects of sleep deprivation and sleep disorders. Finally, we ask why we sleep, and to what extent is sleep involved in learning?

Chapter 13 examines the related topic of dreams. Dreaming is the altered state of consciousness with which everyone is most familiar. What do people dream about, and why do we dream? The subject of dreams is naturally a time to revisit Freud, but there are many other accounts of dreaming, and they are not necessarily contradictory. We ask how the brain generates dream content, and we examine dream pathology – the nightmare. We also consider lucid dreaming, when people are aware that they are dreaming and can sometimes influence dream content.

Chapter 14 discusses hypnosis. There has been much debate among psychologists and psychotherapists about whether hypnosis is indeed an altered state of consciousness, and this chapter examines the debate and the evidence. How do we induce hypnosis, and why are some people more easily hypnotised than others? We look at how post-hypnotic suggestions work, and what the clinical applications of hypnosis are. And we also address the issue of whether people can be hypnotised to do things they don’t want to do.

Chapter 15 reviews the effects of psychoactive drugs – drugs that influence our mental state. There are a huge number of such drugs with many different effects – some synthesised, some naturally occurring, some used as medical treatment, some for recreation, some legal, some illegal. This chapter focuses on those drugs that tell us the most about consciousness, particularly LSD. The key question is, how do changes to the brain (particularly the chemistry of the brain) lead to changes in perception and consciousness? We look at

what the study of psychoactive drugs tells us about ‘normal’ consciousness. Also included is a brief discussion of the social context of these drugs, looking at how recreational drugs might have helped shape cultural changes.

Chapter 16 examines meditation. What is meditation, and does it work – and, if it does, how? An overwhelming amount of evidence suggests that regular meditation is beneficial in a large number of ways, and this chapter considers these. The chapter also examines the related idea of mystical and religious experiences. The chapter concludes by asking whether there is a state of consciousness that is in some way ‘better’ than our normal resting state, or at least a ‘heightened’ state of consciousness.

Chapter 17 reviews the existence of paranormal phenomena, and the methodological difficulties involved in testing for them. What is the evidence for extrasensory perception and related phenomena? And what if anything does the subject tell us about consciousness?

Finally, Chapter 18 revisits the questions posed at the end of the first chapter and summarises what we have learned.

ACKNOWLEDGEMENTS

I have many people to thank for this book. Several anonymous reviewers have improved the book immeasurably. The discussion of artificial intelligence has benefitted from years of argument with Richard Loosemore.

This book would not have happened in this form without the enthusiasm and encouragement of Allan Hobson. I am grateful for his generosity, hospitality, experience, knowledge and enthusiasm. I am conscious of the fact that he won't always approve of the approach I have taken, but nevertheless, Allan, this book is for you. Numerous other people helped. Matthew Bennett of Cambridge University Press (CUP) got the project rolling, and I am grateful to CUP for all their help and particularly their patience. I would like to thank Lisa Pinto for all her guidance and patience, and Linda Stern for all her detailed comments and hard work; I hope you think it has paid off. Jane Adams has been a superb editor. Particular thanks are due to Rachel Norridge for the extraordinary amount of time and help she has given me. I have had many conversations over many years with Richard Wilton about many of the topics in this book. We have recently written a book together (*Science and Psychology*), which has a chapter about consciousness and another about free will, and I am sure my current approach to the legal issues surrounding free will has been influenced by cowriting the latter chapter in particular. Frank John Snelling read chapters as an 'intelligent lay person', and his comments on what he found difficult or needing definition were illuminating.

Finally, here is a word of consolation. The study of consciousness is difficult; if you find it hard going at times, it isn't just you. It's right up there in conceptual difficulty with quantum mechanics and relativity. And more difficult than rocket science and brain surgery.

ABBREVIATIONS

ACC	Anterior cingulate cortex
AI	Artificial intelligence
AIM	Activation input modulation
APA	American Psychological Association
ASC	Altered state of consciousness
ASPD	Antisocial personality disorder
AVH	Auditory verbal hallucination
CBD	cannabidiol
CN	Caudate nucleus
CSF	Cerebrospinal fluid
CLIS	complete locked-in syndrome
DBS	Deep-brain stimulation
DCH	dynamic core hypothesis
DID	Dissociative identity disorder
DLPFC	Dorsolateral prefrontal cortex
DMN	Default mode network
DMT	N,N-dimethyltryptamine
DN	Default network
DSM	The American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders
EEG	Electroencephalogram
ESM	Experience sampling method
ESP	Extrasensory perception
fMRI	Functional magnetic resonance imaging
fNIRS	functional near infrared spectroscopy
GWT	Global workspace theory
GESP	a general extrasensory perception
HPPD	hallucinogen persisting perception disorder
IIT	Integrated information theory
LIFG	left inferior frontal gyrus
LRE	life review experience
LIS	Locked-in syndrome
MAOI	Monoamine oxidase inhibitor
MEG	Magnetoencephalography
mPFC	Medial prefrontal cortex
MCS	Minimally conscious state
MRI	Magnetic resonance imaging
ms	Millisecond, 1/1000 th of a second
MSR	Mirror test of self-recognition

MVPA	multi-voxel pattern analysis
NCC	Neuronal correlates of consciousness
NDE	Near-death experience
NREM	Non-rapid eye movement sleep
OBE	Out-of-body experience
OCD	Obsessive-compulsive disorder
OFC	Orbito-frontal cortex
PCC	Posterior cingulate cortex
<i>PCP</i>	phencyclidine
PET	Positron emission tomography
PK	psychokinesis
PGO	Ponto-geniculo-occipital
POSTS	Positive occipital transients of sleep
PPC	posterior parietal cortex
PTSD	Post-traumatic stress disorder
PVS	Persistent vegetative state
REM	Rapid eye movement (sleep)
REST	Restricted environmental stimulation therapy
RP	Readiness potential
SCN	Suprachiasmatic nucleus
SSRI	Selective serotonin re-uptake inhibitor
SWS	slow-wave sleep
TUTs	task unrelated thoughts
TST	threat simulation theory of dreaming
THC	Tetrahydrocannabinol
TLE	Temporal lobe epilepsy
TMS	Transcranial magnetic stimulation