

What's new here?

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Abstract: O'Brien & Opie's (O&O's) theory demands a view of unconscious processing that is incompatible with virtually all current PDP models of neural activity. Relative to the alternatives, the theory is closer to an AI than a parallel distributed processing (PDP) perspective, and its treatment of phenomenology is ad hoc. It raises at least one important question: Could features of network relaxation be the "switch" that turns an unconscious into a conscious network?

Having argued for some years (1) that phenomena like blind sight and implicit learning are often mediated by nonsensory experiences, (2) that PDP networks naturally model consciousness better than do classical AI models, and (3) that consciousness is an information bearing medium (i.e., roughly, a vehicle) – I am grateful to O'Brien & Opie (O&O) for introducing these possibilities to a wider audience. (See Mangan 1991; 1993b; 1993c for points 1 and 2 above; see Mangan 1993a; 1998 for point 3 above.) And though I cannot speak for him, many of these issues have also been addressed, independently and in somewhat different ways, by Dan Lloyd (1988; 1991; 1995a; 1996).

The new element in O&O's target article is their claim that *only* fully settled networks are represented in consciousness, and that *no* full network relaxation ever takes place unconsciously. This certainly gives them a unique thesis. But it also brings with it a huge problem – for it goes completely against current PDP thinking about the operation of unconscious neural networks in the brain. PDP networks yield the most information when they are fully relaxed; unstable networks are almost always less informative than stable networks.

To accept O&O's theory, we must first conclude that most neural networks forego, for some reason, the very great information processing advantage that full stabilization would otherwise provide them. Why should this shortfall occur? So far as I can see, O&O have neither neural nor behavioral evidence nor PDP theory to justify this extraordinary assertion about the nature of unconscious processing. There is, of course, always the possibility that they are right, and that PDP thinking has made a mistake about one of its fundamental applications. But some sort of strong argument supporting this claim is required, and none is provided. Yet their entire theory of consciousness rises or falls on this point.

In one sense, O&O's concern with phenomenology is on firmer ground. They have a general interest in the "parallel" aspects of experience, which is natural for any PDP attempt to understand consciousness. But their specific task is to show that they can account for our phenomenology on the assumption that only fully relaxed networks occur in consciousness. This presents various obstacles that the other PDP theories of consciousness do not have to face, because they do not make such restrictive assumptions. So O&O have ended up with a fairly rigid theory of conscious, one that distinguishes conscious from unconscious processes more in the mood of classical AI than PDP. As they themselves note: "As was the case with classicism, such a connectionist vehicle theory [i.e., their theory] would embrace the distinction between explicit representation and potentially explicit/tacit representation, as the boundary between the conscious and the unconscious" (sect. 4.2, para. 1).

In consequence, O&O's position is somewhat retrograde. Their theory will not let them take advantage of one of the central ideas found in all other PDP theories of consciousness: that is, that network relaxation can be represented in consciousness even when full stabilization has not occurred, thereby allowing consciousness to represent dynamic as well as fully stable states of neural activity. In rejecting this view, O&O have had to make many ad hoc assumptions about the relation of the brain to conscious experience (see sect. 5) before being able to move on to explain the same sort

of "parallel" phenomenology the other theories can address much more directly.

O&O's theory requires that we accept a new view of unconscious processing that is maintained without benefit of supporting evidence, and is at odds with virtually all existing PDP models of neural activity. Even if we set this problem aside, the ability of the theory to handle the phenomenological facts is more cumbersome and ad hoc than the alternatives already developed.

But I suspect all current PDP theories of consciousness will look very deeply flawed in ten or twenty years. The late philosopher of science Paul Feyerabend held that a theory in science can serve many functions besides proclaiming an eternal "truth." Whatever its status, O&O's theory still raises an important question: Is there something about the way a network stabilizes that could "switch" it from unconscious to conscious processing? The standard view is to suspect that activation levels may perform this function. But O&O in effect suggest that the switching mechanism could derive from a more complex aspect of network behavior. I doubt that full network stabilization could work as a consciousness switch, but the general question O&O raise is important, even if no answer is in sight.

References

The letters "a" and "r" before authors' initials refer to target and response article references, respectively.

- Akins, K. (1996) Lost the plot? Reconstructing Dennett's multiple drafts theory of consciousness. *Mind and Language* 11:1–43. [aGO]
- Anderson, J. R. (1995) *Cognitive psychology and its implications*, 4th edition. Freeman. [rGO]
- Arbib, M. & Hanson, A. (1987) *Vision, brain, and cooperative computation*. MIT Press. [rGO]
- Aurell, C. (1989) Man's triune conscious mind. *Perceptual and Motor Skills* 68:747–54. [RE]
- Azzopardi, P. & Cowey, A. (1997) Is blindsight like normal, near-threshold vision? *Proceedings of the National Academy of Sciences USA* 94:14190–94. [RWK]
- Baars, B. J. (1988) *A cognitive theory of consciousness*. Cambridge University Press. [arGO]
- (1994) A thoroughly empirical approach to consciousness. *Psyche* 1(6). <http://psyche.cs.monash.edu.au/v2/psyche-1-6-baars.html>. [rGO]
- (1996) *In the theater of consciousness: The workspace of the mind*. Oxford University Press. [DED, GW]
- (1997) In the theatre of consciousness: Global workspace theory, a rigorous scientific theory of consciousness. *Journal of Consciousness Studies* 4:292–309. [JO]
- Baddeley, A. (1986) *Working memory*. Oxford University Press. [JGT, GW]
- Barbur, J. L., Harlow, A. J. & Plant, G. (1994) Insights into the different exploits of colour in the visual cortex. *Proceedings of the Royal Society of London, Series B* 258:327–34. [RWK]
- Bechtel, W. (1988a) Connectionism and rules and representation systems: Are they compatible? *Philosophical Psychology* 1:1–15. [aGO]
- (1988b) Connectionism and interlevel relations. *Behavioral and Brain Sciences* 11:24–25. [aGO]
- Bechtel, W. & Abrahamsen, A. (1991) *Connectionism and the mind*. Blackwell. [aGO]
- Becker, S., Moscovitch, M., Behrmann, M. & Joordens, S. (1997) Long-term semantic priming: A computational account and empirical evidence. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 23:1059–82. [AC]
- Berti, A. & Rizzolatti, G. (1992) Visual processing without awareness: Evidence from unilateral neglect. *Journal of Cognitive Neuroscience* 4:345–51. [rGO, MZ]
- Bickhard, M. H. & Terveen, L. (1995) *Foundational issues in artificial intelligence and cognitive science: Impasse and solution*. North Holland. [TP]
- Blachowicz, J. (1997) Analog representation beyond mental imagery. *Journal of Philosophy* 94:55–84. [rGO]
- Block, N. (1993) Book review of Dennett's *Consciousness explained*. *Journal of Philosophy* 90:181–93. [aGO]
- (1995) On a confusion about a function of consciousness. *Behavioral and Brain Sciences* 18:227–87. [arGO, JO]
- Boden, M. (1990) *The creative mind*. Abacus. [rGO]
- Bower, G. H. (1975) Cognitive psychology: An introduction. In: *Handbook of learning and cognitive processes* (vol. 1), ed. W. K. Estes. Erlbaum. [DED]
- Cam, P. (1984) Consciousness and content-formation. *Inquiry* 27:381–97. [aGO]
- Campion, J., Latto, R. & Smith, Y. M. (1983) Is blindsight an effect of scattered light, spared cortex, and near-threshold vision? *Behavioral and Brain Sciences* 6:423–86. [RWK, arGO]
- Carlson, R. A. (1992) Starting with consciousness. *American Journal of Psychology* 105:598–604. [RAC]
- (1997) *Experienced cognition*. Erlbaum. [RAC]
- Carlson, R. A. & Dulany, D. E. (1988) Diagnostic reasoning with circumstantial evidence. *Cognitive Psychology* 20:463–92. [DED]
- Carruthers, P. (1996) *Language thought and consciousness. An essay in philosophical psychology*. Cambridge University Press. [JP]
- Chalmers, D. J. (1995) Facing up to the problem of consciousness. *Journal of Consciousness Studies* 2:200–19. [aGO]
- (1996) *The conscious mind: In search of a fundamental theory*. Oxford University Press. [AC, aGO]
- Charland, L. C. (1995) Emotion as a natural kind: Towards a computational foundation for emotion theory. *Philosophical Psychology* 8:59–84. [aGO]
- Chomsky, N. (1980) Rules and representations. *Behavioral and Brain Sciences* 3:1–62. [aGO]
- Churchland, P. M. (1990) Knowing qualia: A reply to Jackson. In: *A neurocomputational perspective*. MIT Press. [rGO]
- (1995) *The engine of reason, the seat of the soul*. MIT Press. [arGO, RVG, BvH, GW]
- Churchland, P. S. & Sejnowski, T. (1992) *The computational brain*. MIT Press. [arGO, TP]
- Clapin, H. & O'Brien, G. J. (1998) A conversation about superposition and distributed representation. *Noetica: Open Forum* 3(10). <http://psy.uq.edu.au/CogPsych/Noetica/>. [rGO]
- Clark, A. (1989) *Microcognition: Philosophy, cognitive science, and parallel distributed processing*. MIT Press. [aGO]
- (1993a) *Associative engines: Connectionism, concepts and representational change*. MIT Press/Bradford Books. [HC, aGO]
- (1993b) *Sensory qualities*. Oxford. [DL]
- Clark, A. & Karmiloff-Smith, A. (1993) The cognizer's innards: A psychological and philosophical perspective on the development of thought. *Mind and Language* 8:487–519. [AC, aGO]
- Clark, A. & Thornton, C. (1997) Trading spaces: Computation, representation and the limits of uninformed learning. *Behavioral and Brain Sciences* 20:57–90. [aGO]
- Cleeremans, A. (1997) Principles for implicit learning. In: *How implicit is implicit learning?*, ed. D. C. Berry. Oxford University Press. [AC, rGO]
- Cleeremans, A. & Jiménez, L. (submitted) Implicit cognition with the symbolic metaphor of mind: Theoretical and methodological issues. [AC]
- Cleland, C. E. (1993) Is the Church-Turing thesis true? *Minds and Machines* 3:283–313. [aGO]
- Collins, A. M. & Loftus, E. F. (1975) A spreading activation theory of semantic processing. *Psychological Review* 82:407–28. [MZ]
- Copeland, B. J. (1997) The broad conception of computation. *American Behavioral Scientist* 40:690–716. [aGO]
- Corteen, R. S. (1986) Electrodermal responses to words in an irrelevant message: A partial reappraisal. *Behavioral and Brain Sciences* 9:27–28. [aGO]

- Corteen, R. S. & Wood, B. (1972) Electrodermal responses to shock-associated words in an unattended channel. *Journal of Experimental Psychology* 94:308–13. [aGO]
- Cottrell, A. (1995) *Tertium datur?* Reflections on Owen Flanagan's *Consciousness reconsidered*. *Philosophical Psychology* 8:85–103. [aGO]
- Cowey, A. (1996) Visual awareness: Still at sea with seeing? *Current Biology* 6(1):45–47. [rGO]
- Crick, F. (1984) Function of the thalamic reticular complex: The searchlight hypothesis. *Proceedings of the National Academy of Sciences, USA* 81:4586–90. [aGO]
- Crick, F. & Koch, C. (1995) Are we aware of neural activity in primary visual cortex? *Nature* 375:121–23. [DG]
- (1998) Consciousness and neuroscience. *Cerebral Cortex* 8:97–107. [DG]
- Cummins, R. (1986) Inexplicit representation. In: *The representation of knowledge and belief*, ed. M. Brand & R. Harnish. University of Arizona Press. [HC, aGO]
- (1989) *Meaning and mental representation*. MIT Press. [rGO]
- (1996) *Representations, targets, and attitudes*. MIT Press. [arGO]
- Cummins, R. & Schwarz, G. (1991) Connectionism, computation, and cognition. In: *Connectionism and the philosophy of mind*, ed. T. Horgan & J. Tienson. Kluwer. [GO]
- Cussins, A. (1990) The connectionist construction of concepts. In: *The philosophy of artificial intelligence*, ed. M. Boden. Oxford University Press. [aGO]
- Damasio, A. R. (1994) *Descartes' error*. Putnam. [NN]
- Dennett, D. C. (1981) Three kinds of intentional psychology. In: *Time, reduction and reality*, ed. R. Healy. Cambridge University Press. (Reprinted in Dennett, D. C. (1987) *The intentional stance*. MIT Press. [RVG]
- (1982) Styles of mental representation. *Proceedings of the Aristotelian Society (New Series)* 83:213–26. [JC, DCD, DED, arGO, TP, MSCT] Reprinted in *The Intentional Stance*. MIT Press. [HC]
- (1984) Cognitive wheels: The frame problem of AI. In: *Minds, machines and evolution*, ed. C. Hookway. Cambridge University Press. [aGO]
- (1987) *The intentional stance*. MIT Press/A Bradford Book. [DCD]
- (1991) *Consciousness explained*. Little, Brown. [DCD, MK, arGO]
- (1993) The message is : There is no medium. *Philosophy and Phenomenological Research* 53:919–31. [arGO]
- (1998) The myth of double transduction. In: *Toward a science of consciousness, II*, ed. S. R. Hameroff, A. W. Kaszniak & A. C. Scott. MIT Press/Bradford Books. [DCD]
- Dennett, D. C. & Kinsbourne, M. (1992) Time and the observer: The where and when of consciousness in the brain. *Behavioral and Brain Sciences* 15:183–247. [TP]
- Dienes, Z. & Berry, D. (1997) Implicit learning: Below the subjective threshold. *Psychonomic Bulletin and Review* 4:3–23. [rGO, JP]
- Dienes, Z., Broadbent, D. E. & Berry, D. (1991) Implicit and explicit knowledge bases in artificial grammar learning. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 17:875–78. [aGO]
- Dietrich, E. (1989) Semantics and the computational paradigm in cognitive psychology. *Synthese* 79:119–41. [aGO]
- Dixon, N. F. (1971) *Subliminal perception: The nature of a controversy*. McGraw-Hill. [MV]
- (1981) *Preconscious processing*. Wiley. [MV]
- Dretske, F. (1993) Conscious experience. *Mind* 102:263–83. [MK, aGO]
- (1995) *Naturalizing the mind*. MIT Press. [aGO]
- Dulany, D. E. (1968) Awareness, rules, and propositional control: A confrontation with S-R behavior theory. In: *Verbal behavior and general behavior theory*, ed. T. Dixon & D. Horton. Prentice-Hall. [DED]
- (1991) Artificial representation and thought systems. In: *Advances in social cognition IV*, ed. R. S. Wyer, Jr. & T. K. Srull. Erlbaum. [DED, arGO]
- (1997) Consciousness in the explicit (deliberative) and implicit (evocative). In: *Scientific approaches to consciousness*, ed. J. Cohen & J. Schooler. Erlbaum. [DED, aGO]
- Dulany, D. E., Carlson, R. A. & Dewey, G. I. (1984) A case of syntactical learning and judgement: How conscious and how abstract? *Journal of Experimental Psychology: General* 113:541–55. [aGO]
- Edelman, G. M. (1987) *Neural Darwinism: The theory of neuronal group selection*. Basic Books. [GNR]
- (1989) *The remembered present: A biological theory of consciousness*. Basic Books. [aGO]
- Edelman, S. (1998) Representation is the representation of similarities. *Behavioral and Brain Sciences* 21(4):449–98. [rGO]
- Ellis, R. (1995) *Questioning consciousness: The interplay of imagery, cognition and emotion in the human brain*. John Benjamins. [RE]
- Ellis, R. D. & Newton, N. (1998) Three paradoxes of phenomenal consciousness. *Journal of Consciousness Studies* 5(4):419–42. [NN]
- Elman, J. L. (1990) Finding structure in time. *Cognitive Science* 14:179–211. [AV]
- Eriasson, K. A. & Simon, H. A. (1993) *Protocol analysis*. MIT Press. [DL]
- Farah, M. J. (1994a) Visual perception and visual awareness after brain damage: A tutorial overview. In: *Attention and performance XV: Conscious and nonconscious information processing*, ed. C. Umiltà & M. Moscovitch. MIT Press/Bradford Books. [MSCT, MZ]
- (1994b) Neuropsychological inference with an interactive brain: A critique of the "locality" assumption. *Behavioral and Brain Sciences* 17:43–104. [MSCT]
- Farah, M. J., O'Reilly, R. C. & Vecera, S. P. (1993) Dissociated overt and covert recognition as an emergent property of a lesioned neural network. *Psychological Review* 100:571–88. [MSCT]
- Field, H. (1978) Mental representation. *Erkenntnis* 13:9–61. [aGO]
- Files, C. (1996) Goodman's rejection of resemblance. *British Journal of Aesthetics* 36:398–412. [rGO]
- Flanagan, O. (1992) *Consciousness reconsidered*. MIT Press. [arGO]
- Flohr, H. (1991) Brain processes and phenomenal consciousness: A new and specific hypothesis. *Theory and Psychology* 1:245–62. [RVG]
- Fodor, J. A. (1975) *The language of thought*. MIT Press. [aGO]
- (1981) *Representations*. MIT Press. [DL, aGO]
- (1983) *The modularity of mind*. MIT Press. [arGO]
- (1987) *Psychosemantics*. MIT Press. [aGO]
- (1990) *A theory of content*. MIT Press. [MK]
- Fodor, J. A. & Pylyshyn, Z. W. (1988) Connectionism and cognitive architecture: A critical analysis. *Cognition* 28:3–71. [aGO]
- Fuster, J. (1989) *The prefrontal cortex*. Raven Press. [JGT]
- Gardenfors, P. (1996) Mental representation, conceptual spaces and metaphors. *Synthese* 106:21–47. [arGO]
- Garfield, J. (1997) Mentalese not spoken here: Computation, cognition and causation. *Philosophical Psychology* 10:413–35. [JO]
- Gawne, T., Kjaer, T. & Richmond, B. (1996) Latency: Another potential code for feature binding in striate cortex. *Journal of Neurophysiology* 76(2):1356–60. [DG]
- Gibson, J. J. (1979) *The ecological approach to visual perception*. Houghton-Mifflin. [RAC]
- Glover, J. (1988) *I: The philosophy and psychology of personal identity*. Penguin Press. [rGO]
- Goldman-Rakic, P. (1996) Memory recording experiences in cells and circuits-diversity in memory research. *Proceedings of the National Academy of Sciences USA* 93:13435–37. [JGT]
- Green, C. (1998) Are connectionist models theories of cognition? *Psychology* 9(4):1–11. [DED]
- Greenwald, A. G. (1992) New look 3: Unconscious cognition reclaimed. *American Psychologist* 47:766–79. [JP, GW]
- Groeger, J. A. (1984) Evidence of unconscious semantic processing from a forced error situation. *British Journal of Psychology* 75:305–14. [rGO, MV]
- Hardin, C. L. (1988) *Color for philosophers*. Hackett. [aGO]
- Harman, G. (1973) *Thought*. Princeton University Press. [aGO]
- Hatfield, G. (1991) Representation in perception and cognition: Connectionist affordances. In: *Philosophy and Connectionist Theory*, ed. W. Ramsey, S. Stich & D. Rumelhart. Erlbaum. [aGO]
- Haugeland, J. (1981) Semantic engines: An introduction to mind design. In: *Mind design*, ed. J. Haugeland. MIT Press. [aGO]
- (1985) *Artificial intelligence: The very idea*. MIT Press. [aGO]
- Hebb, D. O. (1949) *Organization of behavior*. Wiley. [DCD]
- Heller, J., Hertz, J., Kjaer, T. & Richmond, B. (1995) Information flow and temporal coding in primate pattern vision. *Journal of Computational Neuroscience* 2:175–93. [DG]
- Heywood, C. A., Cowey, A. & Newcombe, F. (1994) On the role of parvocellular (P) and magnocellular (M) pathways in cerebral achromatopsia. *Brain* 117:245–54. [RWK, rGO]
- Heywood, C. A., Kentridge, R. W. & Cowey, A. (1998) Cortical colour blindness is not 'blindsight for colour.' *Consciousness and Cognition* 7:410–23. [RWK]
- Holender, D. (1986) Semantic activation without conscious awareness in dichotic listening, parafoveal vision, and visual masking: A survey and appraisal. *Behavioral and Brain Sciences* 9:1–66. [arGO, MV]
- Hopcroft, J. E. & Ullman, J. D. (1979) *Introduction to automata theory, languages and computation*. Addison Wesley. [aGO]
- Hopfield, J. J. (1982) Neural networks and physical systems with emergent collective computational abilities. *Proceedings of the National Academy of Sciences USA* 79:2554–58. [GNR]
- Horgan, T. & Tienson, J. (1989) Representations without rules. *Philosophical Topics* 27:147–74. [aGO]
- (1996) *Connectionism and the philosophy of psychology*. MIT Press. [aGO]
- Hummel, J. E. & Holyoak, K. J. (1997) Distributed representations of structure: A theory of analogical access and mapping. *Psychological Review* 104:427–66. [DED]
- Hurley, S. (1993) Unity and objectivity. *Proceedings of the British Academy* 83:49–77. [rGO]

References/O'Brien & Opie: Connectionism and phenomenal experience

- Jackendoff, R. (1987) *Consciousness and the computational mind*. MIT Press. [DED, arGO]
- Jackson, F. (1982) Epiphenomenal qualia. *Philosophical Quarterly* 32:127–36. [rGO]
- James, W. (1890) *The principles of psychology*. Holt. [DL, arGO]
- Johnson-Laird, P. N. (1988) *The computer and the mind: An introduction to cognitive science*. Fontana Press. [aGO]
- Johnston, W. A. & Dark, V. J. (1982) In defense of intraperceptual theories of attention. *Journal of Experimental Psychology: Human Perception and Performance* 8:407–21. [aGO]
- Johnston, W. A. & Wilson, J. (1980) Perceptual processing of nontargets in an attention task. *Memory and Cognition* 8:372–77. [aGO]
- Keijzer, F. A. & Bem, S. (1996) Behavioral systems interpreted as autonomous agents and as coupled dynamics systems. *Philosophical Psychology* 9:323–46. [EMA]
- Kentridge, R. W., Heywood, C. A. & Weiskrantz, L. (1997) Residual vision in multiple retinal locations within a scotoma: Implications for blindsight. *Journal of Cognitive Neuroscience* 9:191–202. [RWK, rGO]
- (in press) Effects of temporal cueing on residual visual discrimination in blindsight. *Neuropsychologia*. [RWK]
- Kihlstrom, J. F. (1987) The cognitive unconscious. *Science* 237:1445–52. [GW]
- (1996) Perception without awareness of what is perceived, learning without awareness of what is learned. In: *The science of consciousness: Psychological, neuropsychological, and clinical reviews*, ed. M. Velmans. Routledge. [MV]
- King, S. M., Azzopardi, P., Cowey, A., Oxbury, J. & Oxbury, S. (1996) The role of light scatter in the residual visual sensitivity of patients with complete cerebral hemispherectomy. *Visual Neuroscience* 13:1–13. [RWK]
- Kinsbourne, M. (1988) Integrated field theory of consciousness. In: *Consciousness in contemporary science*, ed. A. Marcel & E. Bisiach. Clarendon Press. [aGO, RVG]
- (1995) Models of consciousness: Serial or parallel in the brain? In: *The cognitive neurosciences*, ed. M. Gazzaniga. MIT Press. [aGO]
- Kirsh, D. (1990) When is information explicitly represented? In: *Information, language, and cognition*, ed. P. P. Hanson. University of British Columbia Press. [HC, rGO, JS]
- Kleene, S. C. (1967) *Mathematical logic*. Wiley. [aGO]
- Kurthen, M. (1995) On the prospects of a naturalistic theory of phenomenal consciousness. In: *Conscious experience*, ed. T. Metzinger. Imprint Academic. [MK]
- Kurthen, M., Grunwald, T. & Elger, C. E. (1998) Will there be a neuroscientific theory of consciousness? *Trends in Cognitive Sciences* 2:229–34. [MK]
- Lackner, J. R. & Garrett, M. F. (1972) Resolving ambiguity: Effects of biasing context in the unattended ear. *Cognition* 1:359–72. [aGO]
- Làdavas, E., Paladini, R. & Cubelli, R. (1993) Implicit associative priming in a patient with left visual neglect. *Neuropsychologia* 31:1307–20. [rGO, MZ]
- LeDoux, J. E. (1996) *The emotional brain*. Simon and Schuster. [GW]
- Lehky, S. R. & Sejnowski, T. J. (1990) Neural network model of visual cortex for determining surface curvature from images of shaded surfaces. *Proceedings of the Royal Society of London B* 240:51–78. [rGO]
- Lestienne, R. (1994) Frequency insensitive measures of temporal correlations in spike trains. *Dynamics of Neural Processing International Symposium. Extended Abstract Book* 68–72. [DG]
- Levine, J. (1983) Materialism and qualia: The explanatory gap. *Pacific Philosophical Quarterly* 64:354–61. [aGO]
- (1993) On leaving out what it is like. In: *Consciousness: Psychological and philosophical essays*, ed. M. Davies & G. Humphreys. Blackwell. [aGO]
- Lewicki, P. (1986) *Nonconscious social information processing*. Academic Press. [rGO]
- Lewis, D. (1990) What experience teaches. In: *Mind and cognition*, ed. W. Lycan. Blackwell. [rGO]
- Libet, B., Alberts, W. W., Wright, E. W., Delattre, L. D. & Feinstein, B. (1964) Production of threshold levels of conscious sensation by electrical stimulation of human somatosensory cortex. *Journal of Neurophysiology* 27:546–78. [JGT]
- Lloyd, D. (1988) Connectionism in the golden age of cognitive science. *Behavioral and Brain Sciences* 11:42–43. [BM, aGO]
- (1989) *Simple minds*. Bradford Books/MIT Press. [DL]
- (1991) Leaping to conclusions: Connectionism, consciousness, and the computational mind. In: *Connectionism and the philosophy of mind*, ed. T. Horgan & J. Tienson. Kluwer. [DL, BM, arGO]
- (1992) Towards an identity theory of consciousness. *Behavioral and Brain Sciences* 15(2):215–16. [DL, EMA]
- (1994) Connectionist hysteria: Reducing a Freudian case study to a network model. *Philosophy, Psychiatry, and Psychology* 1(2):69–88. [DL]
- (1995a) Consciousness: A connectionist manifesto. *Minds and Machines* 5:161–85. [DL, BM, arGO]
- (1995b) Access denied. *Behavioral and Brain Sciences* 18(2):261–62. [DL]
- (1996) Consciousness, connectionism, and cognitive neuroscience: A meeting of the minds. *Philosophical Psychology* 9:61–79. [DL, BM, arGO, GNR, MSCT]
- (1997) Consciousness and its discontents. *Communication and Cognition* 30(3/4):273–85. [DL]
- (1998) The fables of Lucy R.: Association and dissociation in neural networks. In: *Connectionism and psychopathology*, ed. D. Stein. Cambridge University Press. [DL]
- Lu, Z. L., Williamson, S. J. & Kaufman, L. (1992) Behavioural lifetime of human auditory sensory memory predicted by physiological measures. *Science* 258:1668–70. [JGT]
- MacKay, D. G. (1973) Aspects of a theory of comprehension, memory and attention. *Quarterly Journal of Experimental Psychology* 25:22–40. [aGO]
- (1990) Perception, action, and awareness: A three-body problem. In: *Relationships between perception and action*, ed. O. Neumann & W. Prinz. Springer-Verlag. [RAC]
- MacLeish, A. (1952) *Collected poems*. Houghton-Mifflin. [DL]
- Mandler, G. (1985) *Cognitive psychology: An essay in cognitive science*. Erlbaum. [aGO, GW]
- Mangan, B. (1991) Meaning and the structure of consciousness: An essay in psycho-aesthetics. Doctoral dissertation, University of California, Berkeley. [BM]
- (1993a) Dennett, consciousness, and the sorrows of functionalism. *Consciousness and Cognition* 2:1–17. [DCD, BM, aGO]
- (1993b) Taking phenomenology seriously: The “fringe” and its implications for cognitive research. *Consciousness and Cognition* 2:89–108. [BM, arGO, MSCT]
- (1993c) Some philosophical and empirical implications of the fringe. *Consciousness and Cognition* 2:142–54. [BM]
- (1996) Against functionalism: Consciousness as an information-bearing medium. Paper presented at the Second Tucson Conference on Consciousness, “Toward a science of consciousness – Tucson II,” University of Arizona, Tucson, April 8–13. [DCD, aGO]
- (1998) Against functionalism: Consciousness as an information bearing medium. In: *Toward a science of consciousness: The second Tucson discussions and debates*, ed. S. Hameroff, A. Kaszniak & A. Scott. MIT Press. [BM]
- Marcel, A. J. (1983) Conscious and unconscious perception: Experiments on visual masking and word recognition. *Cognitive Psychology* 15:197–237. [arGO, JP]
- (1993) Slippage in the unity of consciousness. In: *Experimental and theoretical studies of consciousness. Ciba Foundation Symposium 174*, ed. G. R. Block & J. Marsh. Wiley. [rGO]
- Marr, D. (1982) *Vision: A computational investigation into the human representation and processing of visual information*. Freeman. [rGO, JS]
- Massaro, D. (1988) Some criticism of connectionist models of human performance. *Journal of Memory and Language* 27:213–34. [DED]
- Masson, M. E. J. (1995) A distributed memory model of semantic priming. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 21:509–14. [MZ]
- Mathis, D. W. & Mozer, M. C. (1995) On the computational utility of consciousness. In: *Advances in neural information processing systems 7*, ed. G. Tesoro, D. S. Touretzky & T. K. Keen. MIT Press. [AC]
- (1997) Conscious and unconscious perception: A computational theory. In: *Proceedings of the Eighteenth Annual Conference of the Cognitive Science Society*. Erlbaum. [AC]
- McClelland, J. L. (1979) On the time relations of mental processes: An examination of systems of processes in cascade. *Psychological Review* 86:287–330. [AC]
- (1995) Constructive memory and memory distortions: A parallel-distributed processing approach. In: *Memory distortion*, ed. D. L. Schacter. Harvard University Press. [DED]
- McClelland, J. L. & Rumelhart, D. E., eds. (1986) *Parallel distributed processing: Explorations in the microstructure of cognition, vol. 2: Psychological and biological models*. MIT Press. [arGO]
- McCloskey, M. (1991) Networks and theories: The place of connectionism in cognitive science. *Psychological Science* 6:387–95. [DED]
- McRae, K., de Sa, V. R. & Seidenberg, M. S. (1997) On the nature and scope of featural representations of word meaning. *Journal of Experimental Psychology: General* 126:99–130. [MZ]
- Meadows, J. C. (1974) Disturbed perception of colours associated with localized cerebral lesions. *Brain* 97:615–32. [RWK]
- Merikle, P. M. (1992) Perception without awareness. *American Psychologist* 47:792–95. [GW]
- Milner, A. D. & Goodale, M. A. (1993) Visual pathways to perception and action. In: *Progress in brain research, vol. 95*, ed. T. P. Hicks, S. Molotchnikoff & T. Ono. Elsevier. [rGO, JP]
- (1995) *The visual brain in action*. Oxford University Press. [RWK, rGO]
- Milner, A. & Rugg, M., eds. (1992) *The neuropsychology of consciousness*. Academic Press. [aGO, MZ]

- Mowbray, G. W. (1964) Perception and retention of verbal information presented during auditory shadowing. *Journal of the Acoustical Society of America* 36:1459–64. [aGO]
- Murphy, S. T. & Zajonc, R. B. (1993) Affect, cognition and awareness: Affective priming with optimal and suboptimal stimulus exposures. *Journal of Personality and Social Psychology* 64:723–39. [GW]
- Nagel, T. (1974) What is it like to be a bat? *Philosophical Review* 83:435–50. [arGO, MV]
- Neely, J. H. (1991) Semantic priming effects in visual word recognition: A selective review of current findings and theories. In: *Basic processes in reading*, ed. D. Besner & G. W. Humphreys. Erlbaum. [MZ]
- Neisser, U. (1988) Five kinds of self-knowledge. *Philosophical Psychology* 1:35–59. [RAC]
- Nelson, T. O. (1978) Detecting small amounts of information in memory: Savings for nonrecognized items. *Journal of Experimental Psychology: Human Learning and Memory* 4:453–68. [aGO]
- Nemirov, L. (1990) Physicalism and the cognitive role of acquaintance. In: *Mind and cognition*, ed. W. Lycan. Blackwell. [rGO]
- Neumann, O. & Klotz, W. (1994) Motor responses to nonreportable, masked stimuli: Where is the limit of direct parameter specification? In: *Attention and performance XV: Conscious and nonconscious information processing*, ed. C. Umiltà & M. Moscovitch. MIT Press. [JP]
- Newell, A. (1980) Physical symbol systems. *Cognitive Science* 4:135–83. [aGO]
- Newman, J. (1995) Thalamic contributions to attention and consciousness. *Consciousness and Cognition* 4:172–93. [aGO]
- Newstead, S. E. & Dennis, I. (1979) Lexical and grammatical processing of unshadowed messages: A reexamination of the MacKay effect. *Quarterly Journal of Experimental Psychology* 31:477–88. [aGO]
- Newton, N. (1989) Visualizing is imagining seeing: A reply to White. *Analysis* 49(2):77–81. [NN]
- (1996) *Foundations of understanding*. John Benjamins. [NN]
- Nolan, K. A. & Caramazza, A. (1982) Unconscious perception of meaning: A failure to replicate. *Bulletin of the Psychonomic Society* 20:23–26. [aGO]
- O'Brien, G. (1993) The connectionist vindication of folk psychology. In: *Folk psychology and the philosophy of mind*, ed. S. Christensen & D. Turner. Erlbaum. [aGO]
- O'Brien, G. J. (forthcoming) Connectionism, analogicity and mental content. *Acta Analytica*. [rGO]
- O'Brien, G. J. & Opie, J. (1997) Cognitive science and phenomenal consciousness: A dilemma, and how to avoid it. *Philosophical Psychology* 10:269–86. [rGO]
- (1998) The disunity of consciousness. *The Australasian Journal of Philosophy* 76:378–95. [rGO]
- (forthcoming) A defense of Cartesian materialism. *Philosophy and Phenomenological Research*. [rGO]
- Opie, J. (1998) *Consciousness: A connectionist perspective*. Ph.D. thesis, University of Adelaide. [rGO]
- Palmer, S. (1978) Fundamental aspects of cognitive representation. In: *Cognition and categorization*, ed. E. Rosch & B. Lloyd. Erlbaum. [arGO]
- Penrose, R. (1989) *The emperor's new mind*. Penguin Books. [aGO]
- Perenin, M. T. (1978) Visual function within the hemianopic field following early cerebral hemidecortication in man. II. Pattern discrimination. *Neuropsychologia* 16:697–708. [aGO]
- Perenin, M. T. & Jeannerod, M. (1975) Residual vision in cortically blind hemifields. *Neuropsychologia* 13:1–7. [aGO]
- Perkins, D. N. (1981) *The mind's best work*. Harvard University Press. [rGO]
- Perruchet, P. & Gallego, J. (1997) A subjective unit formation account of implicit learning. In: *How implicit is implicit learning?*, ed. D. C. Berry. Oxford University Press.
- Perruchet, P. & Pacteau, C. (1990) Synthetic grammar learning: Implicit rule abstraction or explicit fragmentary knowledge? *Journal of Experimental Psychology: General* 119:264–75. [aGO]
- Perruchet, P. & Vinter, A. (1997) Learning and development: The implicit knowledge assumption reconsidered. In: *Handbook of implicit learning*, ed. M. A. Stadler & P. A. Frensch. Sage Publications. [AC]
- (1998a) Learning and development. In: *Implicit learning: Representation and process*, ed. P. Frensch & M. Stadler. Erlbaum. [rGO, AV]
- (1998b) PARSER: A model for word segmentation. *Journal of Memory and Language* 39:246–63. [AV]
- Phaf, R. H., Mul, N. M. & Wolters, G. (1994) A connectionist view on dissociations. In: *Attention and performance XV: Conscious and nonconscious information processing*, ed. C. Umiltà & M. Moscovitch. MIT Press. [GW]
- Phaf, R. H. & Wolters, G. (1997) A constructivist and connectionist view on conscious and nonconscious processes. *Philosophical Psychology* 10:287–307. [GW]
- Plaut, D. C. (1995) Associative and semantic priming in a distributed attractor network. In: *Proceedings of the 17th Annual Conference of the Cognitive Science Society*. Erlbaum. [MZ]
- Posner, M. I. & Rothbart, M. K. (1992) Attentional mechanisms and conscious experience. In: *The neuropsychology of consciousness*, ed. A. D. Milner & M. D. Rugg. Academic Press. [RE]
- Purcell, D. G., Stewart, A. L. & Stanovich, K. K. (1983) Another look at semantic priming without awareness. *Perception and Psychophysics* 34:65–71. [aGO]
- Pylyshyn, Z. W. (1980) Computation and cognition: Issues in the foundations of cognitive science. *Behavioral and Brain Sciences* 3:111–69. [aGO]
- (1984) *Computation and cognition*. MIT Press. [HC, aGO]
- (1989) Computing in cognitive science. In: *Foundations of cognitive science*, ed. M. Posner. MIT Press. [aGO]
- Pynte, J., Do, P. & Scampa, P. (1984) Lexical decisions during the reading of sentences containing polysemous words. In: *Preparatory states and processes*, ed. S. Komblum & J. Requin. Erlbaum. [MV]
- Ramsey, W., Stich, S. & Rumelhart, D. E., eds. (1991) *Philosophy and connectionist theory*. Erlbaum. [aGO]
- Reber, A. S. (1967) Implicit learning of artificial grammars. *Journal of Verbal Learning and Verbal Behavior* 5:855–63. [aGO]
- (1993) *Implicit learning and tacit knowledge*. Oxford University Press. [rGO]
- (1997) How to differentiate implicit and explicit modes of acquisition. In: *Scientific approaches to consciousness*, ed. J. D. Cohen & J. W. Schooler. Erlbaum. [MV]
- Reeke, G. N., Jr. (1996) Book review: Patricia S. Churchland and Terrance J. Sejnowski, *The computational brain*. *Artificial Intelligence* 82:381–91. [GNN]
- Rey, G. (1992) Sensational sentences. In: *Consciousness: Psychological and philosophical essays*, ed. M. Davies & G. Humphreys. Blackwell. [aGO]
- Robertson, I. H. & Marshall, J. C., eds. (1993) *Unilateral neglect: Clinical and experimental studies*. Erlbaum. [MZ]
- Roediger, H. L. & McDermott, K. B. (1993) Implicit memory in normal human subjects. In: *Handbook of neuropsychology, vol. 8*, ed. F. Boller & I. Grafman. Elsevier. [GW]
- Rorty, R. (1993) Holism, intrinsicity, and the ambition of transcendence. In: *Dennett and his critics*, ed. B. Dahlbohm. Blackwell. [MK]
- Rozeboom, W. W. (1972) Problems in the psycho-philosophy of knowledge. In: *The psychology of knowing*, ed. J. R. Royce & W. W. Rozeboom. Gordon and Breach. [EMA]
- Rubel, L. A. (1989) Digital simulation of analog computation and Church's thesis. *Journal of Symbolic Logic* 54:1011–17. [aGO]
- Rumelhart, D. E. (1989) The architecture of mind: A connectionist approach. In: *Foundations of cognitive science*, ed. M. Posner. MIT Press. [aGO]
- Rumelhart, D. E. & McClelland, J. L., eds. (1986) *Parallel distributed processing: Explorations in the microstructure of cognition, vol. 1: Foundations*. MIT Press. [aGO]
- Rumelhart, D. E., Smolensky, P., McClelland, J. L. & Hinton, G. E. (1986) Schemata and sequential thought processes in PDP models. In: *Parallel distributed processing: Explorations in the microstructure of cognition. Vol. 2: Psychological and biological models*, ed. J. L. McClelland & D. E. Rumelhart. MIT Press. [aGO]
- Sacks, O. (1985) *The man who mistook his wife for a hat*. Picador. [RWK, aGO]
- (1996) *An anthropologist on Mars*. Picador. [aGO]
- Schachter, D. (1989) On the relation between memory and consciousness: Dissociable interactions and conscious experience. In: *Varieties of memory and consciousness: Essays in honor of Endel Tulving*, ed. H. Roediger & F. Craik. Erlbaum. [aGO]
- Schwartz, N. (1990) Feelings and information: Informational and motivational functions of affective states. In: *Handbook of motivation and cognition: Foundations of social behaviour*, ed. R. Sorrentino & E. Higgins. Guilford Press. [aGO]
- Searle, J. R. (1983) *Intentionality*. Cambridge University Press. [aGO]
- (1992) *The rediscovery of mind*. MIT Press. [AC, rGO, JO]
- Sejnowski, T. J. (1986) Open questions about computation in cerebral cortex. In: *Parallel distributed processing: Explorations in the microstructure of cognition. Vol. 2: Psychological and biological models*, ed. J. L. McClelland & D. E. Rumelhart. MIT Press. [aGO]
- Sejnowski, T. J. & Rosenberg, C. (1987) Parallel networks that learn to pronounce English text. *Complex Systems* 1:145–68. [arGO]
- Shallice, T. (1988a) *From neuropsychology to mental structure*. Cambridge University Press. [aGO]
- (1988b) Information-processing models of consciousness: Possibilities and problems. In: *Consciousness in contemporary science*, ed. A. Marcel & E. Bisiach. Clarendon Press. [aGO]
- (1997) Modularity and consciousness. In: *The nature of consciousness*, ed. N. Block, O. Flanagan & G. Güzeldere. MIT Press. [rGO]
- Shanks, D. R. & St. John, M. F. (1994) Characteristics of dissociable human learning systems. *Behavioral and Brain Sciences* 17:367–447. [AC, arGO, MV]
- Shepard, R. & Chipman, S. (1970) Second-order isomorphism of internal representations: Shapes of states. *Cognitive Psychology* 1:1–17. [rGO]

References/O'Brien & Opie: Connectionism and phenomenal experience

- Shepard, R. & Metzler, J. (1971) Mental rotation of three-dimensional objects. *Science* 171:701–03. [rGO]
- Smith, S. M. & Blankenship, S. E. (1989) Incubation effects. *Bulletin of the Psychonomic Society* 27:311–14. [rGO]
- (1991) Incubation and the persistence of fixation in problem solving. *American Journal of Psychology* 104:61–87. [rGO]
- Smolensky, P. (1987) The constituent structure of connectionist mental states: A reply to Fodor and Pylyshyn. *Southern Journal of Philosophy* 26(Supplement):137–61. [aGO]
- (1988a) On the proper treatment of connectionism. *Behavioral and Brain Sciences* 11:1–23. [arGO]
- (1988b) Putting together connectionism - again. *Behavioral and Brain Sciences* 11:59–74. [EMA]
- (1991) Tensor product variable binding and the representation of symbolic structures in connectionist systems. In: *Connectionist symbol processing*, ed. G. Hinton. MIT Press. [JS]
- Sterelny, K. (1990) *The representational theory of mind*. Blackwell. [aGO]
- Stoerig, P. & Cowey, A. (1995) Visual-perception and phenomenal consciousness. *Behavioural Brain Research* 71:147–56. [RWK]
- Stoerig, P., Kleinschmidt, A. & Frahm, J. (1998) No visual response in denervated V1: High-resolution functional magnetic resonance imaging of a blindsight patient. *Neuroreport* 9:21–25. [RWK]
- Strawson, G. (1994) *Mental reality*. MIT Press. [aGO]
- Swinney, D. A. (1979) Lexical access during sentence comprehension: (Re)consideration of context effects. *Journal of Verbal Learning and Verbal Behavior* 18:645–59. [MV]
- (1982) The structure and time-course of information interaction during speech comprehension: Lexical segmentation, access, and interpretation. In: *Perspectives on mental representation*, ed. J. Mehler, E. C. T. Walker & M. Garrett. Erlbaum. [MV]
- Swoyer, C. (1991) Structural representation and surrogative reasoning. *Synthese* 87:449–508. [arGO]
- Taylor, J. G. (1996) A competition for consciousness? *NeuroComputing* 11:271–96. [JGT]
- (1998a) *The race for consciousness*. MIT Press. (forthcoming) [JGT]
- (1998b) Cortical activity and the explanatory gap (with commentaries). *Consciousness and Cognition* 7:107–49; 216–37. [JGT]
- Thorndike, E. L. (1949) *Selected writings from a connectionist psychology*. Appleton- Century-Crofts. [DED]
- Tienison, J. L. (1987) An introduction to connectionism. *Southern Journal of Philosophy* 26(Supplement):1–16. [aGO]
- Tovee, M. J. (1996) *An introduction to the visual system*. Cambridge University Press. [rGO]
- Tye, M. (1983) On the possibility of disembodied existence. *Australasian Journal of Philosophy* 61(3):275–82. [NN]
- (1992) Visual qualia and visual content. In: *The contents of experience*, ed. T. Crane. Cambridge University Press. [aGO]
- (1996) The function of consciousness. *Nous* 30:287–305. [aGO]
- (1997) A representational theory of pains and their phenomenal character. In: *Essays on consciousness*, ed. N. Block, O. Flanagan & G. Guveldere. MIT Press. [aGO]
- Umiltà, C. (1988) The control operations of consciousness. In: *Consciousness in contemporary science*, ed. A. Marcel & E. Bisiach. Clarendon Press. [aGO]
- Umiltà, C. & Zorzi, M. (1995) Consciousness does not seem to be linked to a single neural mechanism. *Behavioral and Brain Sciences* 18:701–02. [MZ]
- Van Gelder, T. (1990) Compositionality: A connectionist variation on a classical theme. *Cognitive Science* 14:355–84. [aGO]
- (1991) What is the “D” in “PDP”? In: *Philosophy and connectionist theory*, ed. W. Ramsey, S. P. Stich & D. E. Rumelhart. Erlbaum. [HC]
- Van Gulick, R. (1993) Understanding the phenomenal mind: Are we all just armadillos? In: *Consciousness: Psychological and philosophical essays*, ed. M. Davies & G. Humphreys. Blackwell. [aGO]
- Velmans, M. (1991) Is human information processing conscious? *Behavioral and Brain Sciences* 14(4):651–726. [MV]
- (1993) Consciousness, causality and complementarity. *Behavioral and Brain Sciences* 16(2):409–16. [MV]
- (1996) Consciousness and the “causal paradox.” *Behavioral and Brain Sciences* 19(3):537–42. [MV]
- (1998) Goodbye to reductionism. In: *Toward a science of consciousness II: The second Tucson discussions and debates*, ed. S. Hameroff, A. Kaszniak & A. Scott. MIT Press. [MV]
- Vision, G. (1998) Blindsight and philosophy. *Philosophical Psychology* 11:137–59. [rGO]
- Von Eckardt, B. (1993) *What is cognitive science?* MIT Press. [aGO]
- Weiskrantz, L. (1980) Varieties of residual experience. *Quarterly Journal of Experimental Psychology* 32:365–86. [aGO]
- (1986) *Blindsight: A case-study and implications*. Clarendon Press. [aGO]
- (1987) Residual vision in a scotoma: A follow-up study of “form” discrimination. *Brain* 110:77–92. [JP]
- Weiskrantz, L., Barbur, J. L. & Sahaie, A. (1995) Parameters affecting conscious versus unconscious visual discrimination with damage to the visual cortex (V1). *Proceedings of the National Academy of Sciences USA* 92:6122–26. [RWK, rGO]
- Weiskrantz, L., Warrington, E., Sanders, M. & Marshall, J. (1974) Visual capacity in the hemianopic field following a restricted occipital ablation. *Brain* 97:709–28. [aGO]
- Williams, B. (1973) Imagination and the self. In: *Problems of the self*. Cambridge University Press. [NN]
- Zeki, S. (1993) *A vision of the brain*. Blackwell. [RWK, arGO]
- Zeki, S. & fytche, D. H. (1998) The Riddoch syndrome: Insights into the neurobiology of conscious vision. *Brain* 121:25–45. [RWK, rGO]
- Zihl, J., von Cramon, D. & Mai, N. (1983) Selective disturbance of movement vision after bilateral brain damage. *Brain* 106:313–40. [RWK]