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Book Review

PERCEPTUAL CONTROL THEORY: A PARADIGM SHIFT?

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A Review of the Book

The Interdisciplinary Handbook of Perceptual Control Theory: Living Control Systems IV

Edited by Warren Mansell, 2020.
Academic Press, London, UK, 630+ pages.
ISBN 978-0-12-818948-1 (Paperback, UK £160, US$ 170.00)

I must first declare an interest, in both senses of the word. Firstly I find Perceptual Control Theory (PCT) very interesting and promising, and secondly I have long known and admired the work of Frans Plooij who has a chapter in this book and who introduced me to PCT. I am also indebted to his critique of an earlier draft of this review, thereby helping me avoid showing too much of my ignorance and avoid some of my more egregious misunderstandings. But there is a meta message here, which is that PCT practitioners often claim it represents a Kuhnian paradigm shift in behaviour studies, but it has not gained the traction within scientific community it perhaps should have done. PCT theorists might say that is the fate of many radically new ideas, it takes time to get them accepted. But there may be another reason exemplified by some chapters in this

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book, which is that some authors are so clearly immersed in the PCT way of thinking that they find it difficult to tailor their language to those of us not so fluent in these ideas.

Inevitably too, this book is theory inspired, so there is much abstract thinking and this reader often got lost and longed for it to be tied down to hard reality.

The book sets itself a hard task, which is to provide PCT accounts from many disciplines. This inevitably means that the terminology, history, data and theory of some fields will not be familiar to readers not from that field. Some authors have tried to compensate for this, the most successful, to my mind, being Frans Plooij who uses the very accessible approach of providing a narrative of personal discovery. Other successful chapters are ones which, implicitly or explicitly, test PCT ideas by applying them to psychological therapy or to creating intelligent machines and chapters which report convincing data on the existence of structures implied by PCT in living beings. At the other extreme is writing where there are too many generalisations and too few interesting data and ideas, and they read like polemics for PCT repeating what is summed up in the title of Bill Powers 1973 book, "Behavior – The Control of Perception".

The volume starts with preface by Warren Mansell, in which he introduces Perceptual Control Theory to the reader. PCT asserts as its core tenet, that the focus of analysis should be on the inputs that are sought, and not the behaviour. An individual behaves to achieve a certain input and their behaviour is determined by the discrepancy between the input desired and the actual input, in much the same way, in principle, as a thermostat responds to changes in temperature by ordering more heating or cooling. Figure 1 illustrates the core idea of the control loop in the PCT model. Note that the actual input is compared with the "reference value", the desired input, in the comparator and output adjusted accordingly. Moreover, because the model is hierarchical, the reference values can come from other control loops up the hierarchy and the output of a control loop can be the reference value of a control loop next down in the hierarchy. This is discussed later.

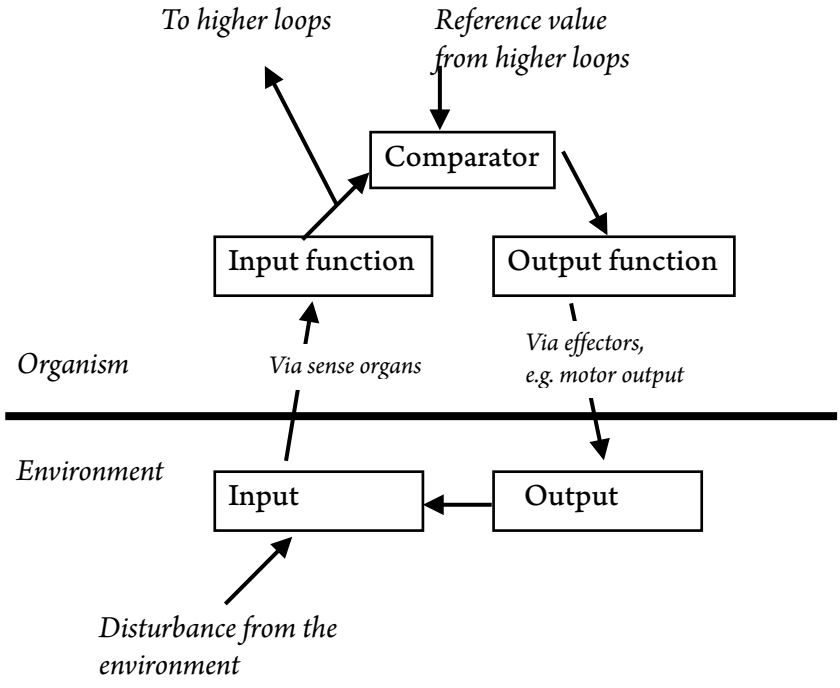

Figure 1: The basic control loop in PCT. Control loops are arranged hierarchically and only the lowest in the hierarchy actually outputs to behaviour and other responses.

If there is a comment about the introduction to PCT, I suspect it would be that it could be even simpler, perhaps in a boxed section ("PCT for Dummies"[1]) and with a way of describing how many of the terms of PCT are used a little differently from the usual meanings, something which can make reading heavy going when one has not got clear the differences, as already mentioned. It may be that one of the reasons why PCT, despite its power, has made less headway into the intellectual arena than it has, is the difficulty in properly understanding the subtle differences in meaning and their considerable implications. Perhaps PCT needs the equivalent of Darwin's Huxley.

The next four chapters have the heading "Why do we need perceptual control theory?". The first is an overview chapter by the late Bill Powers, the originator of PCT. It was written in March 2013 two months before he died. The essential theme, echoed many times throughout the book, is behavioural output is best understood as a means of achieving certain perceptual input rather than within the stimulus-response paradigm. He notes the development of control systems in engineering (e.g. thermostats) and their ubiquity now.

The next chapter, "Understanding purposeful systems: the application of control theory in engineering and psychology" by Richard Marken compares the f*orward engineering* in building, say, a thermostat, with the psychologist's need to *reverse engineer* when trying to understand behaviour. In the former, the engineer, or the user, defines the "reference values" (the desired input, the desired perception), for instance the desired temperature, and the feedback control systems deliver that, altering the output of the system (heating or cooling) to achieve the desired result (the temperature) whatever the prevailing conditions. In the latter case, reverse engineering, the reference values are not known and one task of the researcher is to discover them. Ethologists might add that perhaps the ultimate "reference values" are known and supplied by evolutionary theory, and are gene and meme survival. That apart, finding the intermediate reference values is done, essentially, by disturbing the input from the individual's environment and seeing whether the individual reacts and if so how (echoes of Tinbergen's natural experiments). This gives clues as to what (what perceptual input) they might be trying to achieve. Out of this can be generated, estimates of what the reference values are. This investigatory process is called the "Test for the Controlled Variable" or TCV, where the variable (c.f. temperature), which the system works to control, can be inferred, and the "reference value" (c.f. the desired temperature) be ascertained.

This can be brought into sharper focus by Plooij's work on the development of the perceptual abilities. For instance, at about 19 weeks babies develop the ability to perceive repeated patterns, so called "events", but they cannot register the connection between two sorts of event. That does not happen until about 25 weeks. So if an 21 week old happens to knock a lever which causes a flap to open, he does not look at both but just carries on with whatever repetitive activity he was doing, but after 25 weeks the same knock on a lever followed by a flap opening, can lead to intense looking from one to the other and perhaps an attempt to repeat this. The baby is now beginning to be able to process relationships between events. The test for the controlled variable would pick that

[1] referring the book series, "xx for Dummies" published by John Wiley which attempts non intimidating, jargon free introductions to topics. The reader who, like me, needs such an introduction could look at the Wikipedia entry (https://en.wikipedia.org/wiki/Perceptual_control_theory)

up. Before that, a change in the conjunction of two events would not be noticed, since the perceptual/neurological apparatus to do that had not yet developed – "relationships" would not be a "variable" the baby was "controlling" because they could not yet perceive that.

The next chapter is by Henry Yin who wants to argue that PCT should the new paradigm in the coming Kuhnian paradigm shift away from S-R, or cause-effect, neuroscience. It is a difficult chapter to read, being in places too detailed without setting up what the detail is about, at times too general, and overall has a feel of proselytizing zealotry with the narrowness of perception which such zealotry often carries with it. He accuses many authors of errors, when what he is really pointing to is a difference of emphasis, or, to my mind, simply misinterpreting their ideas. He confuses data with inference, for instance saying that Mittelstaedt's work on reafference in flies, just looks at the environmental conditions and the fly's responses and does not take the perspective of the fly. The former is the data, the latter (the fly's perspective) is inference.

He talks about how the comparison of the input with the reference value is inside the system in PCT but is put *outside* the system in other worker's ideas of control. At first I did not understand the point he was making. How could a mechanism which compares input and reference value be outside any system? But Frans Plooij came to the rescue pointing out that it is the reference value (e.g. the desired temperature) that is injected from outside. This seems to revolve around whether the thermostat, for instance, is considered to be outside the system that does the actual heating (the boiler), or inside the total system controlling temperature. Again the terminology and history of a term's usage, gets in the ways of relative outsiders, like me, understanding easily.

Henry Yin criticises linear "cause precedes effect" thinking: "This assumption of linear or unidirectional causation is unquestioned among most students of behavior, be they reflexologists, psychophysicists, ethologists, Hullian or Skinnerian behaviorists, cognitive scientists, or systems neuroscientists. None of them ever imagined that it could be wrong, but it is." But causes do precede effects, *a priori*, and even in a feedback system there is a chain of causes and effects, it is just organised in a way that involves feedback processes. He includes ethologists in his list of miscreants, but many ethologists would raise an eyebrow or two at their inclusion arguing that motivational systems are essentially ways of achieving reference values . Ethologists might also add Darwinian evolutionary theory itself was the apogee of discussion of reference values, namely survival and reproduction, or now, gene (and meme) survival. Again Frans Plooij came to the rescue, referring to his chapter especially pages 213-216. In that he describes ethological research and theory which does seem to have more of a linear causation model and does not discuss feedback loops, also that the data on phenomena like Fixed Action Patterns are not so fixed as was thought and the actual subtlety varying behaviour can be better modelled with PCT.

Bill Powers, in his introduction, also argues against the S-R model. It may be that the swathes of psychology research of which he was aware embodied the thinking he criticises, but there were, and are, plenty of ideas about feedback systems being crucial to understanding behaviour, such as ethology's motivational systems already mentioned, Von Holst and Mittelstaedt's (1948) ideas on "reafference" (which Yin criticises) or the TOTE units (Test-Operate-Test-Exit) of Miller et al (1960), although these were published in the same year as Power's first papers on PCT (Powers et al , 1960a & b) and

are argued by Mansell in the final chapter to be more limited and different in important ways. The very idea of homeostasis (Canon, 1926), an idea first coined by Bernard in 1849, involves feedback and control, a point again properly alluded to by Mansell. Whilst usually focussed on physiological states, homeostasis nevertheless involves behaviour and the achievement of reference values through feedback systems. So they are in danger of creating the impression, at least for the untutored reader like me, that they are erecting straw men in making these points so emphatically. All through the book a number of authors labour this point as if the idea of acting to achieve a certain feedback (a.k.a. PCT's controlling perceptions) is a akin to a Damascene revelation. This a pity since there is much that seems distinctive in PCT, in particular the hierarchical structure and the dynamic way that operates. Mansell in his final chapter does not fall into this trap, and tries to show how PCT is different from these other ideas and importantly how PCT is a more comprehensive theory.

In his chapter Bruce Nevin mentions TOTE units but draws a distinction between their iterative sequential problem solving, each time going around and around the whole TOTE unit, and the way that in PCT any one variable is *concurrently* the effect of the prior variable and cause of the next.

Pellis and Bell start off with the same point comparing the descent of a rock and a falcon, the rock's speed and trajectory are easily described by the laws of physics, whereas the falcon's are not (unless, I would perhaps flippantly add, it is dead, as may be observed in the killing fests on the grouse moors of Scotland). Many of the authors are essentially labouring the point that living systems are different from inanimate ones and behave purposefully. My first thought was that for (human) ethologists at least, being told what they already know and assume in their work, is likely to become tedious. However my historical ignorance was gently pointed out by Frans Plooij, who quoted Tinbergen (1951/1974) in his chapter: "In classical ethology it was not seen as appropriate to "point to the goal, end, or purpose of behavior, or of any life process.". Yet this position seems to have been dropped later since one of Tinbergen's "4 Whys" concerns function.

Just because the thinking in PCT seems less unusual than some of its protagonists make out, certainly does not mean it is not interesting or useful or has nothing to add. It has. An example is the ideas of the hierarchical organisation of control systems which Plooij and his late wife Hetty applied so brilliantly to infant development. Plooij describes their journey to this understanding most interestingly in Chapter 8 ("The phylogeny, ontogeny, causation and function of regression periods explained by reorganizations of the hierarchy of perceptual control systems") and in the process shows clearly the sophistication and superiority of careful direct observation based in an ethological approach and how that may be combined with PCT.

Richard Kennaway's chapter, "When causation does not imply correlation: robust violations of the faithfulness axiom" is half highly technical and mathematical, but his essential point may be summed up by his conclusion: "… control systems … specifically destroy the connections between correlation and causation…" Essentially causal connections can be difficult to spot because the system is constantly trying to maintain a certain input, and the output will bear little relation to the presumed causal conditions, or, as he says, "The output automatically takes whatever value it needs to, to prevent the disturbances from affecting the perception. The very function of a control system is to actively destroy the data that current techniques of causal analysis work from." This may

be true for some types of research, but it must still be possible to plot the (causal) connections between changes in the environment and changes in output otherwise the Test for the Controlled Variable (TCV), essential to discovering reference values, could not be done. His main point seems to be that the data can begin to make a coherent pattern when seen in terms of control systems. Again we have the danger of confusing (i) the ability to collect data to show causal mechanisms and (ii) the inferences or theories underlying what data are collected, how it is collected, and how the data are understood.

The next section is entitled "Models of brain and behavior". The first chapter by Pellis and Bell entitled "Unravelling the dynamics of dyadic interactions: perceptual control in animal contests" discusses the application of PCT better to understand the behaviour of animals in competitive relationships, (e.g. fighting, predator-prey). A key argument is that the behaviour becomes much better understood when the "controlled variables" are identified. These are "the perceptions that are maintained constant at some specific reference level". This is a little more subtle than meaning "what the animal wants to achieve", like winning the contest. As they note, "… from a PCT perspective, the distance between the attacker's weapons (e.g., horns, teeth) and the species-specific body targets is the perception that is controlled {by their behaviour] during interactions". The target, for example, the vulnerable part of the opponent's body, becomes the controlled variable that the behaviour flexibly aims to achieve. The authors give a number of examples from agonistic and predatory behaviour where the controlled variables are identified through observation and where they economically describe the behaviour, which would otherwise seem highly complex and without a clear pattern or predictability. The authors commendably go into detailed behavioural description. To get a better idea of how successful this approach is one would need to read the many cited studies, but their approach seems promising.

The next two chapters are by Erling Jorgensen entitled "How the brain gets a roaring campfire: Structuring for perceptual results" and "How the brain gets a roaring campfire: Input and output functions". The reader is invited to imagine a couple on a camping holiday who want to revive their campfire so they can they enjoy a nightcap together in front of the roaring fire. "Roaring campfire" is in the title since discussion of the many actions needed to achieve this is used to illustrate the hierarchy of perceptions that need to be met to reduce the mismatch between the reference value (roaring campfire) and the actual perception (barely glowing embers.)

The hierarchical organisation of control loops is an essential aspect of PCT. Crucially, it is only at the lowest level that the loop output gives rise to motor output, the output of a higher level feeds into, and define, the references values of the loop one down in the hierarchy. The diagram (Figure 2) borrows from his chapter and adds some data on age of first appearance in humans.

As Jorgensen usefully describes going up the hierarchy defines *why* the reference value in one control loop is important, and going down informs *how* it will be achieved by adjusting the reference values of lower control loops. He points out that from a neurological point of view a key problem is how the signals entering from above (the why?) and below (the how?) can be of a form where they can be compared in the comparator.

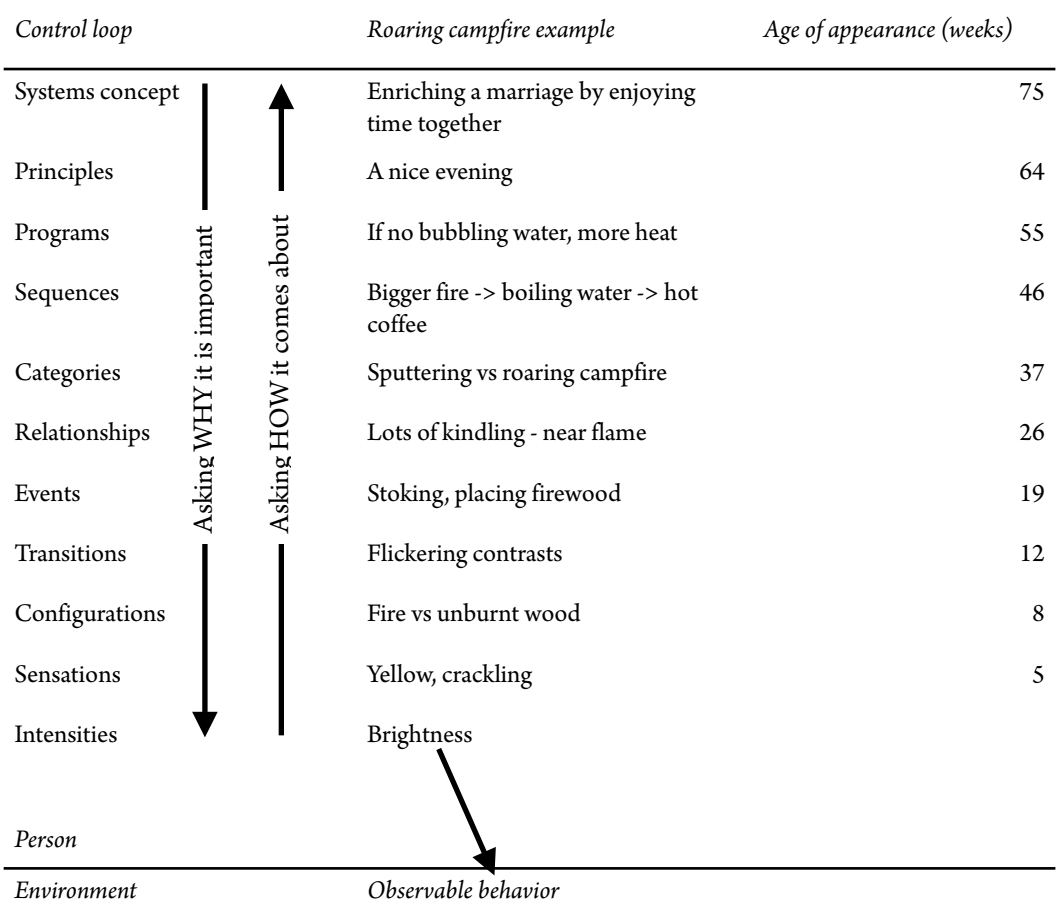

Figure 2: The hierarchy of control loops. Examples given by Jorgensen in his Roaring Campfire example. The age at which these perceptual abilities first appear in infants (van de Rijt Plooij and Plooij ,1992, 1993. 2010)

A modification of the hierarchy can be found in Plooij's chapter where he provides evidence for how children develop perceptual abilities progressively up the hierarchy in the first 18 months.

I was tempted to relate PCT hierarchical organisation to the hierarchies of actions put forward by Baerends (1976) and by Tinbergen, (1950). Certainly there are similarities. In the Tinbergen and Baerends models, the motivation to achieve higher order goals (e.g. incubating eggs, escaping threats) triggers and guides the lower order sub goals and their associated actions. In the classic studies of v Holst and v St Paul (1963), they used intracranial stimulation in chickens and showed how stimulation at different brain loci gave rise to behaviour consistent with the hierarchical organisation of drives inferred from observation of behaviour. They even showed that simultaneous stimulation of loci associated with different motivational systems gave rise to displacement activities, which from behavioural observation, occur when the two motivational systems are inferred to be activated and are in conflict. I suspect that PCT theorists would argue that these models focus on the organisation of output, the behaviour, as in Tinbergen's classificatory system for reproductive activities of the male

three spined stickleback (see Hinde ,1966, page 609). PCT, on the other hand, focusses on the organisation of input – the hierarchy of reference values.

Nevertheless the similarity is the attempt to map a hierarchical organisation of behaviour inferred from observation, and then relate that to the anatomy and physiology of the brain. The difference may in the end be one of emphasis, Ethologists emphasising the observable behaviour and just implying the input analysis, whereas PCT theorists emphasise the input analysis and give less attention to the organisation and development of output.

Related to this, some contributors, e.g. Jorgensen, seem to downplay the idea that an organism makes predictions, and emphasise the continuous dynamic feedback aspects central to PCT. But after the acquisition of any skill, it is implicit that there is a prediction that a goal will be achieved if a series of actions, albeit continuously monitored and micro adapted, is executed. The learning process is embraced in PCT by the process of "reorganisation" but this is unfortunately given little attention in this book, other than to say it is produced by a trial and error process where perceptual input is monitored.

Jorgensen pursues this interesting quest exploring the points of contact and similarity between PCT and the ideas derived from brain structure. The Hierarchical Temporal Memory theory of Hawkins and Bakerslee (2004), further elaborated by George (2008), was developed independently of PCT and focuses on brain anatomy and function. There is a detailed argument of how the functions hypothesised in PCT could map onto this more anatomical / physiological based theory. Whilst the details required more knowledge than this reader possesses, the exciting general point is that when a functional / behavioural level theory like PCT, describes mechanisms which seem to closely map onto the physiology and anatomy of the brain, then this reinforces the belief that a better understanding is being generated, in much the same way as it did in the work of v. Holst and v. St Paul.

Jorgensen's next chapter continues to explore how different parts of the brain might function to bring about a "roaring campfire". He separates the different levels of perceptual control loops (events, relationships etc.) and hypothesises their linkage. The details of brain anatomy and function and control theory was again beyond this reader's knowledge to understand fully but one is left with a sense that this is likely to be a promising line of enquiry.

The next chapter, already mentioned, "The phylogeny, ontogeny, causation and function of regression periods explained by reorganizations of the hierarchy of perceptual control systems" by Frans Plooij (who organised ISHE's 1992 Amsterdam conference) is easier reading for ethologists as the title suggests, also easier because he uses the format where he plots their[2] journey of discovery of regression periods in the chimp and then in humans in early development and how PCT informed the understanding of the cognitive progression the infants go through. He shows that the development of perceptual abilities from birth to 18 months through progressive steps of brain reorganisation, many coinciding with spurts in brain expansion, closely follows the hierarchy proposed by Powers. The periods of regressive behaviour – when the infant was "clingy, cranky and crying", mark these jumps up the PCT hierarchy. The child is able to compute progressively more complex perceptions. Note the elegance of this

[2] The work was done with his late wife Hetty van de Rijt-Plooij.

approach, the cognitive categories are not imposed by the researcher *a priori*, as in some psychology research, they are derived from what changes across each regression period (real observable phenomena). Plooij allows the natural phenomena to indicate what concepts might be a useful, albeit informed by PCT, and thus what might be useful to understand and predict behaviour. It opens the way to mapping that onto brain functioning in the ways discussed in previous chapters.

Kent McClelland's chapter: "Social structure and control: perceptual control theory and the science of sociology" begins the section on Collective Control and Communication. He wishes to apply PCT ideas to that part of the loop which is outside the individual, i.e. in the environment. It comprises over 60 pages of theorising with no data other than examples of everyday behaviour, described in everyday ways that are then re-described in PCT terms, repeating over and over the idea about controlling perceptions. It almost feels like he is substituting, say, "he drinks" with "he quenches his thirst" (or gets drunk, or toasts the host, or …). He makes various distinctions none of which are particularly novel and one is left with wondering whether this has taken us any further. Probably I missed it.

In the section on application Jeffrey Vancouver provides a useful account of PCT applied to Industrial-Organisational (I-O) Psychology in "Perceptions of control theory in industrial-organizational psychology: disturbances and counter-disturbances", contrasting PCT with a competing approach, Locke's "Goal Setting" theory which has been widely used in business settings.

Warren Mansell and David Goldstein offer a readable account of PCT applied to psychotherapy in "Method of Levels" (MOL) therapy. They emphasise the therapist's role is to help the client discover their own solutions through asking them questions. They recognise the similarities with other therapeutic approaches: thus like humanistic therapies, MOL is person centred, like psychodynamic therapies it recognises the importance of internal conflicts and like CBT it is emphasises helping the client to bring certain thoughts into awareness. The authors quote efficacy studies which suggest such therapy is more effective and efficient than the therapies it has reasonably been compared with.

All therapists need a guiding theory (Mandell, 1967), and here it is PCT. To ask whether the actual practice of the therapy is radically different from many others including standard counselling, is perhaps unfair since overlaps are inevitable given that all are operating in (evolving in) the same environment, so some "adaptive convergence" would be expected. Therapies which are backed by a more coherent theoretical understanding are likely to be more effective and so flourish better and survive (to continue the evolutionary analogy). Mansell and Goldstein would argue that PCT offers greater coherence and explanatory power than other theories and is thus more efficacious in guiding therapy.

Perhaps inevitably, given this is a discussion of clinical work, the issue of awareness / consciousness is brought in, as it is in some other chapters. In the final chapter, The Synthesis, Mansell rightly rebuts critiques of PCT which say it does not embrace consciousness and so cannot be an adequate theory of behaviour and reduces humans to machines. It is a pity that Powers himself (Powers 2005 pages 201-203) argues that awareness is a sign that reorganisation is taking place. Outside of PCT, Glen McBride (2012) for one has made similar arguments linking consciousness to the orienting

reaction which is elicited by novel or unexpected stimuli, a reaction which heralds new learning, or, in PCT terms, reorganisation. The objections to PCT- that it reduces humans to being "just" machines, misses the point, and it is a category mistake. We *are* machines, albeit biological not electronic, and it is part of the approach of science to eschew concepts like consciousness, despite such concepts being very relevant to everyday social life (Richer 2016). So if PCT is treating the control of human behaviour mechanistically, then, from the point of view of scientific study, the proper response is a grateful, "glad to hear it"!

The next application is to robotics, Rupert Young, in "Robotics in the real world: the perceptual control theory approach" reprises the theme of focussing on perception not behaviour. On the one hand, there is what he says has been the common approach in robotics of constructing models of the world in which the robot is intended to operate and programming in appropriate behaviours to achieve whatever ends the robot is designed for in that world. By contrast a PCT based approach would programme in the desired perceptions, often organised hierarchically, and let the machine behave in ways which achieve and maintain the reference values (the desired perceptions). This, he says, is able to deal with the uncertainties of the real world. This is what living systems, he implies, have developed through natural selection, namely by iterating simple processes (the control loop) to achieve complex outcomes. For robots this "simple, lean, general and adaptive architecture" is a far more economical and effective way of achieving whatever goals the robot has. This seems an example of biomimesis[3]. What is unclear to the naïve reader is how the robots, or animal, learns, how it reorganises its perceptions to develop new skills.

Roger Moore, in "PCT and beyond: toward a computational framework for 'intelligent' communicative systems", provides an interesting historical overview of intelligent systems including those which communicate. He states some requirements for intelligent systems, namely that "future autonomous systems will indeed need to be intelligent - they must integrate seamlessly into real-world environments, act appropriately in complex physical and temporal situations, solve difficult logistical problems, interact effectively with human users/operators using accepted social conventions (such as speech and language), be robust in the face of unpredictable disturbances and interruptions, operate independently within an accepted ethical framework, and be at least partially responsible for their own behaviors" He argues that these "requirements for intelligent systems/robots are so demanding that insights need to be integrated from a wide array of disciplines ranging from engineering and computer science to psychology, cognitive neuroscience and linguistics". Also "it is very likely that approaches will also need to be based on a deeper understanding of how existing intelligent systems - living organisms – solve" problems. More biomimesis.

Moore starts with the shortcomings of Good Old Fashioned Artificial Intelligence (GOFAI) based on principles similar to S-R psychology (a theme throughout this book) where they failed "to respond quickly to changing situations and contexts". He moved through other attempts at creating systems and ends with a proposal of his own which

[3] Biomimetics is an approach where technological problems are informed by the evolved solutions to similar problems "in nature". Richer, J.M. (2016).

embodies PCT principles, as well as drawing on the discovery of mirror neurons and the idea that communicating system need to interpret the behaviour of other intelligent systems. He ends with stating "if behavior is the control of perception … then perception (at least for communicative agents) can be said to be the *simulation* of behavior".

The book ends with a synthesis by Warren Mansell, "Ten vital elements of perceptual control theory, tracing the pathway from implicit influence to scientific advance" in which he argues for the distinctiveness of PCT, its convergence with some other theories, and some empirical tests of features of PCT. He addresses critiques of PCT and looks at its limitations and future directions. It is a much needed chapter, and some readers might benefit from reading it before the other chapters.

Overall this is an ambitious book with chapters of varying readability. In places, it is fairly hard going for those not well versed in PCT or in the historical issues which authors address. It can be seen as overclaiming the distinctiveness of PCT, but that slightly dismissive perception may arise from a failure fully to grasp the ideas in their rounded entirety, a perception to which I must occasionally plead probably guilty. It does argue for PCT theorists looking, as Warren Mansell admirably does, to how PCT has been misunderstood and how PCT may be better explained to connect with others. Dare I say some of the methods of market research might inform this. That this is a challenge does not take away from the importance of this volume, for which Warren Mansell is to be congratulated, or from the importance of PCT, which, in my view, should be a theory known and understood to all who study behaviour.

And does it, will it, constitute a paradigm shift? A question for the future.

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JOHN RICHER is a child clinical psychologist at the University of Oxford and the University Hospital. He has published many peer reviewed journal articles, books and book chapters. His research interests focus include on the application of ethology to "disturbed" behaviour, especially in children, attachment, hyperactivity, autism and behaviour problems, consciousness, and nutritional effects on behaviour. He has worked with multinational companies on psychological issues and is frequently asked to offer advice to Family Courts.

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