

ECOLOGICAL PSYCHOLOGY, RADICAL ENACTIVISM AND BEHAVIOR: AN EVOLUTIONARY PERSPECTIVE

Thomas E. Dickins¹
Middlesex University, London, U.K.

ABSTRACT: Ecological psychology and enactivism are close relatives in that they share an interest in positioning the behaving organism as an active agent and in interpreting this with reference to ecological and evolutionary ideas. But they also differ in their uses of biology and the concept of information. I review these uses, relate them to ideas in behaviorism, and conclude that a version of enactivism, championed by Daniel Hutto and colleagues, is the more viable hypothesis. I extend this radical enactivist effort into evolutionary enactivism as an exercise in parsimonious theory building that aims to avoid essentialism.

Keywords: Information; Behavior; Behaviorism; Evolution; Ecological Psychology; Enactivism; Language

¹ Address correspondence to the author at the Faculty of Science and Technology, Middlesex University, The Burroughs, Hendon, London NW4 4BT or directly to t.dickins@mdx.ac.uk

Representational views of cognition have been a dominant tradition in psychology and related disciplines. However, this view has been challenged by radical behaviorism (Day, 1983), ecological psychology (Gibson, 1979) and enactivist approaches (Di Paolo & Thompson, 2017).

Behaviorist positions have been well documented as a transition from concerns about the formal and scientific inaccessibility of mental representation through to a more radical view based upon the three-term contingency of antecedent, behavior, and consequence (Barrett, 2012). The behaviorist challenge is very much one from outside, a purely non-cognitive position whether or not one decides simply to pragmatically sidestep internal mental states for epistemological reasons or those of ontological commitment. The challenge from ecological psychology and enactivism has been from within, addressing topics in psychology that are usually the concerns of cognitive theorists (Costall, 1984).

In recent years, ecological psychology, and particularly Gibson's version of that discipline, has been revived and extended into embodied cognition (Anderson, 2003). Meanwhile, enactivism has become radicalized, moving away from its early view that permitted internal representations (Noë, 2008) to those that suggest that representation is (at most) a cultural product, rather than an internal cognitive one (Hutto & Myin, 2013; 2017). Both embodied and radical enactivist approaches converge on an ambition to model cognition without recourse to the manipulation of contentful mental states (van Dijk, Withagen, & Bongers, 2015). Both focus upon the individual organism and its interactions with the world. As such, these two traditions aim to establish functionally defined proximate accounts of patterned and effective agency. Ecological psychology and radical enactivism are loath to commit the patterning and efficacy to internal content and computational views of brain function (Hutto, Kirchoff, & Myin, 2014; Raja & Anderson, 2019). Nonetheless, this does not stop talk of cognition, and radical enactivists seek to remove internal representation and content from the definition of cognition. It is here that these positions are apparently at odds with some behaviorist views.

The desire to retain talk of cognition is not unrelated to an error in the use of definitions (Popper, 1945). According to Popper, the business of science is not the creation of a list of types, or essences; something associated with the Aristotelian project. Popper equates this practice to reading definitions from left to right, such that we might say that "cognition is x," where x is a set of properties. Instead, we should read from right to left and ask what we might term that set of properties. Cognition then becomes what we choose to call a particular phenomenon or set of phenomena; it is useful scientific shorthand. If we conceptually or empirically remove x, for example, if we find good reason not to believe in computational processes, then we have nothing left to label. The label does not carry any extra information.

In the same year as Popper, Skinner called upon the behavioral science community to more thoroughly inspect their use of definitions of psychological terms (Schlinger, 2013; Skinner, 1945). His contention was that psychology, as a discipline, all too often assumed that words such as *mind*, *consciousness*, and *memory* referred to real things in want of explanation. In other words, the expectation for those quotidian terms was that they be read from left to right in the context of a definition and science was to provide that definition. Skinner's view was that such terms should be analyzed as instances of verbal behavior in order to determine their reinforcement history as *tacts* (Skinner, 1957) and to better understand what behaviors occur when those terms are commonly used. This was especially important for those psychological terms that had a long pre-scientific presence in common parlance.

Discussions of methodological behaviorism have noted that the practices of cognitive psychologists are similar to those of some behaviorists: an independent variable is manipulated, and that manipulation is credited as the cause of the behavioral change (Day, 1983). In Watson's early rendition, methodological behaviorism asserted that only observable data could be incorporated into a psychological account. This later changed to use of unobservable constructs derived from observable data in order to explain S-R transitions, a position sometimes referred to as mediational neo-behaviorism (Moore, 2013). But note that is a derivation of constructs from data collected under laboratory conditions; it is not the practice to lead with the construct. Skinner was of the view that when psychology has sought to define terms such as *memory* those definitions often include a list of operations and properties that are not observable, nor have they been entirely derived from observable data. This kind of approach runs counter to the strong empiricism at the heart of behaviorism.

This observation about definitions should cause all those interested in psychology and related fields to pause. Just what is it that *cognition*, as a bracket term for representational processes, was supposed to explain? If cognition captured a class of mechanisms, what did those mechanisms do? The answer to this question is, of course, a statement of the *explanandum*. Arguments against a representational *explicans* do not do away with what is to be explained.

In this paper I argue that by focusing upon what behavior is, as a functional question, we provide both ecological psychology and radical enactivism with another tool for challenging cognitivism. Furthermore, I argue that a phylogenetic view of behavior supports both a basic view of affordances from ecological psychology and the ambition of radical enactivists to avoid contentful representation. Following the Popperian line, I see no value in retaining cognitive constructs if the fundamental principles of representation and internalism are found wanting.

The paper begins with a brief overview of some modern views on representational theories of mind, then a survey of ecological psychology and enactivism, before moving to evolutionary considerations of behavior. This last raises a particular interpretation of data and information, which is clarified before moving onto applications of evolutionary thinking to the project of explaining behavior from an ecological or enactivist position. The paper ends with a schematic discussion of learning, demonstrating how this fits the evolutionary framework, and also leads to potentially fresh thinking about human language in a behaviorist context, which I propose as a fruitful line of continuing work. This paper should be read as a part of the general project to naturalize the behavioral sciences, by grounding them in biology.

Thought and Representation

Our own experience of an internal mental life and its apparent relation to what we do has supported a long tradition of introspection within psychology (Costall, 2006). As Hebb noted, thought is not fully under the control of environmental stimuli, but appears to cooperate with it to some extent to produce behavior (Hebb, 1949). Thought is therefore in need of some kind of explanation, with reference to behavior, something Hebb saw as reducible to neurophysiology.

For philosophers, the key concept in discussions of thought has been intentionality, regarded as the hallmark of mental activity ever since Brentano (Huemer, 2019). Intentionality captures a quality of mental states such that they can be said to point toward something, and therefore be about something: they are representations. This quality permits a number of different positions on the mind that can be summarized

as neo-Cartesianism, neo-behaviorism, and neo-pragmatism (Haugeland, 1990; Hutto & Satne, 2015).

Neo-Cartesianism

The neo-Cartesian position assumes that mental states have representational content and that this content not only directs behavior, but is historically prior to any socio-cultural interactions that might produce new innovations in behavior. Thus, as with Descartes, there is a mind within that has control. The novelty of this position arises from its adherence to representational hypotheses. The most prominent neo-Cartesian has been Fodor (1975), who argued that thought was a syntactic process operating over contentful representations. The computational operations of thought enabled compositionality. Thus, if one can think aRb – a in some relation to b – then one should be able to think bRa (thus if *Nicola loves Tom*, then it is possible to entertain that *Tom loves Nicola*). This property is compositionality. Truth preservation is a fundamental outcome of logical inference – indeed a property of logic. According to neo-Cartesians, and in particular computational neo-Cartesians, these two properties characterize thought.

Throughout the 1980s and beyond, neo-Cartesians attempted to naturalize mental content, bringing it into line with biologically plausible theories of behaving organisms. Their principal question was: *where does content come from?* Teleosemantic approaches to this task, in which natural selection is responsible for tailoring content, have been the front-runners. The basic idea is that mental states have proper functions that are understood as delivering fitness appropriate behavior in the relevant context (Millikan, 1984). Where teleosemantic approaches fall short is in explaining truth in mental content. Natural selection can build an organism that responds, but that response is designed to maximize average lifetime inclusive fitness; cognitive processes that do not directly, and truthfully, represent the world could conceivably achieve this. For example, a reliance upon heuristics that at best sum salient features of the world, but in no sense act to coordinate all relationships between those features, might be a more straightforward outcome for natural selection (Gigerenzer & Todd, 1999). More strongly, it is theoretically possible for mental content to be entirely false but to deliver a fitness appropriate response. It is the response that natural selection attends to. This has left neo-Cartesians with work to do.

Neo-behaviorism

Neo-behaviorists recognize that it is possible to invoke mental state terminology in order to gain some predictive leverage with regard to behavior. The ambition for those pursuing this approach has been to use current social practices in mental state ascription in order to characterize and categorize the conditions under which it works. This is an instrumental approach to the problem of naturalizing content, perhaps best captured by Dennett (Dennett, 1987), and is not dissimilar to Skinner's recommendations for inspecting the reinforcement history of psychological terms (Skinner, 1945). However, neo-behaviorists require an account of the ability to ascribe mental states and, to date, they have relied upon the contentful minds of those taking an intentional stance, which then introduces a problematic circularity to the project (Hutto & Satne, 2015). In many ways, this project is an epistemological one, as opposed to the ontological one of neo-Cartesians.

Both neo-Cartesian and neo-behaviorist positions have looked for some correspondence between thought and the natural world. For the neo-Cartesians this is a purely representational task – mental states have contents that represent the external world. Neo-behaviorists see correspondence between ascribed mental states, behavior, and the functional demands of the real world. Mental state ascription may simply be a scientific heuristic, but careful attention to the success conditions for such ascription should help to narrow the design features essential to a mind. Hutto and Satne, in keeping with others (Godfrey-Smith, 1996), conclude that it is not possible to take a side at this point, under the current rules of the naturalist game within the more cognitive approaches. And those rules state that intentionality must be grounded in physical stuff. This leaves us with neo-pragmatist positions still to consider.

Neo-pragmatism

Hutto and Satne (2015) claim that neo-pragmatism advocates that “contentful tokens, like ritual objects, customary performances, and tools, occupy determinate niches within the social fabric – and these niches ‘define’ them as what they are” (p. 522). It is through social practice, social learning, and cultural transmission that content is born; such group-level processes enable linguistic tokens, for example, to take on the property of intentional thought. Thus, neo-pragmatism externalizes intentionality, embedding it within specific symbolic behaviors that get cultural tasks done. This is a shift from the internal considerations of the previous positions.

Within the neo-pragmatist position there is also a problematic circularity: how can individuals appropriately engage with cultural processes if they do not already possess content-bearing mental apparatus to assist them in making good choices and adding to the process? Hutto and Satne list the component parts of what they term this essential tension:

1. Participating in and mastery of socio-cultural practices requires intelligence;
2. Intelligence requires intentionality;
3. Intentionality requires content. (2015: 528)

The third component is an assumption that can be questioned. Hutto and Myin (2017) argue that philosophical treatments of intentionality have been driven by a top-down approach. Specifically they single out Searle’s treatment of the property of intentionality in the context of beliefs and desires (Searle, 1983). Searle states that any belief or desire must be about something; there is no such thing as a generic belief or a generic desire. In focusing upon beliefs and desires, Searle locates discussion and analysis of intentionality squarely in content; most specifically in propositional content, or content structured linguistically. As with Fodor (1975), language provides the model for thought, and then sets a very specific (and anthropocentric) agenda for those disposed to naturalism.

Hutto and Myin see this Searlean approach as top-down, and as one that has unduly influenced all other possible views of intentionality. They do not doubt that beliefs and desires occur, and demand content, but they see these states and processes as the end point of a lengthy developmental and evolutionary process. Searle stands accused of eliding propositional content with mental states and, in so doing, setting the agenda for much of contemporary philosophy of mind and cognitive science. The result of this is difficulty when it comes to thoroughly grounding intentionality in the natural

world. In short, Hutto and Myin see this approach as obscuring the building blocks of simpler forms of intentionality, upon which more sophisticated cognitive abilities rely, and they argue that focusing upon content as an essential property makes any form of reductionism conceptually impossible. In effect, Hutto and Myin are making Skinner's (1957) point – Searle has led with the unobservable constructs and claimed that these constructs are propositional and language-like in their functioning. The neo-pragmatists seek to derive their constructs from observation of behavior and build a model of intentionality from the bottom up.

Ecological Psychology and Enactivism: A Brief Overview

Ecological Psychology

Gibson is most often regarded as the founder of modern ecological psychology (Gibson, 1979; Lobo, Heras-Escribano, & Travieso, 2018). He was highly influenced by behaviorism, and in particular Holt's work, but in his dealings with stimulus-response formulations, he came to believe that perception was not a response, but rather an act (Costall, 1984; Costall & Morris, 2015). His ambition was to understand perception without recourse to the standard representational toolkit of cognitive psychology, but his problems with behaviorism led him to take a new approach. He achieved this by redefining the task demands of psychology and by thinking ecologically. Most specifically, Gibson did not accept the (neo-) Cartesian distinction between an internal mind and the external world, such that the organism was separated from the environment and merely acting upon it; instead, in keeping with Behaviorist views, he saw the organism and environment as coordinated (Costall, 1984).

Ecological psychology is a naturalistic perspective with a number of historical roots all grounded in ecological thinking (Heft, 2012). Heft situates ecological thinking within a transactional meta-theory. For Heft, a meta-theory is a shared set of assumptions that can operate across a number of specific theories. The transactional meta-theory regards organisms and environments as dependent upon another, as forming a dynamic system. Entities within such systems have specific functional roles and the organisms have goals, which mean they can be regarded as agents. The actions agents use to achieve goals are contingent upon situational factors. Heft gives the example of reaching. This is a type of behavior, but its tokens differ across situations because objects vary in many dimensions such as size and position. Reaching is not to be understood in isolation, but as contingent upon the detail of relevant circumstance. Actions are constantly calibrated against changes in circumstance and can be understood as attempts to maintain the stability of the dynamic system. This is not to say that organisms are wedded to one system only. They can move between various goal-oriented actions and as they do, aspects of the environment that are initially important drop out of relevance as new aspects become salient. Heft notes how the books on his shelf are not a part of his coffee cup reaching system. The size and position of the cup as well as the nature of the handle and how much coffee is left in the cup are some of the core environmental components for that system. But when he needs a book for reference, the properties of the cup drop out and the position of the shelf relative to his desk etc. become salient.

Gibson's transactionalism was influenced by the discipline of ecology. His view was that environments were those things that are without the organism, but that there were specific aspects of the environment that organisms could actively use.

(T)he characteristics of an environmental medium are that it affords respiration or breathing; it permits locomotion; it can be filled with illumination so as to permit vision; it allows detection of vibrations and detection of diffusing emanations; it is homogeneous; and finally, it has an absolute axis of reference, up and down. All these offerings of nature, these possibilities or opportunities, these affordances as I will call them, are invariant. They have been strikingly constant throughout the whole evolution of animal life. (1979:18-19)

This brief taxonomy of the parts of physical environment that can afford, permit, or offer certain actions to organisms is done at a high level of abstraction. It is essentially a list of types of available affordances. Later, Gibson refined this view:

Ecologists have the concept of a *niche*. A species of animal is said to utilize or occupy a certain niche in the environment. This is not quite the same as the *habitat* of the species; a niche refers more to *how* an animal lives than to *where* it lives. I suggest that a niche is a set of affordances. (1979:128)

Gibson's use of the ecological niche concept makes clear that the affordances of the physical environment are a function of the interaction with the organism and its properties and capabilities. These capabilities, or effectivities, are the complements of affordances (Michaels, 2003). Thus, the surface of a pond will afford standing and locomotion for a pond skater (*Gerris lacustris*), but not for a gray squirrel (*Sciurus carolinensis*) in part as a function of mass interacting with surface tension.

For Gibson an affordance is a possible action that may or may not be performed by an organism. Organisms may not yet exist that can utilize various possible affordances (see Chemero, 2003 for an argument that affordances should only be seen in terms of organism-environment relations). This means that those features of the world that provide affordances do not depend on organisms for their existence, but it is the case that the evolution of organisms reveals opportunities. More strongly, affordances can be understood as central to natural selection, for they provide an environmental backdrop against which to select variation (Fultot & Turvey, 2019).

Gibson was concerned with the perception of visual affordances. He argued that there was sufficient information (not data) in the environment for organisms to directly perceive it and to react accordingly. This view places meaning in the external world, and that meaning is directly perceived by organisms. The classical cognitive view is that there is no meaning in the environment, and that this must be constructed internally in order to then deliver an appropriate behavior (Jones, 2003). Representational content provides context for incoming data and this creates meaning (Floridi, 2010), and it is for this reason that neo-Cartesians have been eager to naturalize content through a teleosemantic approach.

Gibson related direct perception to action, as he made clear in a passage reflecting on past work:

I meant (or should have meant) that animals and people *sense* the environment, not in the meaning of having sensations but in the meaning of *detecting*... For even then I realized that perceiving is an act, not a response, an act of attention, not a triggered impression, an achievement, not a reflex. (1979:149)

His was a theory of active perception that included the role of eye and head movements, as well as those of the whole body (Heft, 2012). Movement and active exploration reveal invariant environmental information and thus enable affordances. Instead of

relying on offline inferential processes to generate hypotheses about what might be done, the exploration of the organism actively delivers this. One might see organisms as foraging for affordances under a set of task demands (Fultot, Nie, & Carello, 2016).

Enactivism

Enactivists, like ecological psychologists, are concerned with perception as an action.

Perception is not something that happens to us, or in us. It is something we do. Think of a blind person tap-tapping his or her way around a cluttered space, perceiving that space by touch, not all at once, but through time, by skillful probing and movement. This is, or at least ought to be, our paradigm of what perceiving is. The world makes itself available to the perceiver through physical movement and interaction. In this book I argue that all perception is touch-like in this way: perceptual experience acquires content thanks to our possession of bodily skills. What we perceive is determined by what we do (or what we know how to do); it is determined by what we are ready to do. In ways I try to make precise, we enact our perceptual experience; we act it out. (Noë, 2008:660)

Noë argues that only organisms with particular motor skills will be able to perceive because perception is a bodily act. Thus, it is not an internal representational process in the brain. Noë does not dismiss contentful brain processes as a possibility more generally, but the argument here is that perception is not in the business of building accurate representations of the external world for later processing and the production of outputs (Noë, Pessoa, & Thompson, 2000).

For such enactivists, cognition is not symbolic computation, but instead the coupling of organism and environment (O'Regan & Noë, 2001). This is a similar view to Gibson's, and this form of enactivism sees active perception as central to the process of sensorimotor coupling with the environment, which is Gibson's and the behaviorists' notion of coordination. For the sensorimotor enactivist, this exploration is guided by knowledge and mastery of sensorimotor contingencies; a form of *knowing how*, rather than the traditional representationalist view of *knowing that*, which relies upon propositional calculus and truth preservation. Organisms build models of how to get about, of how to meet fitness demands. As such, this is a neo-pragmatist approach (Hutto, 2005) where knowing how provides context for sensory inputs. Without this knowledge, the organism is malfunctioning where function is understood purely in terms of behavioral outcomes. This view has been criticized as too conservative, for it allows propositional knowledge in through the back door. In particular, Hutto has taken sensorimotor enactivists to task for cashing out knowledge *how* in terms of knowledge *that*. There is an assumption that particular kinds of movement, for example, will yield particular perceptual experiences and procedural knowledge underpins the delivery of these behaviors (Hutto, 2005; Hutto & Myin, 2013).

This focus upon pragmatic interpretation emerges from a particular view of agency, that of autopoiesis. Autopoiesis is a term that refers to a system that can maintain itself and reproduce itself. This concept is related to the idea of autonomy such that a system that has less complexity than its immediate external environment, or ecological niche, is likely to come under environmental control. Such a system could be allocated an autopoiesis score of <1 (Gershenson, 2015). Conversely, a score of >1 suggests the system has more control, and therefore greater autonomy. Those systems that have high levels of autonomy are often regarded as alive (Ginsburg & Jablonka, 2019).

Autopoietic enactivists are focused upon autonomous self-maintaining and reproducing agents interacting with their ecological niche; these interactions are seen as closely related to definitions of life. Where sensorimotor enactivism permitted some talk of representations, autopoietic enactivism opposes this, making great effort to outline feasible ways of ignoring brain-body dualisms, and embedding the whole organism within its niche as a complex system (Dennett, 1993; Thompson & Varela, 2001). There is no room here for procedural knowledge having oversight. Nonetheless, for radical enactivists the autopoietic approach does not go far enough because at times it still makes use of higher order cognitive concepts, such as meaning (Hutto & Myin, 2013). For example:

Intersubjectivity involves distinct forms of sensorimotor coupling, as seen in the so-called ‘mirror neurons’ discovered in area F5 of the premotor cortex in monkeys. These neurons display the same pattern of activity both when the animal accomplishes certain goal-directed hand movements, and when the animal observes a conspecific (or the experimenter) performing the same actions. The recognition of the *intentional meaning* of actions in others apparently depends on patterns of neural activity in premotor areas that are similar to those internally generated to produce the same type of action. There is evidence for a mirror-neuron system for gesture recognition in humans, and it has been proposed that this system might be part of the neural basis for the development of language. (Thompson & Varela, 2001:424 [emphasis added])

Not only do Thompson and Varela see meaning as something real in want of an explanation, but they also go on to imply that such systems account for a species-specific trait in humans: language. Thompson and Varela are perhaps guilty of adopting Searlean assumptions about intentionality, rather than following Skinner’s (1945) advice and closely inspecting the historical use of those terms.

Radical enactivists rule out representational, contentful minds as the basic design of organisms. As Hutto and Myin (2013) note they have much in common with the earlier eliminative materialists who sought to eliminate the representational theories and to ground the behavioral sciences in connectionist accounts of brain function (Churchland, 1981)². But radical enactivists differ in seeing a role for contentful representations in the cultural practices of language. Unlike the intuition being primed by Thompson and Varela (2001), where meaning is a prerequisite for language, radical enactivism regards language as a cultural invention of a propositional tool that in turn could be used for “getting around,” as Hutto and Myin characterize the core problem.

Summary of ecological psychology and enactivism

The views from both ecological psychology and the enactivism are predominantly focused upon the acting or behaving agent. Agents are understood to be coordinating with the environment, and in this, both positions share common ground with behaviorism. In spite of this common ground, some variants of enactivism retain a role for representation, however ecological psychology and radical enactivism do not. Whilst Gibson’s debt to behaviorism is clear from his own personal history within the field, it is odd that the enactivist literature makes no reference to its shared behaviorist ambitions. One can only speculate that this is a consequence of the ready use of the

² Churchland (1981) spends much time demonstrating that representational theories of mind are nothing more than superficial folk theories but stops short of discussing the reinforcement history of the core terms in use. Moreover, Churchland references cognition as a topic worthy of account.

term *cognition* within this field, a term so readily seen as an antonym for behaviorism. But also, it is possible that enactivism is wedded to the Aristotelian project and has not heeded Popper's advice to shed this essentialist commitment.

The notion of agency at work in ecological psychology and enactivism is that of autonomy, such that the organism can do things to maintain itself without falling under total environmental control. Behavior is very much the *explanandum* and the autonomy perspective gives a broad functional account of what behavior is for. But autonomy is hard won because environments are complex, heterogeneous places that are subject to change. To truly naturalize the behavioral sciences, we must understand how evolutionary processes have designed organisms that can deal with such change.

Behavior in Evolutionary Perspective

Within standard evolutionary theory, behavior fits into a more general account of the property of *robustness*. The vehicles that genomes are embodied within meet a number of environmental conditions. Whilst it is common to consider DNA to contain data about ancestral environments, it would be unexpected to find natural selection had built solutions to very particular conditions that may never be repeated. Indeed, natural selection could not get off the ground if this were so³. Natural selection is instead in the business of developing design solutions for *robustness*, which means being able to deal with a changeable and heterogeneous environment. There are a number of different strategies for delivering this *robustness*. I shall discuss two, bet hedging and plasticity, and then comment on the notion of data at work in these accounts.

Bet hedging

For an organism, and therefore its genome, to weather different conditions that might stochastically present, one solution is to get by in as many environmental states as possible. Compare this to a specialist strategist that can deal optimally with one, or a few environmental circumstances. Under those conditions, the specialist will attain higher arithmetic mean fitness than any other kind of strategist; but once conditions shift away from this optimal point, fitness significantly drops off. The specialist will then have to seek a new area that meets ability or await local reversion to optimal conditions. This is unlikely to pay off in the long run and any localized wins could be lost. A generalist, that can get by in most available conditions, will sacrifice arithmetic mean fitness in order to do this, but it will gain geometric mean fitness over time, which will be sufficient for this kind of strategy to be selected (Starrfelt & Kokko, 2012). The generalist is referred to as a conservative bet-hedger.

Diversified bet-hedging enables the production of more than one phenotype in a generation. We might imagine that two different morphs, A and B, can be produced at point of reproduction, each specialized to a particular environment, A' and B' respectively. There is a probability distribution for the likelihood of morph A or B being produced. If the probability of production of A and B matches the encounter rate with A' and B' then the underlying genome will go to fixation through natural selection. Of course, an A morph in a B' situation will not do as well as a B morph and vice versa, but at a suitable encounter rate these losses will be buffered. Natural selection will thus operate to fine tune the probability of production in the context of A' and B' likelihoods.

³ Mutation rates and generational turn over have to outstrip environmental change for evolution to occur. The focus here is the common situation of environmental change outstripping mutation rates and generational transitions. For environmental variability not to destabilize prior adapted solutions, natural selection will need to find strategies.

Again, this strategy will outcompete the generalist over the long term, as each diversified phenotype will produce high arithmetic means when in the correct situation. Thus, conservative bet hedging tends to see the reduction of arithmetic mean fitness in favor of geometric means, whilst diversified bet hedging reduces the fitness correlations between individuals (with the same genotype) (Starrfelt & Kokko, 2012).

Plasticity

Where bet hedging produces the phenotype ahead of environmental encounters, developmental plasticity responds to data derived from the current environment. Thus, phenotypes are fitted to an environment. This strategy is expected when current environmental state (during development) is a good predictor of future environmental states (Meyers & Bull, 2002). Meyers and Bull give the example of the development of jaw morphology in cichlids tracking early diet. Fish that were fed snails, as opposed to insects, developed significantly larger and more powerful jaw muscles in preparation for that dietary ecology. As Meyers and Bull note, not all developmentally induced phenotypic change is necessarily adapted, and each case must be scrutinized.

Whilst bet hedging and developmental plasticity introduce between-individual, non-genetically derived variation from the same genome, they are typically regarded as distinct strategies for *robustness*. However, Frankenhuis et al. (2016) make a case for diversified bet hedging that leads to offspring morphs that are more or less developmentally plastic. This might be understood as more or less sensitive to incoming environmental data. This implies that there will be some costs to plasticity under certain environmental conditions.

Physiological plasticity enables the non-genetic generation of variation within individuals. As with developmental plasticity, this strategy relies on environmental data to induce physical and behavioral changes within a single organism. For example, the ability of organisms to migrate to new environments in order to access resources is a physical response to changes in daylight and temperature modulated by neurohormonal changes.

Developmental and physiological plasticity are processes that use environmental data to calibrate organisms across developmental and moment-to-moment time scales: this means that they enable organisms to have autonomy in an autopoietic sense. It is this latter time scale, where physiological plasticity operates, and where behavior has been located. This form of plasticity delivers an organism in direct, responsive mode and such organisms should be regarded as agents. Just as Frankenhuis et al. suggested a relationship between bet hedging and developmental plasticity, it is entirely possible that developmental responses will fine tune physiological responsiveness to environmental parameters (Frankenhuis, Panchanathan, & Barto, 2018).

Bet hedging relies upon data captured in the gene, whereas plastic responses do not. Developmental and physiological plasticity are flexible relative to that genetic data endowment. But this plasticity is constrained by definition because it is data led: only specific types of data can be processed, and those data must be available. The context for developmentally and physiologically tracked data is the developing and learning organism in an environment. The capacity to develop and learn is phenotypically given, and to avoid an infinite regress we need a point of origin for those capacities: it cannot be more development or more learning. Genetic arguments fulfill that role within standard evolutionary theory. This implies a form of hierarchical organization of systems, beginning with a historically grounded data structure (genes). It is useful to

draw a type-token distinction here. Biological organization enables the processing of certain types of data, and that typology is historically derived via evolutionary processes. But developmental and physiological systems will, throughout a lifetime, capture specific tokens of data that are a consequence of external change. It is entirely possible that the dynamics of such data tracking, at the token level, will in turn impact ongoing selection because of introduced variation in the abilities to track (which may amount to variance in sensitivity to thresholds of data perception, for example). It is also possible that the bandwidth of permitted types of data may be subject to standard genetic variation and thus selection. Finally, sustained, directional plastic response may change selection on genetic variation (Dayan, Graham, Baker, & Foster, 2019).

Data and information

The evolutionary account of behavior relies on the concept of data. Data are not information, and data have no content. What data amount to is input. But a crucial thing to note is that input, in this case, relies upon a notion of *permission*. Not everything can be treated as an input. That *permission* is simply afforded by the design of the relevant system. So, we might imagine that a person can consume food and also rocks, but only food will be treated as an input leading to state changes in the digestive system, whereas rocks will either prove catastrophic or inert. This is a consequence of design resulting from evolutionary processes. A clear way of interpreting those processes would be within an adaptationist framework where natural selection has played a key role (Andrews, Gangestad, & Matthews, 2002; Williams, 1996).

Data have a role within systems and that is to change their state. In biology, Shannon's concept of information is deployed at this point (Godfrey-Smith, 2007). If we imagine a system that can be in a number of different states, any datum that is inputted to that system and changes the state say from S_1 to S_2 , will be informative. This is because the new datum causes the system to update its current state. Thus, physiological systems take data as cues external to the system (organism) in order to either maintain internal stasis (and therefore the cues have little informational value) or to change (and therefore the cues have high informational value). The conditional and probabilistic architectures associated with those data-led responses (Nettle & Bateson, 2015) are designed by natural selection to maximize lifetime inclusive fitness (West & Gardner, 2013). These responses help to define the ecological niche for organisms, which is close to Chemero's (2003) view on such matters, as they enable the use of particular environmental data. This is a view of affordances.

Following the autopoietic line, highly complex systems that can respond to much data are also highly autonomous with respect to a changeable environment. But that autonomy nonetheless has parameters set by natural selection. Some environmental change will be beyond the data processing of a given system. This can, at times, prove fatal.

The preceding account has no need of content or representation, and information has been understood purely as a functional outcome of a designed interaction between permitted inputs and systems. Gibson's later use of the concept of *information for*, when accounting for the functionality of affordances, comes very close to this view and does away with enactivist concerns about the role of this term (van Dijk et al., 2015). There is no representation, only coordination or calibration.

This account has also aligned behavior and its production with physiology, giving a remarkable array of possible mechanisms for delivering autonomy. The usefulness of data has been delivered through correlation and contingency, as a result

of natural selection. Here is where the design happens. Thus, the explanatory tasks have been set at a mechanistic level within a coherent biological functionalism.

Prior to Darwinian evolution, the instincts of the natural theologian would have been to look at such design in nature and to assume an agent as designer, an agent with a well-formulated set of rules for the acceptance of data (Ruse, 2003). When an agent is given a role in the design of such systems it is perhaps legitimate to talk of meaning, where there is some external ability to understand the system and that understanding is implicated in its creation. It is this natural theological instinct that is perhaps at work in psychology, assuming that behavior is the product of agents and therefore under some kind of internally understood design. It is in this conceptual space that the sensorimotor enactivist's elision between *knowing how* and *knowing that* is perhaps most likely to occur, because some see a requirement for *knowing*. But standard evolutionary theory does not require this. Natural selection is the outcome of chance and necessity; chance in the production of new variation and necessity when a new variant effectively solves a contingent problem of fitness (Monod, 1971).

Applying Evolutionary Considerations

We can adopt evolutionary theory for another purpose in this analysis and reflect upon the history of life and ask: At what point, if any, would a representationally-based proximate mechanism be required to solve problems of robustness? This is using evolution as a tool for parsimonious theory building (Dickins, 2003).

Hutto and colleagues have begun to think phylogenetically about sensorimotor couplings by exploring the nature of more basic, primitive minds (Hutto & Myin, 2013, 2017; Hutto & Satne, 2015). For these authors, hypothesizing about basic minds, that coordinate a behavioral relationship between the external environment and the organism, is a way of determining what can be done without representation. It is not a categorical rejection of representation. This view sees the traditional perspective on cognition fading away at the edges as simpler coordinating systems deliver the same job in less complex circumstances, and indeed this graded continuum of calibrating mechanisms comes close to a determining the origins of life (Keijzer, 2017).

To make the idea of basic minds operational, and to test the limits of non-representational models we must turn our attention to nervous systems. The bedrock assumption of every attempt to explain behavior and to naturalize any concept of the mind is that the proximate mechanisms at the core will be neurophysiological. Not all nervous systems are equal, either now or across time, and this suggests a variety of physiological solutions for dealing with environmental change.

The evolution of nervous systems marks a transition from simple, diffuse nerve nets, through increasing localized signal coordination in ganglia, to brain-like accumulations of ganglia at the anterior of the body in tandem with cephalization (Kaiser & Varier, 2011; Sporns, Chialvo, Kaiser, & Hilgetag, 2004). These transitions are readily related to increasing complexity of the ecological niches occupied by organisms.

The traditional view of a nervous system is of a sensory-motor input-output mechanism in which environmental stimuli serve as inputs to be transduced, or processed in some way, in order to deliver an output (Keijzer, van Duijn, & Lyon, 2013). Such a model could easily permit behavioral calibration to a changeable environment, but nervous systems also act to deliver internal coordination of multicellular processes involved in physiology and growth and development and so have a role in more general plastic response (Jekely, Keijzer, & Godfrey-Smith, 2015). And

nervous systems act to produce behavior through complex coordinated motor outputs (Godfrey-Smith, 2016).

Keijzer et al. (2013) make this last point when outlining their skin-brain thesis. They propose an early stage for nervous system evolution that was not a through-conducting, input-output system. Instead, early nervous systems evolved to coordinate response in sheets of muscle located under the skin. In this scenario, the muscle is served by a diffuse nerve net that constantly fires. Any contact with the muscle disturbs the low-level activity afforded by this firing pattern. The result of nervous activity is contraction and relaxation of the muscle. If we think of an aquatic animal, basic low-level activity might keep the muscle sheets in one position, enabling the organism to drift with tides. But being touched at one point on a sheet will lead to a wave of contraction that causes the animal to move away from the stimulus. Such systems are readily interpreted as input-output systems if only the data about contact (stimulus) and moving away (response) are recorded, but Keijzer et al. exhort us to rethink this assumption and to see the functionality of the nervous system here in terms of sheets of muscle dedicated to building bodies in particular ways. Thus, simple, constantly active sheets can be tied together in ways that deliver complex behavioral functionality, that deliver autonomy.

The skin-brain thesis does not obviate centralized nervous system requirements, but it does change basic assumptions about through-conduction as the only way to produce behavior. Moreover, our imaginary aquatic animal can avoid danger without any need of internal representation. It is possible that these kinds of coordination systems were retained during evolution, but more importantly, it is possible that the emergence of ganglia and localized control, were built upon such activity. For example, with the emergence of specific front end sensory systems in response to foraging demands and predation risks (Godfrey-Smith, 2016), inputs from those systems could be coordinated by ganglia in a way that would give more control over directionality. None of this architecture requires internal representation to deliver the behavioral goods. These ideas give good support to the general principle that at least some of what might be labeled cognition is effectively embodied (Keijzer, 2017; Wilson & Golonka, 2013). And they support the ecological niche perspective on affordances, such that natural selection enables them.

As organisms embodied more functional sensorimotor couplings, the nervous system would in turn become more complex, relying upon ganglia to coordinate multiple motor responses in order to deliver multiple behaviors. In recent years this order of coordination has been explored demonstrating a complex set of ethologically relevant actions such that the motor cortex is organized into functionally relevant zones (Graziano, 2006). Stimulation of these zones elicits hand to mouth behaviors, grasping behaviors, defensive behaviors, and other sequences of motoric response. One can imagine these sequences being activated under different thresholds in part influenced by other data relevant to the situation and the animal's state. This could be packaged as a *knowing how* system, but as previously argued there is no need for knowing here, there are only responses.

Summary

Evolutionary transitions have built organisms that embody a hierarchy of fitness needs in order to exploit ecological niches. The more stochastic those niches, or the more heterogeneous the niches, the more fitness demands there are. Because natural selection leads to additive design, via descent with modification, these needs will be met by

increasing hierarchical control within the overall nervous system, which produces an increasingly plastic behavioral phenotype as more potential sequences of behavior can be produced. The evolution of the nervous system demonstrates increased coordination enabling the sharing of neuronal resource to deliver multiple functions. The apparent intelligence of those adjustments is a product of natural selection, not of an internal mind with controlling oversight.

Statistical Beings

One way to characterize the representational urge from classical cognitivism is as the desire to pack everything in. So rather than have an organism designed to respond to data, one has an organism designed to take data, use it to model the world from which it came, and to run computations with those models in order to select an appropriate output. As implied, this seems to be non-parsimonious from a biological perspective. But one reason to perhaps think that something representational goes on is because of learning, which appears to be a modeling process.

The discussion of the skin-brain thesis led us to imagine simple, responsive creatures that were organized to effectively forage and evade predation. This order of architecture can deal with environments that are predictable in terms of food availability and unpredictable in terms of looming predators. But in a world where there is more to consider, or where predators cannot be so readily evaded, then prediction becomes useful. Learning that predators are more likely to be in certain areas, or that prey move through at particular times, is likely to have an impact on fitness outcomes in a more positive way than relying upon chance. Learning and prediction enable organisms to exploit changeable, stochastic ecologies by tracking sequential and probabilistic events. Learning enables organisms to build statistical models that capture environmental complexity and predict most likely outcomes (Clark, 2013); we should anticipate learning in organisms that move about and exploit multiple niches. Learning is correlation and contingency, in keeping with our commitments to data, and it will be guided by evolved data tracking systems as we have known since the Garcia Effect (Garcia & Koelling, 1966).

Learning as statistical regression

The statistical view of learning presents an opportunity to develop useful hypotheses that are consilient across ecological psychology, radical enactivism and behaviorism. To begin, we might argue that to effectively coordinate with the environment, and more importantly, to predict elements of it, organisms operate as if they are running regression analyses. Regressions reveal regularities between variables in the environment and produce models (for statisticians) of varying fit between x and Y parameters. Typically, we express the underlying formalism of a regression in terms of the General Linear Model⁴ as follows:

$$Y=f(x)$$

Here Y is the dependent variable and is equal to the independent variable (x) under some function (f). Residuals, intercept, and slope determine f in statistical models. This statistical method has been widely recruited within psychology in order to measure the

⁴ I use regression in this section as an intuition pump to categorize a kind of activity.

causal role of x in relation to Y , of stimulus in relation to response, and Skinner noted that when cognitive psychologists adopted this method they were in effect behaviorists (Day, 1983). Thus, the formalisms of a regression analyses may be delivered by classical and operant procedures. A similar point has long been made about the formalisms of optimal foraging, noting that reinforcement histories can introduce variation that causes animals to depart from optimality (Baum, 1981; Dallery & Baum, 1991; McNamara & Houston, 1985, 2009).

Within the internal economy of a nervous system organized around ganglia, a hierarchy of $x \rightarrow y$ relations can be established, where not all y -parameters are outward behaviors, because neural activity is no longer diffuse as in the skin-brain hypothesis, but coordinated, enabling multiple localized stimulus associations to be formed. This ability to derive complex associations can afford greater plasticity but as problems of calibration become more complex, as the number of parameters increase, then the nervous system confronts difficulties associated with co-linearity and potentially begins to lose leverage. The statistician's solution to this is to employ data reduction techniques, such as principal components or nearest neighbor analyses and these techniques are widely used in machine learning (Maini & Sabri, 2017). These factors can be updated as new data are sampled if they have informational value.

The updating of statistical products via continued data sampling is a Bayesian process and Clark has argued that this is central to the production of behavior and relies upon specific neural architecture (Clark, 2013). Clark regards the nervous system as "fundamentally adapted to deal with uncertainty, noise, and ambiguity, and that it requires some (perhaps several) concrete means of internally representing uncertainty" (p.189). The radical enactivist version of this view has no need of internal representation, however, but instead looks to derive regression relations between stimuli and eventual behavior. Thus the statistical models derived from learning are not models *of* the world, as classical representational theories of cognition have it, but pragmatic models that reveal the relevant world to the organism (Anderson, 2003). They are specific configurations of motor responses that facilitate fitness, achieved by adjusting probabilistic conditional architectures (Nettle & Bateson, 2015). The organism is the model; there is nothing offline about this process. But the model is a function of the structural properties of the autopoietic organism. For the ecological psychologist and the enactivist, the very act of behaving is an embodied act of statistical sampling and testing.

A role for symbolic behavior

Hutto and colleagues have been eager to adopt a neo-pragmatist view of radical enactivism in which organisms of the sort outlined above actively engage and coordinate with the world (Hutto & Myin, 2013). As a part of their neo-pragmatism they see content as a cultural product and push all the properties associated with standard representational cognition into the symbolic practices of humans. In short, they argue that humans can adopt content through language-like behaviors.

One way to interpret this cultural claim is to suggest that symbols, including words, act as data reduction products. Traditionally we are to think of the meaning of symbols in intensional terms and we must try to model them as truth-bearing representations (that can, of course, be in error). But Skinner's emphasis upon the learning of *mands* and *tacts* demonstrates a core interest in the development of data reduction techniques for communication (Skinner, 1957) that the Chomskyan position is thought to have side-lined for psychology (but see Hobbs & Chiesa, 2011;

MacCorquodale, 1970; Schlinger, 2008). Through socially coordinated learning, which is what Skinner proposed, symbols (be they vocalizations or written words) are attached to already derived factors in a symmetrical fashion (following Peirce [Dickins & Dickins, 2001])⁵. That attachment gives the illusion of intensional content, but these factors are not immutable and can shift as new data come in. And, no two individuals will have derived precisely the same factors due to individual differences of experience and sensory system and nervous system functioning.

This (neo-) Skinnerian perspective becomes more powerful when we begin to understand language as enabling associations between factors that have been derived by other organisms. What socially embedded language does is add another layer of data about relevant relationships in the world, derived from the behavioral experiences of others. Whilst we might negotiate language use and symbolic reference in order to communicate (Hinde, 1985) and in order to manipulate the behavior of actors in our environment (Krebs & Dawkins, 1984), we also use it to acquire information about how derived factors cohere. We gain secondary experience that can be used to update on-going data reduction processes.

It is the externalizing of a factor that makes it symbolic; once it can be shared (openly introduced into a social covariance matrix) it takes on properties of reference; it takes on properties of theory because a theory is a socially evaluable model. A factor is a modeling outcome that enables prediction. If a factor can be treated referentially then it can enter truth preserving computations, or logical transformations, that enable inference beyond the probability and covariance calculations. This idea I reserve for future work, and I do not see it as core to the central claims here⁶.

Summary

The hypothesis presented here is that data reduction and general regression analyses (underpinned by learning mechanisms) produce calibrating organisms that have no need for representational content. Organisms are not paying any attention to truths, they simply get things done and the agenda for what must be done is both very simple and endlessly complex: simple, because it is ultimately about survival and reproduction; complex because each problem of survival and reproduction is nuanced by local conditions and reinforcement history.

Symbols enable a step away from the direct machinations of the working organism. Put another way, factors emerge as a part of the system's activity; symbols are off-line reflections upon past and possible actions. In essence, a symbol asks the question: If this latent variable worked in this situation, where else can it be applied? The answers are derived through the process of communication, which is primarily social, but can also be autonomous. Given this, the generation and use of symbolic data reduction products are a second order calibrating activity in their own right and very likely create greater flexibility and efficiency in coordinating organisms. Hutto and colleagues appear happy to see symbols as representations, but in keeping with behaviorist views I see symbols as part of a complex of coordinated responses to stimuli and therefore intimately tied to behavior. In this way, this proposal is more radical still.

⁵ Dickins and Dickins (2001) propose that derived stimulus relations, seen in equivalence class formation, may provide the bedrock for symbolic behavior, rather than the precisely operant hypotheses of Skinner. But this still sits well within the tradition of behavior analysis emerging from behaviorism.

⁶ There is evidence to suggest that word meaning is learnt and updated in part due to the statistical co-occurrence of terms in encountered language (Bullinaria & Levy, 2007). My deep intuition is that syntactic operations are fundamentally statistical also; something akin to Markov chain analyses such that particular symbols (data reduction products) get related to one another in multiple step co-occurrence procedures. In essence, this is further order of data reduction process (Clark, 2017).

Summary and Conclusion

In this paper I have made the following claims:

- 1) Behaviorism, ecological psychology, and radical enactivism have no core role for representation in their theories;
- 2) Where behaviorism sat outside cognitive psychology from the start, ecological psychology and enactivism have attempted to address topics from within that field;
- 3) There is strong case for abandoning the term *cognition*, following Popper and Skinner, once representation is itself abandoned and simply focusing upon behavior as the *explanandum* for psychology and the general behavioral sciences;
- 4) Behaviorism, ecological psychology, and enactivism all focus on active animals coordinating with the environment;
- 5) A more thorough grounding in evolutionary biology enables a proper understanding of data and the evolutionary transitions in data processing designs that facilitate increased robustness in changeable environments;
- 6) An evolutionary framework has no role for representation, but it does allow for affordances;
- 7) An evolutionary framework does have a role for learning, as a part of physiological plasticity;
- 8) Learning organisms can be understood in statistical terms, as systems that derive regression-like relations in order to better coordinate with the environment;
- 9) Such learning leads to problems of co-linearity in the data which can be resolved by data reduction techniques such as the derivation of factors that rely upon that co-linearity;
- 10) It is hypothesized that symbolic language is a data reduction technique that enabled second order data collation thereby facilitating more effective coordination.

The position defended in this paper is perhaps best labeled as evolutionary enactivism. This is to be seen as a separate activity from that of evolutionary psychology, which simply assumed a neo-Cartesian model of the mind and sought adaptationist hypotheses about the nature of internal content, therefore pursuing an empirical teleosemantic project. Evolutionary psychology has repeatedly used extensional (observable) behavioral data to derive hypotheses about intensional mental content, but these derivations are based on no more than a predisposition to a neo-Cartesian framework (Dickins, 2003). As such they conform to the general point about the methodological behaviorism of cognitive psychology.

Evolutionary enactivism presents fruitful lines of future enquiry perhaps because it is an effort to start from first principles and to shed past assumptions, much in keeping with Skinner's more general ethic. Human language is one example on which to start work and the hypothesis given here about the function of symbols could be explored within the context of the evolution of language, with reference not to its separation from other communication systems but rather its continuity with all forms of calibrating, coordinating behavior. More specifically, a global understanding of what behavior is, grounded in evolutionary theory, perhaps stands a chance of developing a unified approach with the behavioral sciences.

Acknowledgements

I should like to thank Louise Barrett, Rob Barton, Ben Dickins, Thom Scott-Phillips, and David Shuker for comments on early drafts of this paper. I am also indebted to two anonymous reviewers and the Editor for useful direction and engagement. All errors are my own.

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