Interface Theory

The View from Ecological Psychology

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Abstract

What is the basis for our perceptual experience? Why do we perceive the world as we do? A long-standing assumption is that perceptual systems have evolved to provide us with veridical access to the world, so as to support successful and adaptive behaviour. Interface theory (Hoffman, Singh & Prakesh, 2015) is the radical hypothesis that fitness, not truth, dictates the evolution of perceptual systems and they show, with simulations, that this fact means veridical mappings never get off the ground. They take particular aim at the direct perception, ecological approach to perception (Gibson, 1966, 1979) and work to show that such a system never gets out of the evolutionary gate. This commentary defends the ecological approach from the radical implications of interface theory by showing that a) Gibson does not make the mistakes he is accused of and b) that the ecological hypothesis is so different in kind to the Establishment view of perception that it simply falls outside the scope of interface theory. The view from the ecological approach is rosy, and the radical implications of interface theory remain solely the problem of representational theories of perception.

Introduction

Hoffman, Singh & Prakesh (2015) detailed a radical new view on the nature of perception in the form of their *interface theory*. In brief, the theory states that perception and perceptual learning is not about coming into more veridical contact with our environments; rather, it is about creating an interface that can support functional behaviour. These interfaces are like the desktop metaphor in modern computer operating systems. The computer is not literally made of files and folders, and such an interface literally hides a lot of the actual mechanisms at work when computers do things; it is not a veridical representation of the working parts. However, the interface supports our fast and functional interactions with the computer and in a very real sense this is all that is required to make desktops the preferred interface. Interfaces (perceptual or otherwise) are therefore not required to bear any similarity to the world. In fact, in a series of evolutionary simulations, Hoffman et al demonstrate that veridical interfaces (ones that work to preserve even some of the structure of the environment) are routinely out-competed into extinction by non-veridical interfaces (those built in whatever form required to optimise fitness). Perception, they argue, is an adaptive interface that hides the messy details and instead presents us with a series of useful fictions, including things such as 'objects', 'events', and 'the world as described by physics'.

One theory of perception that seems to immediately lose in this scenario is the direct perception account from James J Gibson's ecological approach (e.g. Gibson, 1966, 1979; Michaels & Carello, 1981; Turvey, Shaw, Reed & Mace, 1981). The directness comes from Gibson's theory of ecological information, which he argued is sufficient to support the perceptual experience of objects and events in the world without further mental processing. This is in contrast to the Establishment hypothesis (Fodor & Pylyshyn, 1981) that sensations lead to perception along an indirect route through a process of inference (e.g. Marr, 1982; Rock, 1983, 1997). If perception does not involve transforming the raw sensory data into anything else, then what we see is what the world is and perception should be veridical. If, however, Hoffman et al are right and evolution will always favour

non-veridical perceptual systems over veridical ones, then evolution will never produce a Gibsonian organism and the ecological approach is dead on arrival. Hoffman et al of course argue precisely this.

This commentary defends Gibson and the ecological approach from the three specific objections Hoffman et al raise. The conclusion will be that the view from the ecological approach is rosy, and the apparently staggering implications of interface theory, to the extent that they hold, apply only to inferential theories of perception. In short, the basic battle lines of the ecological vs the Establishment view of perception remain the same, and interface theory is not our problem.

Three Objections to the Ecological Approach

Hoffman et al (2015) propose three specific errors in Gibson's approach;

> First, Gibson got evolution wrong: He claimed that evolution shapes veridical perceptions of those aspects of the world that have adaptive significance for us.
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> ...
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> Second, Gibson denied that perception involves information processing. The interface theory does not. Evidence for information processing is now overwhelming.
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> ...
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> Third, in place of information processing Gibson proposed direct perception...[but] How could a theory of direct perception explain illusions? Gibson never solved this problem (Fodor & Pylyshyn, 1981)…
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> pg 1500

The last two points can be easily addressed with reference to the existing literature, so let's tackle those first before addressing the first, interface theory specific objection.

The status of information processing: There is indeed a great deal of evidence in favour of the information processing approach. There is also, however, extensive empirical support for the hypothesis that ecological information shapes behaviour directly (e.g. coordinated rhythmic movement, Wilson & Bingham, 2008; Wilson, Collins & Bingham, 2005a, b). This work typically shows that the observed structure in behaviour is explained by the observed structure in the information, suggesting no mediation or transformation has occurred in between perception and action. Neuroscientists have also finally begun investigating the neural dynamics associated with

detecting and using ecological information and have shown the nervous system preserves, rather than transforms, the spatio-temporal dynamics of the information (e.g. van der Meer, Svantesson & van der Weel, 2012).

In addition, on the few occasions information processing and ecological approaches have been explicitly pitted against one another, the ecological approach prevails (e.g. trajectory prediction loses to informational strategies in the outfielder problem, Fink, Foo & Warren, 2009; cue integration loses to information in distance perception, Mon-Williams & Bingham, 2008; schema learning loses to smart perceptual mechanisms in skill acquisition, Zhu & Bingham, 2010; nulling informational errors beats internal simulations of vehicle dynamics; Markkula, Benderius & Wahde, 2014). So the empirical game remains happily afoot.

Illusions: Fodor & Pylyshyn (1981) do claim Gibson cannot explain illusions, but Gibson of course had plenty to say about illusions; he just did not consider them to be of central interest to a theory of perception. de Wit, van der Camp & Withagen (2015) provide a useful review of Gibson's published discussions on illusions in both his 1966 and 1979 books, as well as his extensive related analyses of the information available in pictures of things (e.g. Gibson, 1971; Gombrich, Arnheim & Gibson, 1971). That Fodor & Pylyshyn paper also sparked a substantial defence of Gibson by Turvey, Shaw, Reed and Mace (1981) which included an extensive analysis of the ecological approach to misperception and illusion (Section 8, 'Misperception Misconstrued'). Since then, ecological psychologists have continued to engage with illusion phenomena. For example, Runeson (1988) developed a masterful informational analysis of the Ames Room, while Zhu & Bingham (2011) argued with data that the size-weight illusion is not a misperception of weight but the correct perception of throwability. Claiming the ecological approach has nothing to say about illusions is therefore just demonstrably false.

In summary, these two apparent slam-dunks against Gibson are, in fact, the same old objections to his approach that the information processing theorists have been raising for some time, and in both cases, the empirical and theoretical games are still very much in play.

Gibson and Veridical Perception

I want to turn my attention now to Hoffman et al's primary new objection, that Gibson misconstrued evolution in his search for veridical perception. If the ecological approach is committed to making perception veridical, then the various key results of the evolutionary simulations (including the Invention of Symmetry theorem) apply and Gibson is in trouble. In what follows, I will defend the ecological approach from this objection.

An Obvious Objection: Adaptive Interfaces Out-Evolve Veridical Ones

Hoffman et al pit various perceptual strategies against one another in evolutionary simulations, and find that

> strict interface strategies that are tuned to fitness routinely drive naïve realist and critical realist strategies to extinction….The only situation in which realists have a chance against interface strategies is when payoff varies monotonically with resource quantity, i.e., when truths and payoffs are roughly the same thing.
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> pg 1486

This happens because of the nature of the simulations; the payoff function literally rewards fitness and not veridicality, so when the two are not the same veridicality cannot win. Hoffman et al defend this feature of the simulations by saying

> But we cannot expect, in general, that payoff functions vary monotonically with truth, because (1) monotonic functions are a (unbiased) measure zero subset of the possible payoff functions, and (2) even if they weren't, the ubiquitous biological need for homeostasis militates against them. Thus, we cannot expect, in general, that natural selection has tuned our perceptions to truth, i.e., we cannot expect our perceptions to be veridical.
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> pg 1486-7

Their homeostasis example is about 'amount of water'; the payoff for water is not a monotonic linear function of amount of water; a little and a lot are both bad for you. So fitness and veridicality

are rarely the same thing and because evolution favours fitness, it will always out-compete veridicality. Gibson, they claim, wanted veridical perception and therefore he is out of the game.

The Obvious Defence: Gibson wanted adaptive, not veridical perception

The obvious first move is to point out that veridicality was never Gibson's goal. He didn't demand perception to be *true*, he demanded that it *work*. Gibson's final hypothesis was that higher order, ecological information variables in energy arrays were the only elements capable of supporting flexible, adaptive and functional perception and action. It then was the case that they could do this because of the lawful process that created them and allowed them to specify properties of the world (e.g. Turvey et al, 1981; Frykholm & Runeson, 1983). Gibson's primary goal is the same as Hoffman et al's; an adaptive perceptual mechanism; Gibson just ended up with a veridical one. In fact, Gibson's approach is effectively a hypothesis that, contra Hoffman et al, there is at least one important case where fitness and truth overlap (ecological information) and that this is the basis for perceptual experience.

A Brief Note on the Nature of Ecological Information

This hypothesis deserves to be unpacked a little here; we need to specify both the nature of the world to be perceived and the nature of the information supporting that perception.

Ecologically, the environment to be perceived is best described at the level of *dynamics* (Bingham, 1995; Warren, 2006; Wilson & Bingham, 2001). Specifically, a complete formal description of the world-to-be-perceived requires reference to the states of the world, how they change over time and the forces that caused those changes; units of time, position and it's temporal derivatives, and mass. It is only at this level of analysis that types of objects and events can be identified. If I throw a ball fast and then throw one slowly, they produce different motions but are both examples of the same type of dynamically defined event, namely a projectile motion event, and can be recognised as such (e.g. Zhu & Bingham, 2014). The environment is a *dynamical* place.

As environmental dynamics unfold over time, the various components of the dynamic (e.g. the projectile) interact with various energy media; light bounces of them, they generate sound waves in

the atmosphere, and so on[1]. The light that bounces off a surface is changed by that interaction, and the field of light in a scene is changed from the unstructured, symmetrical, radiant light coming from a source into the structured, asymmetrical ambient light of the optic array; into ecological information for vision.

The structure of these arrays can be completely captured at the level of *kinematics*; time and motions but not force information. The kinematic structure of that information is a) directly caused by the underlying dynamics according to the ecological laws that govern the projection of world into optics (Turvey et al, 1981) but b) that information is not identical to the underlying dynamics because it is a projection into a medium that can only support kinematic activity (the 'perceptual bottleneck'; Bingham, 1988). Information in the optic array *specifies* (maps 1:1) but is *not identical in form to* the part of the dynamical world that created it; the basis of perception is therefore the *Kinematic Specification of Dynamics* (Runeson & Fryholm, 1983).

This can be formalised as a symmetry principle (Shaw & McIntyre, 1974; see Chemero, 2009, Chapter 6 for the excellent and clear review from which I am borrowing here); the way the world is causes the information to be the way it is, which in turn causes perceptual experience to be what it is; this then means that perceptual experience being what it is specifies what the information is, and what the information is specifies the way the world is. This symmetry is the underlying mechanism that allows perception to be direct (this will become important in the context of interface theory in a moment).

Organisms therefore have access to information about the dynamics of the world around them and they can use this information to control their own dynamics to complement the world; they can produce functional, adaptive behaviour. The details of that behaviour are generated by the form of

[1] I will focus on light (and therefore visual perception) for simplicity and access to useful empirical results; this story applies to all the perceptual systems, however.

the information, as it is mediating the organism's contact with the dynamics, but specification allows this mediation to work without complex internal transformations.

The first defence of the ecological approach can now be laid out in some detail. Veridical perceptions can compete if they co-vary with fitness, but Hoffman et al claim that this will essentially never happen. However, it turns out that the formalisation of Gibson's ecological information by Turvey, Shaw, Mace and others is, in fact, a hypothesis that there is at least one veridical perceptual mapping that varies monotonically with fitness (kinematic information that specifies the dynamical world via symmetry) and that this is the mechanism that shapes our perceptual experience of the world. The ecological approach since then has been the empirical investigation of this hypothesis, with many successes.

A Strong Rebuttal of the Defence: The Invention of Symmetry Theorem

Specification rests on a symmetry principle. Here is where Hoffman et al actually have their strongest swing at the ecological approach, in the form of the Invention of Symmetry Theorem, and its corollary, the Invention of Space-Time Theorem. After a formal definition (pg 1498) they summarise it this way:

> The … theorem shows that the world itself may not share any of the symmetries that the observer observes. The world need not have the structure the observer perceives, no matter how complex that structure is and no matter how predictably and systematically that structure transforms as the observer acts.
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> pg 1498

If symmetries do not allow an observer to 'track back' from their perceptual experience to the world, then the ecological approach seems to be doomed.

A Straightforward Defence: This Only Affects Interfaces

The important thing to remember about interface theory is that it is not a theory of physics; Hoffman et al have not discovered anything new about the nature of the universe. It is a theory of perception, specifically an inferential, constructivist, representational theory of perception, so their claims are about how we perceive that universe. The Invention of Symmetry theorem therefore

cannot possibly be saying 'it is physically impossible to track back from *any* symmetrical mapping of the world to the world', it can only be saying "it is psychologically impossible to track back from *some* symmetrical mappings (specifically, interfaces) to the world". Your interface can be richly structured, and vary in all the appropriate ways as you move about the world, but this doesn't say anything about the nature of the world because you build interfaces to be functional, not veridical. This, if true, is an intriguing challenge to Establishment theories of perception.

Luckily for the ecological approach, information is not an interface and so it is not one of those theories. Information is not constructed by us; its form is not optional; the symmetry it has that perception depends on has not been created by a process of inference. It is created by the operation of ecological scale laws of physics, and as such it is not within the scope of the Invention of Symmetry Theorem.

Summary

Interface theory, as described in Hoffman et al (2015) is pitched as a comprehensive competition between all possible perceptual systems, and the competition reveals that evolution will always favour non-veridical interfaces tuned to fitness over ones tuned to truth. Gibson's ecological approach is identified as a kind of naïve realist strategy, one of the veridical mappings that always loses to fitness-tuned interfaces. Gibson fits the definition of naïve realism; perceptual experience (as measured using action; Bingham & Pagano, 1998) preserves the structure of a subset of the world, specifically the structure of ecological information. But information is not a strategy; it is not a mapping between world and experience invented by a cognitive system. Ecological information is lawfully created by the physical interactions of task dynamics with energy media and is available to be sampled by any active organism. Because it is not a psychological invention, the Invention of Symmetry problem does not apply, and the ecological approach is therefore happily sheltered from the implications of interface theory.

The only remaining move is to propose that task dynamics and ecological information are just icons in an interface and none of it is real. But no-one, not even Hoffman et al, wants to be a solipsist, so at the end of the journey we are back where we started – inferential and ecological hypotheses about perception are two very different kinds of theory that come from very different places and work in very different ways (Turvey et al, 1981) and which one is better remains an open theoretical and empirical question.

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