On perceptual expertise

Abstract

Expertise is a cognitive achievement that clearly involves experience and learning, and often requires explicit, time-consuming training specific to the relevant domain. It is also intuitive that this kind of achievement is, in a rich sense, genuinely perceptual. Many experts—be they radiologists, bird watchers, or fingerprint examiners—are better perceivers in the domain(s) of their expertise. This claim is intuitive, but no philosopher has argued for it. Few philosophers have even explicitly considered it. The goal of this paper is to take up this task, and to motivate three related claims, by substantial appeal to recent empirical research on perceptual expertise: Perceptual expertise is genuinely perceptual and genuinely cognitive, and this phenomenon reveals how we can become epistemically better perceivers. These claims are defended against sceptical opponents that deny top-down or cognitive effects on perception, and opponents who maintain that any such effect on perception is epistemically pernicious.

On perceptual expertise

> "The first few days with a wild new hawk are a delicate, reflexive dance of manners. To judge when to scratch your nose without offence, when to walk and when to sit, when to retreat and when to come close, you must read your hawk's state of mind. You do this by watching her posture and her feathers, the workings of which turn the bird's shape into an exquisitely controlled barometer of mood. A hawk's simpler emotions are easily perceived. Feathers held tight to the body mean *I am afraid*. Held loosely mean *I am at ease*. But the longer you watch a hawk the more subtleties you see; and soon, in my hypervigilant state, I was responding to the tiniest of cues. A frowning contraction of the crines around her beak and an almost imperceptible narrowing of her eyes means something like *happy*; a particular, fugitive expression on her face, oddly distant and reserved, meant *sleepy*.
>
> To train a hawk you must watch it like a hawk, and so you come to understand its moods. Then you gain the ability to predict what it will do next. This is the sixth sense of the practised animal trainer. Eventually you don't see the hawk's body language at all. You seem to feel what it feels"
>
> From H. Macdonald, *H is for Hawk*

For many kinds of expertise, the exceptional performance of the expert involves sensory perception in some important way. The expert knows where to look, how to listen, what she is tasting, and so on. She sees things more quickly, distinguishes patterns that others cannot see or hear at all, and rapidly makes comparisons between perceptible features that others can scarcely understand. This kind of achievement clearly involves experience and learning, and often requires explicit, time-consuming training specific to the relevant domain. It is also intuitive that this kind of expertise is, in a rich sense, genuinely perceptual. Put simply, it is plausible that many experts are better perceivers in the domain(s) of their expertise. This claim is intuitive, but no philosopher has argued for it. Few philosophers have even explicitly considered it. The goal of this paper is to take up this task, and motivate three related claims. Perceptual expertise is genuinely perceptual *and* genuinely expert-involving, and this phenomenon reveals how we can become epistemically better perceivers.

Section I provides the relevant theoretical background. Section II provides an initial gloss on perceptual expertise. Section III provides the groundwork for a cognitive architecture and epistemology of perceptual expertise. The analysis divides into three parts, each one centred on a reply to a sceptical challenge. Sceptical challenge 1 claims that the relevant phenomenon, as evidenced by empirical data, is not genuinely perceptual. Sceptical challenge 2 claims that the relevant phenomenon is not genuinely, *cognitively* expert-involving. Sceptical challenge 3 claims that any non-perceptual effects on sensory perception are epistemically pernicious: perceptual experts so-called are not better perceivers, whatever else they might be better at. Accordingly, many of the replies (in particular to sceptics 1 and 2) involve making the case for categorizing the phenomenon in a particular way. The proposed mental architecture that results then provides a basis for epistemological analysis (the reply to sceptic 3).

I. Philosophical and scientific background

There is a preponderance of emphasis on the negative in traditional and contemporary philosophy of perception. There is continued emphasis on illusion and hallucination, as a kind of litmus test for both the structure and epistemic nature of perception. A great deal of discussion is centred around perceptual error and misrepresentation: how do theories of perception explain perceptual error? how can perceptual misrepresentation be naturalized? if there is regular risk for error, what is the epistemically responsible stance to take towards perception? The thread common to these various philosophical problems and theories is an emphasis on how perceivers or their perceptual systems fail, or could fail.

One can identify a similar thread in perceptual psychology. Many designs in behavioural psychology involve experimental tasks that evoke or expose subject error. Subjects may be primed in ways that lead to errors in perceptual report, or ambiguous stimuli may be used, or a conflicting stimulus (perhaps in a distinct sense modality) may be presented in tandem with the target stimulus. Cognitive neuropsychology is largely grounded on lesion studies, where inferences about proper function of sensory systems (identified with neurophysiological structures) are derived from experimentation on subjects with damage to a particular neural structure. The inferential pattern here is to first correlate perceptual errors or task failures with lesions of a distinctive type, and then from this correlation derive the proper psychological or behavioural function of that neural structure for "normal" subjects. There are important differences here and, as we will see, the psychological literature on perception is much less dominated by emphasis on the negative, but here again there is an identifiable thread: a great deal of research in these scientific fields focuses on how perception goes wrong or performs sub-optimally.

Given the epistemic or normative importance of perception, this is a curious feature of the literature. Perception is supposed by all parties, at least when not in sceptical moods, to be crucial to how we come to know about and navigate the world around us. In both related and disparate domains that involve normativity, there is far greater emphasis on the positive, on improvement, on the success cases. In normative ethics, a central theoretical project is to identify how we can become better persons, how to do the right thing, how to achieve virtue. In studies on reasoning and decision making, principles are identified that are supposed to optimize successful inference, planning, and prediction. And, closest to the problems at hand, broader epistemology aims to identify good-making epistemic properties of agents and/or mental acts: reasons, warrant, justification, reliability. So even if explicable, the scarcity of philosophical discussion of the improvement and optimization of perception, once revealed, is worthy of attention.

Another related way to bring out some of these points is via the following analogy with the literature on the cognitive penetrability of perception. Cognitive scientists and philosophers debate whether cognitive states like belief, desire, or intention can influence in some relatively direct or important way, perceptual experience. This is an empirical question, and so the cases made for cognitive penetration highlight data from perceptual psychology and then argue that these data are best explained as an important cognitive effect on perception. There are a number of alternative ways that theorists resist a cognitive penetration explanation of any such empirical case.Two broad alternatives are these. First, for a given case (or type of case), one might argue that the data are better explained in terms of non-perceptual phenomena. For example, one might instead claim that the reports or behaviour of experimental subjects are better explained as indicating some post-perceptual cognitive effect on judgment or belief. So, background cognitive states influence other of one's cognitive states (which show up in perceptual report), while having no relevant effect on perceptual experience. Call this *sceptic 1*. Second, for a given case (or type of case), one might argue that the data are better explained in non-cognitive terms. This alternative explanation grants that there is some change or effect on perception, but denies that this is a consequence of some antecedent cognitive state or process. Instead, the case is typically explained as some intra-perceptual phenomenon, as some kind of purely perceptual learning or perceptual adaptation that requires no explanatory appeal to beliefs or knowledge. Call this *sceptic 2*.

Finally, if one does grant the possibility (or actuality) of cognitive penetration of perception, the consequences then emphasized are predominantly negative. Theorists on both sides of the debate emphasize the epistemic threat of cognitive penetration. Put most simply, the worry is that if perceptual experience is influenced by background beliefs or, worse, non-doxastic states like desire or emotion, then it would not provide sufficiently objective grounds for perceptual belief. On this line of thought, the crucial knowledge or information providing role of perceptual experience is threatened. This encourages a foundational kind of scepticism. Call this *sceptic 3*. Sceptics 1 and 2 are sceptical about the reality of certain kinds of non-perceptual effects *on* perception. Sceptic 3 captures a general epistemic worry about non-perceptual effects on perception, should they actually occur.[1]

[1] For extended discussion of these alternative explanations of alleged cases of cognitive penetration see Macpherson 2012 and Stokes 2013. For discussion of the epistemology of cognitive penetration, see also Lyons 2011, Siegel 2012, Silins 2016. For a recent volume of new papers on cognitive penetration, see Zeimbekis and Raftopoulos 2015.

The present interest is not cognitive penetration.[2] However, the three types of sceptics just identified have clear analogs with respect to perceptual expertise. One might be suspicious that relevant evidence from perceptual psychology is evidence for a genuinely *perceptual* phenomenon (sceptic 1). Or one might be suspicious that such evidence is genuinely expert-involving, in the sense that it is actually sensitive to cognitive or conceptual content of the relevant domain (sceptic 2). And finally, one may grant that there are genuine instances of perceptual expertise—properly called, contrary to sceptics 1 and 2—but conclude that these kinds of higher-level effects on sensory perception are generally epistemically pernicious or otherwise worrisome (sceptic 3). Thus the perceptual expert is not, epistemically, a perceptual expert.

II. An initial characterization of perceptual expertise

Empirical research on perceptual expertise, as it is called by the relevant researchers, traces back to work on face recognition. One point of debate in that literature is whether the *fusiform face area* (FFA) in humans is a neural structure devoted exclusively to the recognition of faces.[3] Experimental research led centrally by Isabel Gauthier in the late 1990s and early 2000s was interpreted to show that the FFA could be recruited in a number of domains other than face perception. For example, some of the first of these studies indicated similar neural activity in FFA in visual recognition of birds and cars, and trained visual recognition of instances of a novel, artificially constructed category of object.[4] This question about the face-specificity of the FFA can be

[2] However: the broad explanation of perceptual expertise advanced in this paper suggests that perception is far more plastic and far more integrated with cognition than sceptics of cognitive penetration suppose. What is distinctive of this explanation and analysis, even if it is separable from any commitment to the cognitive penetration of perception, is that it sheds light on that topic from a positive angle. That is, if the explanation offered is apt, then some cognitive effects on perception (in some sense) amount to humans getting better, not going awry, in perceiving the world.

[3] Sergent et al. 1992, Kanwisher et al. 1997.

[4] Gauthier and Tarr 1997, Gauthier et al. 1999, Tarr and Gauthier 2000, Gauthier et al. 2000.

distinguished from a second question.[5] One can ask, independent of debates about the FFA, whether genuine perceptual expertise is specific or exclusive to the recognition of faces.[6] Ongoing debates in cognitive science centre around both, but it is the second question that is of interest here. It is also the question, of the two, that has received little to no philosophical analysis.

The work of Gauthier and her collaborators has culminated in an international, interdisciplinary research group—the *Perceptual Expertise Network*. Researchers in this Network employ a variety of methods: behavioural, EEG, FMRI, eye-tracking, computational modeling. Studies investigate "real-world" experts: expert bird watchers, fingerprint examiners, radiologists, car-experts, and tree experts, among many others. And researchers study subjects trained in laboratory circumstances: training novice subjects to recognize birds, cars, and other-race faces, among other categories. Another line of research involves training subjects to recognize and classify objects of artificial (laboratory) construction.

Research on perceptual expertise commonly centres around categorization tasks. Both real-world expert or lab-trained expert subjects (plus novice controls) perform a variety of tasks: feature listing, object naming (a subject gives the name that first comes to mind), category verification (a subject confirms or disconfirms a category name provided before an image), and object discrimination (by category, as described just below). In many of these studies, task performance is responsive to a visual presentation (of birds, or cars, or Greebles, etc.). Following research by Rosch and colleagues (1976), research on categorization distinguishes a hierarchy of category names: sub-subordinate (e.g., "eastern kingbird"), subordinate (e.g., "kingbird"), family (e.g., "flycatcher"), domain (e.g., "songbird"), basic (e.g., "bird"), intermediate (e.g., "vertebrate"), or superordinate (e.g., "animal") (Johnson and Mervis 1997: 257). The research by Rosch demonstrated that basic-level

[5] Opposite Gauthier and her collaborators' claims about FFA/OFA is the work of Nancy Kanwisher's lab at MIT, which maintains that these neural areas are genuinely face-specific. For representative publications see, Grill-Spector et al. 2004, Kanwisher and Yovel 2006, McKone et al. 2006 (in addition to the landmark Kanwisher et al. 1997)

[6] For an early example of the (then) unorthodox answer to this question, see Gauthier and Logothetis 2000.

categories enjoy a primacy when making initial classifications of a perceived object. That is, when non-expert humans categorize, say, an Eastern kingbird, 'bird' is the name most readily applied. One important finding of various more recent studies on expert-level subjects is that this basic-level categorization—sometimes called "the entry level"—can shift with acquisition of expertise. Thus the entry-level for the bird expert is commonly at the subordinate level—it shifts to 'Kingbird' for the relevant perceived object. And, as one would predict, experts perform better on other tasks—feature listing, category verification, object discrimination—that are sensitive to subordinate (or even more fine grained) level categorization. Other tasks involve discrimination at an individual level. For instance, researchers have studied expert fingerprint examiners, where after brief presentation of a fingerprint sample image, subjects can quickly identify the target out of two very similar test images.[7]

These same methods are employed for laboratory trained expertise. The most common experimental paradigm here involves Greebles. Greebles are a "class of non-face, novel, cartoon-like objects that can be classified at multiple levels" (Scott 2011: 196) (See figure 1). While Greebles are not faces, they have parts that protrude from a cylindrical body, where those parts tend to be organized according to a few similar patterns. Each Greeble will then vary to some degree along these patterns (no two Greebles are identical). Accordingly, Greebles can be distinguished by two "genders" and five "families". Similar research has been done with "blobs" and "Ziggerins".[8]

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[7] Busey, T. A. and Vanderkolk, J. R. 2005.

[8] See Nishimura and Maurer 2008 and Wong et al. 2009, respectively.

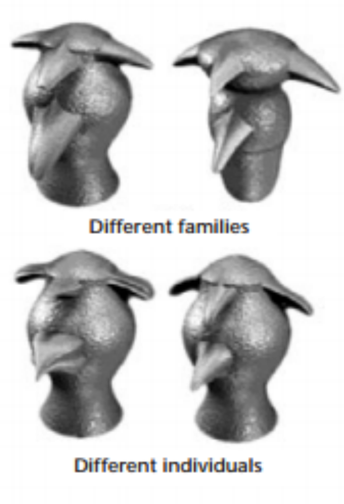

Figure 1 (from Gauthier et al. 1999)

While importantly different in timescale and other details from real-world expertise, this approach affords better control of various factors relevant to expertise acquisition. Once adequately trained, subjects respond more accurately and quickly in both categorizing Greebles (for example, by "family") and individuating a particular Greeble from others, and recognize novel, in-category exemplars. This method also allows researchers to identify changes in perceptual processing of stimuli over the expertise acquisition period. Similar methods, and with similar results, have been used for natural (non-laboratory created) stimuli, where novices are trained to recognize categories of object, like birds or other-race faces. These behavioural methods and results are corroborated with a number of additional physiological and neural methods, including eye-tracking studies to identify attentional patterns of experts; EEG recordings of event related potentials; and fMRI studies on face related neural areas, all to be discussed in III below.

III. On the architecture and epistemology of perceptual expertise

In their domain of expertise, perceptual experts perform with more accuracy, greater speed, and more sensitivity to fine-grained details than novice subjects. This is a statistical claim. Whether this amounts to a perceptual epistemic good of some important kind is left an open question, to be addressed in III.3. III.1 addresses the question: Are these expert achievements constituted by genuine *perceptual* processes? III.2 addresses the question: Are the perceptual achievements constituted by *cognitive* expertise, in a way that is sensitive to the high-level content specific to the domain of expertise?

The claims that emerge from the analyses across III.1-3 separate into two architectural claims, and an epistemic claim. Perceptual expertise is a genuinely perceptual *and* genuinely cognitive, expert-involving phenomenon. And the effects of expertise, on perception, are epistemically enhancing.[9]

III.1 Perceptual expertise as a genuinely perceptual phenomenon

Sceptic 1 resists the claim that perceptual expertise is a genuinely perceptual phenomenon. There are a number of non-exclusive reasons for this scepticism. One may hold a strongly modularist theory of perception. According to this view, perceptual processes operate in a way that is functionally distinct from non-sensory cognitive processes and utilities. As it is sometimes put, perception is *informationally encapsulated* and therefore *cognitively impenetrable*.[10] Although there may be conceptual space to allow for the compatibility of genuinely *perceptual* expertise and a modular account, the default reading of the latter is that perceptual systems are not subject to substantial changes that result from cognitive or conceptual learning.[11] Second, one may commit independently to a sparse theory of perceptual content. Vision, according to such a theory, only represents shape, colour, illumination, and motion. An intuitive way to characterize some instances of acquisition of

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[9] To be clear, these are not universally quantified claims. The claims are existential ones: some perceptual experts (with emphasis on those domains that have received extensive empirical study), enjoy cognitively effected perceptual enhancement, and in many cases this is an epistemic good.

[10] Fodor 1983; Pylyshyn 1984, 1999.

[11] Whether the phenomenon is one that genuinely involves cognitive learning, sensitive to conceptual content of the relevant domain/s is the question to be addressed in III.2.

perceptual expertise is as involving change in recognitional capacities: the subject that learns to distinguish birds at the subordinate level ('kingbird', 'cardinal', 'crow', etc.) is able to recognize instances of these categories as such. And one might be tempted to construe this perceptually: acquiring the capacity to recognize cardinals as cardinals involves acquiring a visual capacity to represent the property 'being a cardinal'. This construal is, however, incompatible with the sparse content theory. Perception, says that theory, does not represent 'being a cardinal' any more than it represents 'being a bird' (or 'being a pine tree', etc). Perception instead only provides information about the shape, colour, and illumination of, say, the bird.[12]

Sceptic 1 can then couple either or both of these theories with a post-perceptual explanation of the performance of experts. The expert bird-watcher and the non-expert control subject enjoy (for the most part) the same perceptual experience of birds—same perceived colours, shapes, illumination, etc. However, the expert better cognizes features that are distinctive of birds of particular subordinate categories and, consequently, behaves in ways sensitive to these features. The expert and the novice see the same, but the expert does more, cognitively, with what she sees: forming judgments, drawing inferences, applying concepts or beliefs to the visual scene.

The case against sceptic 1 takes the form of an inference to the best explanation. The analysis will thus proceed by laying out a variety of behavioural and neural-physiological evidence, and conclude that this variety of evidence is best explained by the hypothesis that much of so-called perceptual expertise is genuinely perceptual.

The first strand of behavioural evidence concerns "automaticity". Not only do experts more rapidly perform categorizations or other forms of recognition (categorizing a bird image at the subordinate or sub-subordinate level, or matching a fingerprint), but they do so in ways that they often cannot carefully describe. For example, expert radiologists often report a sense that there is

[12] There is now a rich literature on the admissible contents of experience. For a recent collection, see Hawley and Macpherson 2011. For early arguments for rich content of experience, see Bayne 2009, Siewert 1998, Siegel 2006.

something anomalous in a medical image before they can point to the anomaly. When asked to describe their phenomenology (once identifications or categorizations are successfully made in a task), experts report that the relevant object or feature is "highly salient, or just "pops out" (pop-out selection is a feature common to both bottom-up and top-down visual attention). They regularly invoke visual terms, reporting that they "just see" the relevant object or feature immediately. These reports and the speed of performance suggest that the expert expends little or no deliberate cognitive effort, and that her performance is non-inferential.[13]

Automaticity is studied using *interference effects*. One relevant method is the *composite task*. Subjects are presented with both the bottom and top half of an object of expertise, with an intermittent mask. (See Figure 2). The task is to determine if the designated half (this is sometimes varied between top and bottom from trial to trial) of the second image (the "test image") is the same as the relevant half of the first image (the "study image"). The targeted (instructed) test half-image can be the same as or different from the study half-image. The two halves of the test image can be congruent or not (congruence condition) and aligned or not (alignment condition). What these studies typically show is that, at test, the irrelevant object half that is to be ignored interferes with *expert* performance. For example, performance degrades (in experts) when, in the test image, the bottom half of a Greeble is incongruent with the (target) top half. Further, this effect is modulated by the alignment of the test image: the magnitude of these interference effects in experts is highest when the object halves of the test image are aligned. This effect is well substantiated for faces as well, about which all subjects are experts, so long as the faces are "within race". The standard explanation for this effect is that experts rely on holistic processing of objects of expertise, and these tasks require them to attend only one part of the whole. And moreover, the holistic process

[13] See Kundel et al. 1972, Manning et al. 2006, Drew et al. 2013,

would seem to be most strongly triggered in cases where the object is intact as the relevant whole (the aligned condition).[14]

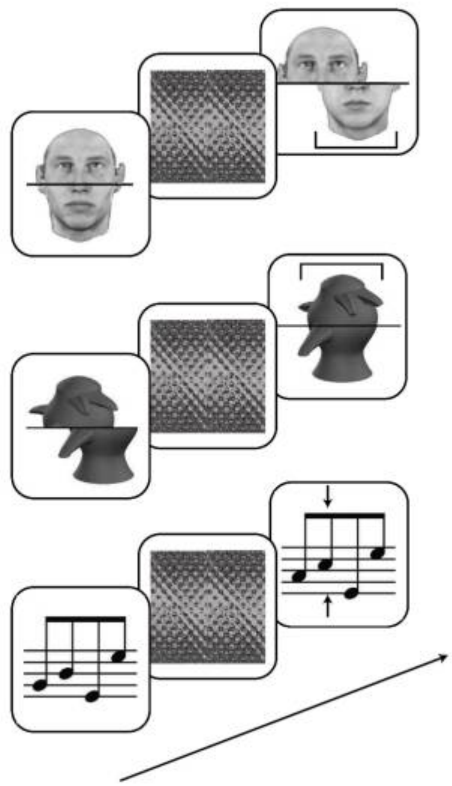

Figure 2 (Richler et al. 2011)

Novices experience interference when the study images are misaligned, but the alignment of the test image has no significant effect. Furthermore, this effect can pervade an entire set of randomized trials: when the experimental context is one where the study images are sometimes misaligned, novice performance suffers interference. Both of these features are importantly different from interference effects in experts. For experts, manipulations to the study image (e.g. alignment) have no significant effect on performance. And a manipulation of experimental context

[14] See Richler et al. 2011.

(randomization) has no effect on interference. All of this suggests the following distinctive explanations for interference in novices versus experts. For novices, if incongruence or misalignment is introduced at the study image, or established as a contextual feature of the experiment through randomized trial structures, subjects will thereby employ strategies to attend to more of the image, searching for anomalies. This deliberate and flexible "wider attention" strategy then extends to the test image such that interference occurs (for instance, when the to-be-ignored half of the test image is incongruent). So the process that is interfered in the novice is a rapidly formed, context-sensitive strategy. By contrast, it appears that the expert process is inflexible and automatic, and it involves holistic processing. What the expert "should" do is selectively attend to only the half of the test image that is to be matched with the half of the study image. If she did this, then incongruence of the to-be-ignored half (or a mismatch between the to-be-ignored half in both test and study images) would have no interference effect. But in fact such interference effects do occur in the expert, and are modulated by alignment. So it appears that the expert cannot "turn off" an automatic, holistic perceptual strategy, and this is why interference is strongest when the two test images are aligned as a whole. And this is also why, in misaligned conditions, experts are "released" to some degree from an interference effect.[15]

Interference effects in composite tasks for experts suggest that holistic processing co-varies with, or becomes more dominant in, acquisition of expertise. Moreover, experts rely heavily upon configural information in an object of expertise: on the spatial relations between features, as much or more than the features taken independently. These are standardly theorized markers in face perception. In the *part-whole task*, subjects are presented with a study image (a face) and then presented two test images and asked which feature is the same as the study image (the eyes). Subjects do significantly better at this task when the test images are wholes (two whole faces) than when the two images are isolated parts (two pairs of eyes). (See Figure 3). Studies also compare *sensitivity to*

[15]See Curby and Gauthier 2010, Gauthier and Tarr 2002, Wong et al. 2009, Gauthier et al. 2003.

*spatial change*s (the space between the eyes) versus sensitivity to feature changes (the size of the eyes). (See Figure 4). The results suggest that although subjects are sensitive to both, they show greater sensitivity to the spatial changes. All of this suggests a greater sensitivity to local and global spatial relationships in faces. This kind of configural processing has been well-evidenced, using the same methods for both real-world and lab-trained experts, for example for cars, fingerprints, and Greebles.[16]

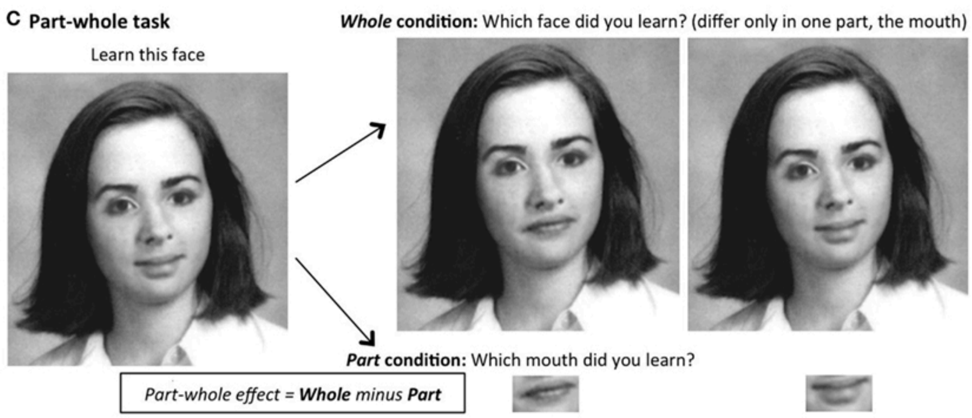

Figure 3 (From Bukach et al. 2006)

[16] See Gauthier et al. 1998, Friere et al. 2000, Barton et al. 2001, Leder et al. 2001, Gauthier and Tarr 2002, Busey and Vanderkolk 2005. For review, see Bukach et al. 2006.

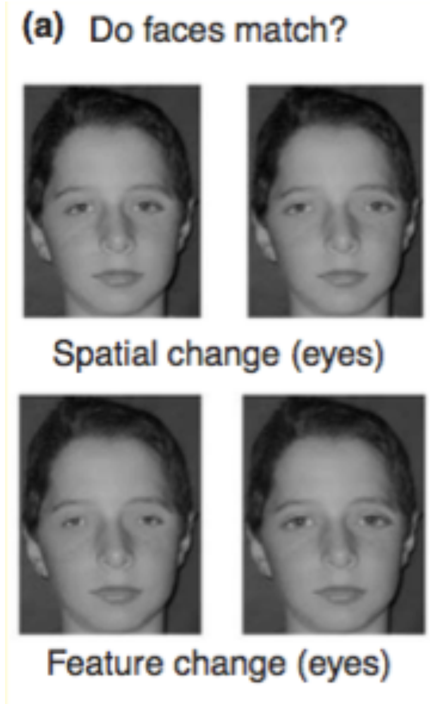

Figure 4 (From Bukach et al. 2006)

Another common method used involves *inversion* of target images. A famous example is the Thatcher illusion. In spite of one's expertise with faces and further, one's familiarity with famous faces, it is more difficult to detect substantial featural changes—complete inversion of the eyes and and mouth—in a face that is perfectly inverted. These changes are horrifically obvious in an upright face.[17] Researchers have found the same effect in a variety of non-face objects, for example, for cars, dogs, Greebles, and fingerprints.[18] Importantly, the magnitude of this effect varies with the relevant expertise. For example, performance on dog breed identification declines sharply for dog show judges when images of dogs are inverted, but novices show little to no difference in performance on

[17] The Thatcher illusion was originally reported in Thompson 1980. It is worth noting that the inversion effect is relatively absent for "other race" faces (faces of a race other than the test subjects), explained by face perception expertise being broadly "own race" sensitive. For recent work on the Thatcher illusion for faces, see Barton et al. 2001 and Dahl et al. 2010.

[18] Cars: Curby et al. 2009, Rossion and Curran 2010. Dogs: Diamond and Carey 1986. Greebles: Gauthier and Tarr 1997. Fingerprints: Busey and Vanderlolk 2005.

upright versus inverted images of dogs. This again encourages the following explanation: the inversion-task method thwarts the expert's holistic processing and thus experts do worse than novices in these tasks.

Another kind of behavioural study involves *expertise-expertise interference*, where non-face expertise interferes with face recognition expertise. A relevant question is whether this is a genuine effect of expertise, where visual resources for, say, car expertise compete for and exhaust the similar resources needed for face recognition, or whether this is simply a consequence of objects of expertise grabbing attention and thus distracting from faces. Researchers use a *rapid serial visual presentation* (RSVP) method to test the two hypotheses. In one such experiment, subjects are presented with a pair of target faces, followed by a fixation cross, and then a sequence of twenty images.[19] Presentation rate is initially set at 7 items per second, and this rate is then adjusted on subsequent trials, subject-by-subject, to converge on an 82% accuracy threshold. In the experimental condition, the RSVP sequence contained both face images and car images (F/FC condition). In one control condition, the sequences contained face and watch images (F/FW condition). Subjects consisted of car experts and non-experts. Subjects then reported, in either condition, which of the two target faces appeared in the RSVP sequence. Car experts, by contrast to non-experts, performed more slowly in the F/FC condition. Thus task-irrelevant car images seemed to undermine face recognition, but only for car-experts. Performance between subject groups in the F/FW condition showed no significant difference. One might be tempted to infer here that the difference is explained in terms of attention. However, the results from a second pair of control conditions suggests otherwise. In these trials, the targets viewed a pair of distinct watches, with an RSVP sequence of either watches and cars (W/WC condition) or watches and faces (W/WF condition). Again subjects were either car-experts or car non-experts (no subjects were watch experts). The important result is that in the W/WC condition, the car-experts perform significantly better than the novices (while

[19] McKeeff et al. 2010.

there is no significant difference between subject groups in the W/WF condition). So, it looks implausible that face recognition interference in car-experts in the F/FC condition is explained by dominant attention (to cars), since this explanation would predict that in the W/WC condition car-experts do equally poorly (since their attention would be drawn to the task-irrelevant distractor images of cars). But the opposite result obtains: car-experts do better in this condition. Similar interference effects have been found (in experts) in visual search tasks[20] and in inversion tasks.[21]

One final set of behavioural studies concerns visual short term memory (VSTM). As it is standardly theorized, VSTM is a short-term (or working) memory system that encodes only visually acquired information. VSTM is limited both with respect to how long memories are available for use and how much information it may store. Different models explain this limited capacity differently: some claim that there are a limited number of "feature slots" available in VSTM, others that VSTM can only handle a limited amount of complex, bound object representations. One well-evidenced feature of VSTM is that it can store "more" (in either sense) memories for faces than for other similarly complex objects. And here again we find an exception for objects in a domain of expertise.[22] Car experts show a VSTM advantage for objects of expertise where, despite the complexity of car images, VSTM capacity increased to the capacity normal for very simple objects (e.g. 3 to 4 coloured circles). This capacity increase is orientation sensitive: when car images are inverted (just as for faces) the VSTM advantage for car-experts is eliminated. (See Figure 5)

[20] McGugin et al. 2011.

[21] Gauthier et al. 2003.

[22] Curby et al. 2009, and Curby and Gauthier 2010.

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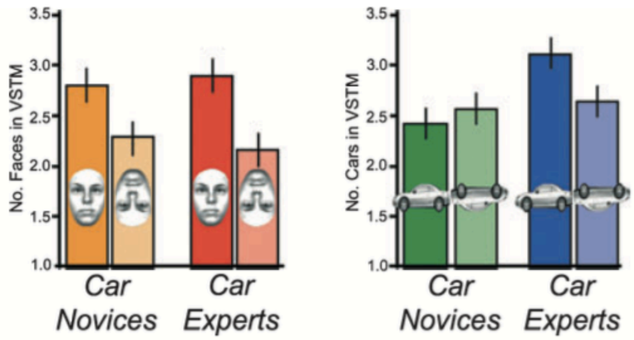

Fig. 1. The maximum number of face (left) or cars (right) in visual short-term memory (VSTM) for upright and inverted faces and upright and inverted cars among participants who were car experts and car novices from Curby et al. (2009). There was a VSTM advantage for upright cars among car experts similar in magnitude to the advantage for upright faces. Car experts, but not novices, showed an inversion effect for cars.

Figure 5 (from Curby and Gauthier 2010)

Curby and Gauthier suggest, "extensive experience with a category can result in a domain-specific increase in VSTM performance for complex objects, perhaps because experts can more efficiently encode and represent complex objects in VSTM" (Curby and Gauthier 2010, 195). This encourages a perceptual explanation. Perhaps experts perform better because, by virtue of more efficient, holistic processing of objects of expertise, the category-specific complexity of an object (a subordinate or sub-subordinate category of car) is already represented by perception. When this representation is given to VSTM, less resources are needed to store the representation, since perception has already done the work of representing the object (or bound features) as being within a category. Put another way, less resources are needed to extract category-specific or category-relevant information because perception has already done the work of representing some of this information. By contrast, the non-expert does not enjoy holistic, or category-bound perceptual representations of cars. This would explain why the non-expert has lesser capacity for car representations in VSTM: these representations exhaust cognitive resources given the feature complexity of cars, where those features have to be extracted through attention for a given task.

These varied behavioural measures have been correlated with ERP amplitudes. Experimenters have long used EEG recordings to study neural correlates of face perception. The ERP component N170 has a typical onset latency between 150-200ms post-stimulus and has been taken as a standard index for face perception; this component responds at higher amplitudes, at this temporal scale, for faces than non-face objects. More recently, researchers find that the N170 component is greater in amplitude in response to objects of expertise, and for both real-world experts (dog experts and bird experts)[23] and for lab-trained expertise for both real-world objects (birds)[24] and artificially constructed objects (Greebles).[25] Similar results are found for interference effects. For example, in trained subjects (but not in untrained novices), the N170 response is reduced for faces when the task involves concurrent presentation of objects of expertise (Greebles), but with no similar interference in N170 amplitude (for faces) when the concurrent object is equally complex but not an object of expertise.[26]

Evidence for face-selectivity in cortical areas FFA and OFA typically proceeds by dissociation inference: performance in object recognition dissociates from performance in face recognition, and deficits in the latter can be correlated with damage to FFA and/or OFA (with no damage to other areas of visual cortex). Using fMRI, researchers find that these same areas show enhanced activity for objects of expertise, for expert subjects by contrast to novice control subjects. This has been shown for real-world experts, for example, car experts and bird experts and for

[23] Tanaka and Curran 2001.

[24] Scott et al. 2006.

[25] Rossion et al. 2002.

[26] Rossion et al. 2004. For similar findings on car experts, see Rossion et al. 2007.

learned expertise with Greebles[27]. Further fMRI studies reveal adaptation in specifiable neural populations, for learned, artificial objects.[28] Eye-tracking studies have been performed on a range of expertise, from radiologists to highly trained visual artists, revealing rapid attentional patterns that differ from (and result in better performance by comparison to) novices.[29] Finally, researchers have enjoyed substantial success in computationally modelling perceptual expertise, for both faces and non-face objects.[30]

Neurological and physiological evidence of this sort is rarely taken to be conclusive regarding (philosophical) questions about perceptual experience, but the evidence is nonetheless suggestive. There is clear evidence for changes in the relevant ERP component and in relevant neural areas FFA and OFA. These changes co-vary with acquisition of expertise, and moreover appear to differentially activate (suffer interference) when tasks involve both faces and objects of expertise. Finally, the activation (as evidenced by the EEG recordings of the N170) occurs in fairly early visual processing, between 150 and 200ms post-stimulus.

Now to bring this diversity of evidence together in an explanation. We know that there is some important difference between expert and novice at the level of mental representation; the question is whether this is importantly *visual* representation (or otherwise sensory perceptual). The neural and physiological data—EEG/ERP data, fMRI data, and eye-tracking data—are standardly taken by our best vision sciences as measures of, or as identifying correlates for, visual representation. This may not be conclusive, but sceptic 1 has to explain these data away. Focusing on evidence from composite studies, part/whole and spatial change studies, interference effects, inversion effects, and expertise-expertise interference, again an explanation in terms of visual

[27] Cars and birds: see Gauthier et al. 2000. Greebles: see Gauthier et al. 1999.

[28] Folstein et al. 2013.

[29] For example, see Kundel and La Follette 1972, Johnson et al. 1999, Vogt and Magnussen 2007, Drew et al. 2013.

[30] Palmeri and Cottrell 2010.

representation is favourable. The kind of automaticity enjoyed, the sensitivity to configural, holistic perceptible features, and competition with other similarly expert-requiring representation all suggests that the expert enjoys some distinctive visual representation. The evidenced VSTM advantage is also most efficiently explained by visual representation: the expert enjoys category rich visual representation, freeing cognitive resources to enable increased short term memory load.

Finally, a point about phenomenology. Subjective reports of experts indicate visual phenomenology, and the automaticity and speed of performance indicates non-inferential psychology. And the various studies discussed above suggest that experts enjoy greater sensitivity to holistic, complex configural and spatial relations of objects of expertise. This implies a difference (between expert and novice) in visual phenomenology: a sensible difference in how those objects are configured or organized, and how they enjoy greater salience in the relevant contexts. These are differences in what it's like for the expert versus the novice

One might resist any such isolated case and the explanation offered. But taken together, the convergence of this evidence grounds a strong case for a visual perceptual explanation. The concluding *architectural claim 1* is that, contrary to sceptic 1, perceptual expertise is a genuinely perceptual phenomenon. This explanation takes seriously the *perceptual* in perceptual expertise.

III.2 Perceptual expertise as genuine cognitively sensitive expertise

The second question is whether this kind of expertise, *with* the perceptual features just described and defended, is sensitive to high level cognition, or is it just a general improvement to perception. This is a question about cognitive architecture, but one of epistemic importance to theories of perception. There is an important difference between perception just improving as a developmental or biological matter versus its improving as a consequence of training and in ways that are highly sensitive to domain-specific conceptual content. Sceptic 2 attempts to motivate the first answer to the question, claiming that the relevant phenomenon is not genuinely expert-involving: high-level or cognitive learning is not needed to explain the various data. What motivates this claim?

Perceptual systems develop, learn, and adapt to perceptible kinds, after repeated exposure and by consequence of evolutionary advantage. Thus one might attempt to explain perceptual expertise as a purely *intra-perceptual phenomenon*. So sceptic 2 grants that the phenomenon is genuinely perceptual, but maintains that it involves some kind of purely perceptual learning, or adaptation or, most simply, perceptual development. Accordingly, there is no need for explanatory appeal to what expert subjects know or believe, or what they have learned about the specific content of the domain of expertise.

Contrary to sceptic 2, the claim defended in this section is that perceptual expertise is genuine, content-sensitive, *expertise*. The perceptual effects described in III.1 non-trivially depend upon cognitive learning: information about categories, diagnostic detail, goals and tasks within that domain. Here again the inference structure is abductive, ranging over behavioural and neural-physiological studies.

First, given objects of expertise like birds and Greebles, one might be tempted to claim that expertise advantages all depend on stimuli that are configurally face-like, and it is already well-established that humans have some kind of perceptual advantage for faces. This claim is easily dispelled. Many objects of expertise are radically, configurally distinct from faces: cars, radiological images, trees, fingerprints, musical notation. So whatever one says about the range of expertise, it is not plausible that experts are just transferring a general face perception sensitivity, after repeated exposure, to face-resembling objects. This does raise, however, an interesting set of questions about the nature of expertise training.

Real-world, "naturally" acquired expertise nearly always involves training of techniques, loaded with semantic content, categories, high-level concepts. This is no less true of in-lab expertise training. A study by Tanaka et al. highlights various important features of expertise training, emphasizing both that explicit auditory feedback is required while mere exposure is insufficient to generate expert performance, and that category-specification must occur at a grain finer than the basic level (for instance, in bird training, subordinate category terms and family-level terms—'eastern screech owl' or 'wading bird'—are needed for significant expertise effects).[31] Similar features of training have been observed in experts trained in non-laboratory contexts. For example, radiologists receive explicit training, where success admits of degree and mere exposure provides no diagnostic advantage (for instance, x-ray technologists regularly exposed to but with no training in diagnostics for radiographic images, perform no better than laypersons).[32]

One should not infer from this, though, that the expert is just learning how to label things. First, as one can glean from the studies just discussed, not all labels make a difference in performance (basic-level labels do not). These results have been correlated with EEG results. The ERP component N250 has a typical onset latency between 230-330ms post-stimulus, and is standardly correlated with familiar or learned objects. For example, this activity in visual cortex spikes, at this temporal scale, in response to one's own face. What Scott et al. (2008) found was that this ERP activity results from training only when subordinate category information is learned, not with mere exposure or basic category training. For example, in car expertise training, changes in N250 response occurred only when subordinate level category training was involved (information about car make or model). So this suggests that subjects get the "familiarity response" in visual cortex only when they have learned categorical, domain-specific information (and again not as a consequence of mere exposure).

The Scott et al. studies also corroborated something that anecdotal evidence already suggests, namely, that expertise is stable across time and across novel task performance. Within their domain of expertise, experts can readily identify novel exemplars of objects in relevant categories,

[31] Tanaka et al. 2005. See also Gauthier and Tarr 1997 and Scott et. al 2008.

[32] Johnson and Mervis 1997.

and make fine discriminations between individuals within categories. Scott and colleagues trained subjects for car expertise, using subordinate category vs basic category only vs exposure only training structures. They then measured subjects' performance pre-training, immediately post-training, and one week post-training. Subjects trained on subordinate categories are the only subjects to make significantly successful discriminations, and this performance persists through the one week post-training measures. This performance correlates with an ERP effect: only the subordinate category training results in increased N250 response, and this also persists through the one week post-training measures. This suggests a lasting and stable perceptual sensitivity to features that are learned as distinctive of members of fine-grained categories. Further, these behavioural and neurological results generalize. Lab-trained experts successfully discriminate untrained (not previously viewed) exemplars within fine-grained categories of cars and birds and greebles. And this shows in further EEG results: both the N170 and N250 responses generalize to untrained exemplars of the trained categories (cars and birds).[33]

Finally, although expertise generalizes (to within-domain stimuli), it typically does not transfer to or from other perceptual domains. So, while one might be tempted to claim that these effects just derive from a general improvement of perceptual skill (say, sharpened attention or enhanced visual acuity), or a pre-expertise superior perceptual skill, various studies suggest otherwise. First, there is ample evidence that low-level perceptual learning rarely generalizes to other stimulus types.[34] Additional studies suggest the same for perceptual expertise. Nodine and Krupinski (1998) compared performance between expert radiologists and non-experts on complicated visual search tasks over non-radiographic images (*Where's Waldo* images and Hirschfield's *Nina* drawings). The radiologists perform no better than non-experts in these tasks. So the expert's skills appear not to transfer outside the domain of expertise.

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[33] Cars and birds: Scott et al. 2008. Greebles: Gauthier et al. 1998.

[34] Ahissar et al. 1998, Fiorentini and Berardi 1980, Poggio et al. 1992.

Again this diversity of data can be unified in an explanation. Here the question is whether perceptual expertise is genuine expertise: is it a learned, cognitive phenomenon? Sceptic 2 claims not: the effect is simply a development or low-level enhancement of perceptual systems. But this position poorly explains the array of studies and effects just discussed. Expert training, in and outside of laboratory circumstances, requires more than mere exposure to stimulus types (by contrast to many examples of low-level perceptual learning, such as colour discrimination). And it requires explicit uptake of domain-specific categories and information, where this training is effective (and the neural-physiological markers evident) only when the learned categories are fine-grained. Expertise is stable across time, once acquired, and generalizes to previously unperceived, novel exemplars of a category. Finally, these skills do not transfer to similarly complex perceptual tasks outside the domain of expertise. The simplest, most parsimonious explanation is that the effects *on* perception, in perceptual experts, depend in substantial ways on the specific conceptual content that is acquired over the cognitive learning period. The concluding *architectural claim 2* is that perceptual expertise is a genuinely cognitive phenomenon, dependent on the conceptual information of the domain of expertise. This explanation takes seriously the *expertise* in perceptual expertise.

III.3. Conclusion: Perceptual expertise as an epistemic good

The traditional picture of perception, traceable at least to Aristotle, is one of a passive faculty that provides purely stimulus-driven (re)presentation of the subject's present environment. More recent models of perception in cognitive science capture this same spirit. Most dominantly, modular theories of perceptual systems maintain that stimulus-driven, proprietary input is processed by, say, vision in a way that is informationally encapsulated from beliefs, goals, and other cognitive representations in the overall mental system. One explicit motivation for Fodorian modularity of this sort is that this kind of functional independence would better ensure reliable, accurate perceptual representation.[35] The analysis given in the previous two sections suggests a widespread challenge to this kind of cognitive architecture: cases of perceptual expertise are candidate counterexamples to the encapsulation required of strongly modular perceptual systems. One may then reason further that any such top-down cognitive influence on perception will be epistemically problematic, since this undermines the independence of (and, thereby, the reliable accuracy of) perceptual representation. This is the challenge of sceptic 3.[36]

Counter to this sceptical challenge, the conclusion here is that perceptual expertise is epistemically enhancing, not pernicious or downgrading. In many ways, this is just a straightforward extension of the two architectural claims, and their broadly empirical motivation, of III.1 and III.2. There the case was made that perception can change—neurophysiologically, representationally, phenomenologically—and in ways sensitive to domain-specific information, that is, to high-level cognitive learning. If successful, this provides the groundwork for a general epistemic claim. For a number of epistemological theories, the epistemic goodness of perceptual expertise comes easy.

What the data show, if they show nothing else, is that experts perform more accurately, more rapidly, with less cognitive effort, and in ways that present advantages for working memory. So expertise is an epistemic good simply because the expert is moving closer to an optimal cognitive stance on the world (or a part of it), where she can better acquire behaviourally relevant category and diagnostic information. This may not be the most richly normative epistemic model, but it stresses the informational connection between the cognitive background and perceptual performance of experts. The expert, whether in laboratory or real-world circumstances, undergoes a laborious training regimen, sometimes spanning years. And it is as a causal consequence of this deliberate, highly cognitive training, that the expert enjoys perceptual experiences rich in information that is missing in the novice's experiences (of domain-specific objects and stimuli). This information

[35] For discussion, see Stokes 2013, Stokes and Bergeron 2015, Silins 2016.

[36] Again, by analogy, this is especially salient in the cognitive penetration literature, where cognitive penetration of perception is dominantly discussed as a possible, epistemically worrying phenomenon.

is behaviourally relevant but not in idiosyncratic or egocentric ways. Whether the expert is diagnosing a cancerous tumour in a mammogram or making a fingerprint match, there are clear and standard conditions for accuracy. In this regard, expertise involves a kind of optimal *perceptual objectification* (Burge 2010), where the expert enjoys a capacity for attributing features to distal objects *and* where the features attributed are ones that, often, only the expert can recognize by *any* cognitive means. What's remarkable—epistemically remarkable—is that these informational patterns are picked up, seemingly automatically, by the perceptual systems of experts. Therefore, on marks of both accuracy and efficiency, the expert is cognitively optimal (or nearing it).

In a similar spirit, the epistemic value of perceptual expertise might be characterized in reliabilist terms. In ecologically valid circumstances (when objects are not inverted, misaligned, and so on), experts statistically, significantly perform better, and thereby form true beliefs with greater frequency, than novices. And this is true across the many and widely diverse domains of expertise studied. Put in old familiar terms of process reliabilism, perceptual expertise involves an enhancement to the already reliable process—perception—of forming beliefs about the world.[37] This leaves open precisely how perception is improved in these ways—for example, by enjoying richer contents or being subject to top-down attentional effects—while maintaining that the epistemic advantage is at least partly a perceptual one.

This reliabilist characterization can be extended, where the epistemic advantage is partly attributed to the expert as an epistemic agent. According to virtue epistemology, agents themselves rather than their doxastic states or commitments are the primary targets for epistemic evaluation. Agents are virtuous if and to the degree they exhibit intellectual virtues. And a cognitive disposition is virtuous just in case it is truth-conducive.[38] For the statistical reasons here discussed, experts acquire skills that are truth-conducive, and manifest these skills consistently in just the right

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[37] Goldman 1979.

[38] Sosa 1980, 2007; Greco 1999, 2009, 2010.

(domain-specific, ecologically sound) circumstances. In this regard, perceptual expertise is a perceptual skill, and one that is improved by agent-driven, accuracy enhancing, training. It is in this intellectual virtue that the epistemic value of expertise consists.

Each of these three sketches could be extended to provide full epistemologies of perceptual expertise. And additional accounts should be given for internalist and knowledge-first epistemologies. For now, a final conclusion returns attention to the objectivity that concerned modular theorists like Fodor, in connection with the final sceptical challenge to the present account (sceptic 3). Fodor's line of reasoning is that objective perceptual representation was a function of perceptual independence. Interference in perceptual processing by a perceiver's beliefs or goals or expectations would undermine that independence and so, by implication, would undermine objectivity of perceptual representation. And because perception is by and large accurate, Fodor reasons, it must be a computational system that is functionally independent of higher-level cognitive systems, ergo, modular. The account given above challenges Fodor's line of reasoning, but without giving up the accuracy upon which that line is premised. Surprisingly, this challenge is well-illuminated by considering a precursor of modularity: the supposed epistemic threat of *theory-ladenness* in philosophy of science.

A classic challenge to certain empiricist theories of scientific inquiry was that the scientist's perceptual observations (as well as, perhaps, her observational reports and language) may be influenced by her background theoretical commitments. The default assumption in much of the literature is that this theory-ladenness may be an epistemic flaw of the scientific enterprise. In fact, it is far from clear that this is supposed to be a pernicious epistemic consequence, at least if we go back to one of the original sources of the relevant philosophical discussion:

> Causes certainly are connected with effects; but this is because our theories connect them, not because the world is held together by cosmic glue. The world may be glued together by imponderables, but that is irrelevant for understanding causal explanation... The difference between generalizing the repeated occurrence of contiguous, propinquitous, asymmetric event pairs and understanding the 'causal' structure of a

> natural phenomenon is like the difference between having a visual impression of a lunaroid patch and observing the moon…
> [E]xperience and reflexion have given us good reason to expect a Y every time we confront an X. For X to be thought of as a cause of Y we must have good reasons for treating 'X', not as a sensation word like 'flash'..., 'bright',..or 'red', but rather as a theory-loaded, explanatory term like 'crater',... 'pendelum'... 'discharge'.
>
> N.R. Hanson, *Patterns of Discovery*, 1958

This is a challenge to certain logical positivist and empiricist accounts of scientific explanation. But it is not an invocation or implication of a sceptical worry. And to infer the second from the first is to mistake the nature of the critique made by Hanson and others. In this context, what was misguided about the strong empiricist model of science was that it assumed that scientific explanation is an entirely objective matter, and in the strongest sense of 'objective'. Scientific explanation on that account is a purely logical relation between claims, devoid of input from the scientist and her context of investigation: no psychology, no sociology, no imagination or creativity. These contextual features surely play a generative role, as a mode of discovering explanation, but they occupy no privileged place in explanation proper. Naturally, then, perceptual observation was supposed to be entirely theory neutral, providing raw sensory confirmation or disconfirmation of the premises that structure the explanatory argument. Hanson and Kuhn were leaders in the demolition of this broad philosophy of science but not, it is crucial to emphasize, in the sense that they inferred that science was thereby epistemically doomed, or even that it was non-objective.

Instead, and this is perfectly salient in the Hanson passages quoted above, the inference we are urged to make concerns the kinds of theoretical frameworks and backgrounds that are inseparable from scientific explanation. Hanson's profound suggestion is that this may go all the way down to perception, and the observations that we employ to support and challenge theories. And moreover, he is here suggesting that this is a good thing. Without these conceptual and theoretical tools, and influences on observation, scientific understanding is impoverished if not lost. Hanson's claim about causal understanding could not be clearer in this respect: to understand causal structure, the scientist needs more than mere observational terms and low-level sensation. She needs theoretical concepts. All the better, more optimal, if these are somehow laden into the scientist's fine-grained, perceptual observations.[39]

If the analysis of perceptual expertise given here is correct, then it is just a broader instance of the same kind of phenomenon—of theory laden perception—and one that involves more efficient, more sophisticated, and more accurate perceptual observation. This is not to abandon the objectivity that concerns philosophers of science, epistemologists, and modularists (even if it is tantamount to abandoning modularity). But it is to abandon, once more, the objectivity of the radical empiricism of the early and mid 20th century. This requires acknowledging that standards for accuracy within a scientific (or other) domain are not objective in a strict mind-independent sense. Those standards are instead sensitive to the inter-subjective, behaviourally relevant needs of trained individuals performing within the domain. In science, and in scientific observation, the view from nowhere is a rare exception, not the norm.[40] Perceptual accuracy can be conceived of the same way: as sensitive to the features and details of the world that suit diagnostic, categorical, and other behaviourally relevant needs. This is is not strict mind-independent objectivity, but neither is it egocentric or idiosyncratic: it is accuracy within a specialized domain. And this is precisely why genuine perceptual expertise is epistemically valuable. It enables more optimal uptake of needed task-specific information. And so it is no surprise that in some specialized domain or for some specialized task it is rational to, as we say, call on the experts. The lesson here is that one makes this call not just for what the experts know but for what they see.

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[39] This of course leaves standing various worries about bad science, pseudoscience, flawed experimental methods, and pernicious instances of theory-ladenness. The claim here is simply that theory-ladenness is not, by some kind of necessity, epistemically pernicious.

[40] This is a point familiar to feminist epistemology and philosophy of science, argued forcefully in the work of Helen Longino (1990; 2002).

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