Perceptual skills

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This chapter has four parts. I distinguishes some types of perceptual skills and highlights their importance in everyday perception. II identifies a well-studied class of perceptual skills: cases of perceptual expertise. III discusses a less studied possible instance of perceptual skill: picture perception. Finally, IV outlines some important mechanisms underlying perceptual skills, with special emphasis on attention and mental imagery.

1. **What are perceptual skills?**

Skills are abilities we can be better or worse at and that characteristically manifest in actions (Ryle 1949, Pavese 2016).[[1]](#footnote-1) Juggling skills are abilities related to keeping three or more balls in the air and we can be better or worse at this. Similarly, perceptual skills are abilities we can be better or worse at and that typically manifest in various perceptually guided actions. Here are some examples of perceptual skills: distinguishing pinot noir and cabernet sauvignon, spotting Waldo in the picture, and recognizing a dominant chord.

These examples may immediately raise eyebrows – are they really *perceptual* skills? Are they genuinely perceptual or are they post-perceptual cognitive skills? After all, however rich the concept of our perceptual experience may be, it clearly does not attribute properties like ‘dominant chord’ or ‘pinot noir’. So, the question is whether these skills are perceptual or cognitive (or, in some sense, both). Before we address this question, here are some more examples standardly given of perceptual skills (starting with the ones we mentioned in the first paragraph):

1. *Perceptual discrimination*: Distinguishing pinot noir and cabernet sauvignon is an example of this. Note that perceptual discrimination does not entail that we can conceptualize the stimuli perceptually discriminated. You may not know what pinot noir or cabernet sauvignon are but you could still reliably distinguish two kinds of red colored liquids by flavour or smell.
2. *Perceptual recognition*: Spotting Waldo and identifying a dominant chord are instances of recognition. Also, most of the examples in the perceptual expertise literature would fall under this heading: recognizing certain bird or plant species, recognizing an original Matisse, and so on. Perceptual skills of this kind (unlike (a)) require conceptualization of some sort.
3. *Picture perception:* Richard Wollheim often referred to picture perception ability as “the perceptual skills of seeing-in” (Wollheim 2003, p. 5). And there is a rich literature in art history about how perceptual skills of looking at pictures influence our experience of these pictures.
4. *Speech perception*: the perception of everyday speech is often also taken to be a form of perceptual skill. As Casey O’Callaghan writes: “the capacity to perceive speech in a manner that enables understanding is an acquired perceptual skill. It involves learning to hear language-specific types of ethologically significant sounds” (O’Callaghan 2015, p. 475)

How could we decide whether these skills would be perceptual or post-perceptual cognitive skills? None of these skills involve only the perceptual system. Recognition of Waldo requires knowing what Waldo looks like, and it leads to a belief that Waldo is hiding behind the garbage truck, and this leads to the action of pointing out Waldo. Restricting perceptual skills to skills that are performed by the perceptual system only would be nonsensical: the perceptual system does not do much by itself (not much that is observable, in any case).

We propose the following as a straightforward and not particularly controversial way of keeping apart perceptual and post-perceptual cognitive skills: if the perceptual system works in the same way in the case of two very different skills, it is not a perceptual skill. If having different skills entails that the perceptual system works differently during the execution of these skills, it is a perceptual skill. Remember that we defined perceptual skill as something the perceptual system does. If we have acquired a new perceptual skill, this implies that the perceptual system works differently.

Let’s consider the example of perceptual discrimination. Fingerprint experts can differentiate two very similar fingerprints quickly and reliably – in a way novices cannot. Before undergoing extensive forensic fingerprint training, the expert did not have this skill, after that training she did. If this change entails a change in the way her perceptual system works (and we know it does, see Busey and Parada 2010, Jarodska et al. 2010, see also Matthen 2015 for a philosophical summary), then this perceptual discrimination skill is a genuine perceptual skill.

One may worry that by identifying perceptual skills with the help of the changes in the functioning of the perceptual system, we have not made real progress, as it is notoriously unclear where perceptual processing ends and cognitive processing begins (see Teufel and Nanay 2017 for a summary). However, we can use the outlined way of identifying perceptual skills in a pro tanto manner. Some parts of mental processing are very clearly perceptual: it is uncontroversial that processing in the primary visual cortex, in V4/V8 or in MT is perceptual processing. So if it turns out to be the case that changes in a skill entail changes in these cortical areas, then the skill in question is unquestionably a perceptual skill. The examples in (a), (b) and (c) are unequivocally perceptual skills according to these criteria (example (d) is a bit less unequivocal (see, e.g., O’Callaghan 2011), so we leave the discussion of it for another occasion).

**II. Perceptual expertise**

Empirical research on perceptual expertise can mostly be traced to research on face perception in the 1990s. With certain qualifications, all humans with normally functioning vision are expert face perceivers. By contrast to equally complex visual stimuli, we are extremely adept at both discriminating and recognizing individual faces.[[2]](#footnote-2) Research on this undeniably perceptual phenomenon has led to research in specialized domains—from birds to cars to fingerprints to radiographic images—and whether and how individuals can become experts at perceiving objects within those domains.[[3]](#footnote-3) That these experts are better at domain-specific tasks is uncontroversial. But an interesting question concerns whether that performance is partly constituted by better perceptual performance. Perceptual experts are thus plausible candidates, and a useful **testbed,** for possession of exceptional perceptual skills.

Behavioural measures for expertise typically concern diagnostic or otherwise categorization tasks. Thus the radiologist is asked to identify tumors in sometimes rapidly presented mammograms; a fingerprint examiner is asked to identify a target fingerprint in an array. Expert birdwatchers or dog show judges are asked to make fine-grained category-sensitive discriminations, as well as recognize previously viewed individuals. One robust finding across these disparate domains is an “entry-level shift”: as expertise is acquired, the category invoked for various tasks shifts from basic (e.g. bird) to subordinate (e.g. kingbird) or sub-subordinate (e.g. eastern kingbird) (Tanaka and Taylor 1991). These experts, within their domains, perform both more accurately and more rapidly. For example, expert radiologists can, above chance, identify an anomaly in a radiographic image in 200ms (Evans et al. 2013). Subjectively, these subjects report pop-out visual phenomenology, often claiming to “just see” the relevant item, performing without felt cognitive effort.

More complicated behavioural measures highlight this apparent automaticity, and corroborate subjective reports. Interference effects suggest that the expert enjoys more holistic perceptual processing of objects of expertise, where incongruence between an irrelevant-to-task object component (e.g. the bottom half of an object) interferes with rapid judgments about the relevant-to-task object component (e.g. the top half of an object). This effect is modulated by alignment of the two components (experts suffer less interference from the irrelevant object half when it is misaligned with the target object half), and this does not occur in non-experts (Richler et al. 2011). Experts are more sensitive to spatial changes between features than stand-alone featural changes (Bukach, Gauthier, and Tarr 2006). And experts, but not non-experts, suffer inversion effects. For example, performance on dog or car identification is significantly hindered in the dog show judge and car expert, respectively, but not the novice, when images of dogs or cars are perfectly inverted (Diamond and Carey 1986; McKeef et al. 2010). The explanation for these effects is that experts rely on holistic, configural processing of objects of expertise and this is what is thwarted by stimulus inversion. All of these effects are found in lab-trained experts for artificial lab-created classes of objects, for example, with “Greebles”. Here subjects undergo a training period after which they can make fine-grained categorical and individual-level judgments, where behavioural performance enjoys all the same markers: interference effects, greater sensitivity to configural features, inversion effects. This paradigm allows researchers to follow the behavioural trajectory of expertise acquisition, and further clarify some of their neural-physiological correlates (Gauthier et al. 1998).

A standard EEG measure for face perception is the N170 ERP component: this component responds at higher amplitudes, 150-200ms post-stimulus onset, to faces. Across a variety of domains, and for both “real-world’ and lab-trained experts, researchers find an enhanced N170 response for experts (Tanaka and Curran 2001; Busey and Vanderkolk 2005; Rossion et al 2002). Another standard, but relevantly controversial, neural measure for face perception is activity in the FFA and the OFA. Here again researchers find enhanced FFA and OFA activity for experts when viewing objects of expertise, and this is true for natural objects (birds), artificial objects (cars), and lab-created artificial objects (Greebles)( Gauthier et al. 1999, Gauthier et al. 2000). Eye tracking measures reveal distinctive saccadic eye movement and fixation patterns for experts, again relative to their domain of expertise, from radiologists to persons with training in the visual arts (Kundel et al. 1972; Vogt and Magnussen 2007). Although there is space for (and is) debate in the vicinity, these neural and physiological patterns are taken by relevant empirical scientists to correlate with visual experience and/or visual attention. So while they may not serve, in isolation, as conclusive evidence, they converge with the behavioural measures discussed just above and in a way that makes a strong case: perceptual expertise is a genuinely perceptual phenomenon involving enhanced, domain-sensitive perceptual skill.

In the face of this convergence of data, one may still wonder how or whether any such skills are grounded in cognitive learning or experience. Maybe perceptual experts just enjoy some kind of low-level perceptual enhancement or development, or perhaps they entered into a domain having already possessed a higher degree of perceptual acuity. Both interpretations, however, are easily dispelled: acquisition of expertise is highly sensitive to the information and category-information within that domain, and does not transfer to similarly complex extra-domain performance. Researchers find that regular, mere exposure to a stimulus type does not suffice for behavioural success (e.g. identifying a tumor in a mammogram), and moreover that achievement and persistence of task success (and neurological changes that correlate with that success) require both explicit feedback, and learning of subordinate-level categories (e.g. the make and model of a car)(Scott et al. 2008). And while expertise generalizes to discrimination of novel exemplars within the domain of expertise (Gauthier et al. 1998), experts perform no better at equally complicated perceptual tasks, such as visual search over complicated images (e.g. Where’s Waldo puzzles) (Nodine and Krupinski 1998).

Perceptual expertise is thus a well-studied example, perhaps an extreme case of, perceptual skill. As a result of domain-specific, cognitive learning, the perceptual systems of experts plausibly work differently.

**III. Picture perception**

We want to spend some more time on (c), on the perceptual skills involved in picture perception, for two reasons. First, these perceptual skills are very widely discussed not just in philosophy of mind or in philosophy in general, but also in art history, film studies, cultural studies and a number of other disciplines. The second reason is that most alleged reasons for taking (c) to be a perceptual skill are based on phenomenology, which leads to some methodological complications, as we shall see.

A good starting point for discussing perceptual skills of kind (c) is the history of vision debate. A recurring theme in art history, film studies, cultural studies and related disciplines is that vision has a history. Hence, understanding the art of foregone ages requires understanding how people in these ages perceived art. This idea was very central to the German formalist tradition (Riegl 1901/1985, Wölfflin 1915/1932) but it is also an important premise of recent post-formalist art history (Summers 2003, Davis 2011, 2015, see also Nanay 2015).

There are stronger and weaker versions of this history of vision claim. According to the stronger version (Riegl 1901/1985, Benjamin 1936/1969), our vision of anything and everything has a history: medieval people saw a birch tree or the Moon differently from the way we do. A more modest version of the history of vision claim is that our perception of pictures has a history (Wölfflin 1915/1932, Baxandall 1972). So when our ancestors looked at a birch tree or the Moon, their visual experience was the same as ours. But when they looked at a painting, their experience was very different from ours when we are looking at the very same painting. What is of interest for the purposes of this paper is the more modest (and less problematic) version.

If vision has a history, what is it really that changes in the course of history? Presumably not the retinal stimulation or the way in which retinal stimulation is transmitted to the lateral geniculate nucleus. But then what? A number of different philosophers and art historians independently suggested that what changes is the set of perceptual skills people have. When people looked at a painting in the 15th century and when we do it now, the retinal stimulation is the same. But we have different perceptual skills and as a result, our perceptual phenomenology is also different. Some versions of this general claim have been held by Ernst Gombrich, Michael Baxandall, David Bordwell and Tom Gunning (Gombrich 1960, Baxandall 1972, Bordwell 1997, Gunning 1986).

Michael Baxandall’s version is the most developed. Baxandall did extensive research on various texts from 15th century Italy about how observers at that time looked at pictures. His conclusion is that the visual skills of 15th century Italian observers were very different from ours and as a result their experiences were also different (they included, for example, the visual skill of volume estimation as well as of recognizing various dance moves).

Baxandall coined the term ‘period eye’ to refer to this phenomenon (Baxandall 1972, p. 29), but he is very clear that it is the visual skills that change, not the retinal image. Tom Gunning has a very similar argument about the history of the perception of film. He argues that there was a radical change in the way people perceived films around 1908 as a result of the emergence of montage, which made people develop very specific visual skills that allowed them to piece the different intercut scenes together. They did not have these skills before, and the acquisition of these skills changed their phenomenology significantly.

Baxandall and Gunning took these skills that vary in history to be visual skills. But what makes them visual? It seems that their main evidence is phenomenological: having these skills makes a difference in our perceptual phenomenology – not our non-perceptual (say, cognitive) phenomenology. Noel Carroll has a structurally very similar solution to understanding how our experience of artworks may have changed throughout history, one that does not allow for the history of vision (Carroll 2001).

According to Carroll what changes are our skills, but not our visual skills. He makes a distinction between seeing and noticing and argues that noticing changes in the course of history whereas seeing does not (Carroll 2001, p. 15). Carroll takes noticing to be a post-perceptual process, hence, vision itself does not have a history. And as noticing is a **skilful** activity, this would be a view according to which picture perception involves not perceptual but cognitive skills (and it is these cognitive skills that change).

All of this raises a crucial question: how can we decide whether the skill involved in picture perception is perceptual or post-perceptual/purely cognitive? We do not think that the traditional reliance on perceptual phenomenology is decisive here, as it is notoriously difficult to settle disagreements about what kind of phenomenology would count as perceptual (Siegel 2006, Bayne 2009, Nanay 2012). Luckily, we have a wide range of experimental findings about how the different pictorial perception skills involve different behavioural patterns.

One particular study compared performance of trained visual artists and non-artists (Kozbelt 2001). Tasks included both an array of drawing tasks, as well as visual tasks—identifying a depicted object in out-of-focus pictures, gestalt completion tasks, mental rotation tasks. Not surprisingly, the artists perform better than the non-artists on the drawing tasks. More surprisingly, they also perform better than non-artists on all the strictly visual tasks, and performance here positively co-varies with drawing skill. Given that these are tasks that require specific performance for success—for example, rotating a geometrical figure in mental imagery to determine if it is the same or different from a target image—it is less natural to describe the artist’s performance as mere noticing.

Further, different pictorial perception skills also involve different patterns of eye movements (Vogt and Magnussen 2007). The eye movement patterns of art experts when they look at a novel picture are very different from eye movement patterns of novices. Novices tend to look at the most salient features of the picture – for example a central figure or a face. The eye movements of art experts, in contrast, are much more distributed and involve longer saccades. Whatever one thinks about perceptual phenomenology, eye movement is something the visual system does – so different patterns of eye movements would be an indicator that the skills involved are perceptual skills (and not cognitive skills).

**IV. The mechanisms of perceptual skills**

We said that perceptual skills are abilities of the perceptual system that we can be better or worse at. But how does one get better at these perceptual skills? In some cases, especially cases of expertise, explicit or implicit effort is involved. The perceptual skills of the fingerprint expert get better as a result of repeated trying.

Is repeated trying a necessary condition on acquiring perceptual skills then? Mohan Matthen thinks so, when he characterizes skills in general as “abilities that are acquired by repeated trying” (Matthen 2015, p. 184). Hence, perceptual skills would come out as perceptual abilities that are acquired by repeated trying. We consider this characterization far too strong. Many perceptual skills are not acquired by repeated trying. One can come to have the perceptual skill of differentiating between pinot noir and cabernet sauvignon by being exposed to the two substances a lot, without trying to categorize them in any way whatsoever.

And the same is true of some of the perceptual skills in picture perception. Some perceptual skills are acquired as a result of extensive training or repeated trying. In the empirically studied cases of expertise, exposure appears to be insufficient for expert perceptual performance. But some other perceptual skills are acquired as a result of mere exposure. This just highlights that not all cases of perceptual skill are cases of perceptual expertise (see Matthen 2015). Accordingly, we could weaken Matthen’s way of characterizing skills in general and perceptual skills in particular as ‘abilities that are acquired by repeated trying or exposure’.

We have considered some examples of perceptual skills and argued that they are in fact perceptual. But what are these perceptual skills – what does the perceptual system do that could be considered to be the basis of these perceptual skills? Of the many activities involved, we will focus on two particularly important ones, attention and the forming of mental imagery.

As discussed in the previous section, one thing that we know changes with the acquisition of a perceptual skill is eye movement patterns. This is true of radiologists, and it’s true of people with training in the visual arts. The eye movement patterns of art experts when they look at a novel picture are different from eye movement patterns of novices.

It is important not to confuse eye movements with attention. We can shift our attention without moving our eyes – this is called a covert shift of attention. So even if your eyes are fixating on the same point, you could move your attention around. As a result, we need to be careful in interpreting these results about eye movements in order to talk about the role of attention in perceptual skills.

Nonetheless a straightforward explanation for the differences in eye movements between experts and novices is that they allocate their attention differently (Connolly 2014). And this should not really come as a surprise. What you attend to will often depend on what you know (or value or expect or intend to find, and so on). If you know that Waldo is dressed in red and white stripes, you attend to those parts of the picture where there are red and white stripes. This consists not in a difference in moving a “spotlight” of attention, but of certain behaviourally relevant features being highlighted or made more salient—the red and white stripe-y ones. Feature or object-based attention of this kind is importantly modulated by higher-level cognition. The ignorant viewer of the Where’s Waldo puzzle will not experience attentional selection of red and white stripe-y things; those features pop-out only if one has some belief or understanding that Waldo’s features are the target of one’s visual search). Analogously, experts in various domains, from fingerprints to radiology to visual art, know more about the task at hand than novices. Just like the compliant Where’s Waldo puzzler, the expert’s attention is informed by these pieces of knowledge, whereas the novice’s is not.[[4]](#footnote-4) And this different allocation of attention is what explains the different eye movement patterns.

Perceptual attention is a genuine perceptual phenomenon. We can be better or worse at attending to a specific kind of perceptual stimulus. Sometimes it is an action in the philosopher’s sense: behavior appropriately captured by at least one description that requires attribution of an intention to the agent. In other words, it can be something we *do* as psychological agents. But it is also something that can be done by our perceptual systems, without our intending or trying, even if it depends upon personal-level states or attitudes. What is crucial is that enhancement of either controlled or automatic attention varies with what we have done as agents: what we have learned about a domain like radiology or art or ornithology. In such cases, we are partly responsible for the etiology of the acquired perceptual skill, even if that skill sometimes deploys automatically. In this regard, attentional differences that come with expertise are attributable to the agent and so are, in this regard, skillful. So attending can be a skill – a perceptual skill.[[5]](#footnote-5)

The other mediator of perceptual skill is less obvious: mental imagery. Closing your eyes and visualizing an apple is a form of exercising your mental imagery. But so is looking at a floor plan and visualizing the building, or looking at a patient’s body and visualizing their inner organs.

Conjuring up mental imagery is something we do. As in the case of attention, often forming mental imagery is an action in the literal philosophical sense – we count to three and visualize an apple. And we know a fair amount about the mechanisms of how we form mental imagery – how this happens in very early perceptual areas – as early as the primary visual cortex (Kosslyn et al. 1995, Pearson et al. 2015, see also Nanay 2018, forthcoming). And mental imagery is something we can be better or worse at. When architects see a floor plan, they can have mental imagery of the building that is much more detailed and much more accurate than the novice’s. And training mental imagery can help surgeons be more precise with their procedure (Sanders et al. 2004, 2008, Immenroth et al. 2007).

So, forming mental imagery is something we do and do with varying degrees of success. In short, it is a skill. And it is a perceptual skill as the processes involved in creating mental imagery are low-level perceptual processes (see the references above as well as Tartaglia et al. 2009). Forming mental imagery is a perceptual skill and mental imagery also underlies other perceptual skills (like the architect’s skills of getting a sense of the spaciousness of a building on the basis of a floor plan or the surgeon’s skill of finding the right place to cut the skin).

Attention and mental imagery often interact. The architect’s attention is at least partly driven by what she visualizes and vice versa, mental imagery is constructed by perceptually attending to some features and ignoring others and forming images on the basis of those materials. And while they are two important mechanisms of perceptual skills they are by no means the only ones.

Importantly, both attention and mental imagery can be and often are sensitive to top-down information (see Mole 2015, Teufel and Nanay 2017, Stokes 2013, 2018). And, as we have seen in II, the same is true of some of the remarkable cases of perceptual skill—perceptual expertise cases—: they are also highly dependent upon the semantic and categorical information specific to the domain of expertise. Therefore, at least some perceptual skills are causally dependent upon non-perceptual mechanisms, whatever mechanisms allow experts to learn category information, diagnostic goals, and relevant technologies. Hence, whatever perceptual mechanisms are responsible for these perceptual skills, be it attention or mental imagery or something else, these skills are also causally dependent on our knowledge, belief and other cognitive states.

**Conclusion.**

We conclude with provocation for future research. Although not widely discussed, perceptual skills are no mere peripheral aspect of human perception, and so should be no mere niche market for philosophical and cognitive scientific theories of perception. This is true for at least two reasons.

The first concerns experience: perceiving the world skillfully is plausibly to experience it differently. What it’s like to perceive an impressionist painting, or a mammogram, or an Eastern screech owl is different for one who is skilled in these domains, by contrast to one who is not. This is a point about phenomenology, but not only a point about phenomenology. We have identified plausible mechanisms—attention and mental imagery—that contribute generally to the phenomenology of perception and would do so no less in cases of perceptual skill. Empirical researchers have identified physiological and neural differences between experts and novices that, again, would make a difference in the functioning in perceptual processing and so, when taken together, imply differences in experience.

The second reason is epistemic. To acquire a perceptual skill is to actively engage and navigate one’s environment, and sometimes to do so with expert levels of success. This highlights both how perception is active, and how it can be improved. And importantly, in many of the cases discussed, the improvement is a credit to the perceiving agent: it is something that the skilled or expert perceiver *does* (or a result of training she has done). Perceptual skills are thereby epistemic virtues; they are truth-conducive dispositions, either acquirable or improvable *by the agent* and, thereby, values attributable to the agent. Surprisingly, the philosophy of perception talks very little about potential for perceptual improvement, but an emphasis on perceptual skill reveals that, and how, we can become better perceivers.

Our view is that these reasons, among others, yield a prescription: we can’t achieve a rich understanding of how we perceive the world without understanding perceptual skills.

**References:**

Baxandall, Michael 1972 *Painting and Experience in Fifteenth Century Italy*. Oxford: Oxford University Press.

Bayne, Tim 2009 Perception and the reach of phenomenal content. *Philosophical Quarterly* 59: 385-404.

Benjamin, Walter 1936/1969 The Work of Art in the Age of Mechanical Reproduction, *Illuminations*, trans. Harry Zohn. New York: Schocken Books.

Bordwell, David 1997 *On the history of film style*. Cambridge, MA: Harvard University Press.

Buckach, C.M., Gautheir, I., and Tarr, M.J. 2006. Beyond faces and modularity: the power of an expertise framework. *Trends in Cognitive Science* 10(4): 159-66.

Busey, T. A., & Vanderkolk, J. R. 2005. Behavioral and electrophysiological evidence

Busey, Thomas A. and Parada, Francisco J. 2010. The Nature of Expertise in Fingerprint Examiners. *Psychonomic Bulletin and Review* 17: 155-160.

Carroll, Noel 2001c Modernity and the plasticity of perception. *Journal of Aesthetics and Art Criticism* 59: 11-17.

Connolly, K. 2014 Perceptual learning and the contents of perception. *Erkenntnis* 79: 1407-1418.

Danto, Arthur C. 2001a “Seeing and showing”. *Journal of Aesthetics and Art Criticism* 59: 1-9,

Danto, Arthur C. 2001b “The pigeon within us all”. *Journal of Aesthetics and Art Criticism* 59: 39-44

Davis, Whitney 2001 Arthur Danto and the historicity of the eye. *Journal of Aesthetics and Art Criticism* 59: 29-38

Davis, Whitney 2011 *A General Theory of Visual Culture*. Princeton: Princeton University Press.

Davis, Whitney 2015 Succession and recursion in Heinrich Wölfflin’s *Kunstgeschichtliche Grundbegriffe* *Journal of Aesthetics and Art Criticism*, 73:

Diamond, R. and Carey, S. 1986. Why faces are and are not special: an effect of expertise. *J. Exp. Psychol. Gen.* 115: 107–117

Evans, K.K., Georgian-Smith, D., Tambouret, R., Birdwell, R.L., Wolfe, J.M. 2013. The gist of the abnormal: above-chance medical decision making in the blink of an eye. *Psychonomic bulletin & review* 20.6: 1170-1175

for configural processing in fingerprint experts. *Vision Research* 45: 431–448.

Gauthier, I., Skudlarski, P., Gore, J.C., and Anderson, A.W. 2000. Expertise for cars and birds recruits brain areas involved in face recognition. *Nature Neuroscience* 3(2): 191-197.

Gauthier, I., Tarr, M. J., Anderson, A. W., Skudlarski, P., & Gore, J. C. 1999. Activation of the middle fusiform “face area” increases with expertise in recognizing novel objects. *Nature Neuroscience* 2: 568-573.

Gauthier, I., Williams, P., Tarr, M., and Tanaka, J. 1998. Training ‘greeble’ experts: a framework for studying expert object recognition processes. *Vision Research* 38: 2401-2428.

Gombrich, Ernst 1960/1972 *Art and Illusion*. Princeton University Press.

Immenroth M, Burger T, Brenner J, Nagelschmidt M, Eberspacher H, Troidl H 2007 Mental training in surgical education: a randomized controlled trial. *Ann Surg* 245: 385–391

Jarodzka, Halszka, Schieter, Katharina, Gerjets, Peter, and van Gog, Tamara 2010. In the Eyes of the Beholder: How Experts and Novices Interpret Dynamic Stimuli. *Learning and Instruction* 20: 146-54.

Karni, A., & Sagi, D. (1993). The time course of learning a visual skill. *Nature*, 365(16 Sept), 250-252.

Karni, A., Tanne, D., Rubenstein, B. S., Askenasy, J. J. M., & Sagi, D. (1994). Dependence on REM sleep of overnight improvement of a perceptual skill. *Science*, 265(29 July 1994), 679-682.

Kosslyn, S. M., Behrmann, M., & Jeannerod, M. (1995). The cognitive neuroscience of mental imagery. *Neuropsychologia*, 33, 1335-1344.

Kosslyn, S. M., Behrmann, M., & Jeannerod, M. (1995). The cognitive neuroscience of mental imagery. *Neuropsychologia*, 33, 1335-1344.

Kozbelt, A. 2001. Artists as experts in visual cognition. *Visual Cognition*, 2001, 8 (6)705–723

Kundel, H.L., and La Follette, P.S. 1972. Visual search patterns and experience with

Matthen, M. 2015 Play, skill, and the origins of perceptual art. *British Journal of Aesthetics* 55: 173-197.

McKeeff, T., McGugin, R., Tong, F., and Gauthier, I. 2010. Expertise increases the functional overlap between face and object perception. *Cognition* 117(3): 355-60.

Meissner, C.A. and Brigham, J.C. 2001. Thirty years of investigating the own-race bias in memory for faces: A meta-analytic review. *Psychology, Public Policy, and Law*. 7(1): 3-35.

Mole, C. 2015. Attention and cognitive penetration. In J. Zeimbekis and A. Raftopoulos (Eds.) *The Cognitive Penetrability of Perception: New Philosophical Perspectives*. (pp. 213-38). Oxford: Oxford University Press.

Nanay, Bence 2012b Perceptual Phenomenology. *Philosophical Perspectives* 26: 235-246

Nanay, Bence 2015 The history of vision. *Journal of Aesthetics and Art Criticism*, 73: 259-271.

Nanay, Bence 2018 Multimodal mental imagery. *Cortex*, in print

Nanay, Bence forthcoming. *Seeing Things You Don’t See*. Oxford: Oxford University Press.

Nodine, C.F. and Krupinski, E.A. 1998. Perceptual skill, radiology expertise, and visual test performance with NINA and WALDO. *Academic Radiology* 5: 603–612.

O’Callaghan, C. 2011, “Against hearing meanings,” *Philosophical Quarterly*, 61: 783–807.

O’Callaghan, C. 2015 Speech perception. In: Mohan Matthen (ed.), *The Oxford Handbook to Philosophy of Perception*, Oxford: Oxford University Press.

Parr, W. V., Heatherbell, D., & White, K. G. (2002). Demystifying wine expertise: Olfactory threshold, perceptual skill and semantic memory in expert and novice wine judges. *Chemical Senses*, 27, 747–755.

Pavese, Carlotta. 2016. “Skill in Epistemology 1: Skill and Knowledge.” *Philosophy Compass* 11:642-649.

Pearson, Joel, Thomas Naselaris,Emily A. Holmes,and Stephen M. Kosslyn 2015 Mental Imagery: Functional Mechanisms and Clinical Applications. *Trends in Cognitive Sciences* 19: 590-602.

radiological images. *Radiology* 103(3): 523-28.

Richler, J., Wong, Y., and Gauthier, I. 2011. Perceptual expertise as a shift from strategic interference to automatic holistic processing. *Current Directions in Psychological Science* 20(2): 129-34.

Riegl, Alois 1901/1985 *The Late Roman Art Industry*. Rome: Giorgio Bretschneider Editore.

Rossion, B., Gauthier, I., Goffaux, V ., Tarr, M.J., and Crommelinck, M. 2002. Expertise training with novel objects leads to left-lateralized facelike electrophysiological responses. *Psychological Science* 13: 250 – 257.

Ryle, Gilbert. 1949. *The Concept of Mind*. Chicago: University of Chicago Press.

Sanders CW, Sadoski M, Bramson R, Wiprud R, Van Walsum K 2004 Comparing the effects of physical practice and mental imagery rehearsal on learning basic surgical skills by medical students. *Am J Obstet Gynecol* 191:1811–1814

Sanders CW, Sadoski M, van Walsum K et al. 2008 Learning basic surgical skills with mental imagery: using the simulation centre in the mind. *Med Educ* 42:607–612

Scott, L. (2011). Face Perception and Perceptual Expertise in Adult and Developmental Populations. In A. Calder, G. Rhodes, M. Johnson & J. Haxby (Eds.), *Oxford Handbook of Face Perception* (pp. 195-214) Oxford: Oxford University Press.

Siegel, Susanna 2006 Which properties are represented in perception? In T. Gendler & J. Hawthorne (Eds.), *Perceptual Experience* (pp. 481-503). Oxford: Oxford University Press.

Stokes, D. 2013. Cognitive penetrability of perception. *Philosophy Compass* 8(7) 646-663.

Stokes, D. 2018. Attention and the cognitive penetrability of perception. *Australasian Journal of Philosophy* 96(2): 303-18.

Stokes, D. forthcoming a. On perceptual expertise. *Mind & Language*.

Stoke, D. forthcoming b. *Thinking and Perceiving*. London: Routledge.

Summers, David 2003 *Real Spaces*. London: Phaidon.

Swensson, R. G. (1980). A two-stage detection model applied to skilled visual search by radiologists. *Perception and Psychophysics*, 27(1), 11-16.

Tanaka , J.W. and Curran, T. 2001. A neural basis for expert object recognition. *Psychological Science* 12(1): 43-47.

Tanaka, J. W. and M. Taylor 1991 Object categories and expertise. *Cognitive Psychology*, 23(3), 457–482.

Tartaglia, E. M. ,L. Barnert, F. W Mast and M. H. Herzog 2009 Human perceptual learning by mental imagery. *Current Biology* 19: 2081-2085.

Teufel, Christoph, and Bence Nanay. 2017. “How to (and how not to) think about top-down influences on perception.” *Consciousness and Cognition* 47: 17-25

Vogt, Stine and Svein Magnussen 2007 Expertise in pictorial perception: eye-movement patterns and visual memory in artists and laymen. *Perception* 36: 91-100.

Wölfflin, Heinrich 1915/1932 *Principles of Art History*. New York: Dover

Wollheim, R. 2003 In defense of seeing-in. In: Hecht, H., Schwartz, R., & Atherton, M. (eds.). (2003). *Looking into Pictures: An Interdisciplinary Approach to Pictorial Space.* Cambridge, MA: MIT Press, pp. 3-16.

1. Some philosophers insist that the actions skills typically manifest in must be an *intentional* action (see Ryle 1949, p. 33 for the locus classicus). We want to leave open the possibility that skills manifest in non-intentional actions. A more thorough discussion of this point would lead to a detailed treatment of the distinction between intentional and non-intentional actions, which is not something we can do here. [↑](#footnote-ref-1)
2. The important qualification is this. While individuals within a race are exceptional (relative to other similarly complex stimuli) at recognizing, identifying, and recalling individual faces from within their “same race” or their “ingroup”, subjects fail or frequently err along the same measures with respect to “cross race” our “outgroup” faces. See Meissner and Brigham 2001 for a review piece. [↑](#footnote-ref-2)
3. Particular studies are cited below. For two review pieces, see Bukach, Tarr, and Gauthier 2006, and Scott 2011. For philosophical analysis, coupled with empirical review, see Stokes, forthcoming a. [↑](#footnote-ref-3)
4. Given the variety of domains of possible perceptual expertise and skill, and the variety of tasks and stimulus types that comes with those domains, we want to be pluralist about the kind of knowledge involved. Sometimes an expert will enjoy relevant propositional knowledge (knowing *that* a target stimulus has such-and-such features); sometimes an expert will enjoy relevant procedural knowledge (knowing *how* to distinguish one individual from another). Very plausibly, many cases of expertise will involve both. [↑](#footnote-ref-4)
5. Indeed, one may go further and characterize some cases of perceptual skill as exceptional cases of intellectual (and, therefore, epistemic) virtue. See Stokes, forthcoming b. [↑](#footnote-ref-5)