CRITICAL NOTICE

Perception, Flux and Learning

Casey O'Callaghan

1. Perceptual learning

Kevin Connolly's *Perceptual Learning* departs from paradigms in philosophy and cognitive science that treat perception in typical human beings as relatively fixed and unchanging.[1] Connolly argues instead that perception can be altered over time by training, deliberate practice or mere exposure. If so, we do not all bring to a scene the same stock of perceptual capacities, and our differences are not just deficits or superpowers.[2]

According to Connolly, expert birders are not just quick to spot a wren, they perceive wrens differently from novices. Experts see patterns of features and discern differences novices miss. Radiologists know more about tumours, but they also see x-rays differently. Their saccades are bigger and fewer, and they take in radiographic images more holistically. Trained experts quickly and accurately notice irregularities that medical students miss. Even participants who spend time in an experimental task sorting artificial objects called 'Greebles' into families improve substantially and become visually sensitive to relevant diagnostic features.

Specialists with esoteric skills or training are not alone. Commonplace speech perception changes as one learns a language. Speech in a language you know sounds different from speech in an unfamiliar language. Familiar speech appears segmented, containing neat gaps and pauses between words and phrases. In hearing unfamiliar speech, the sounds blend seamlessly together into a continuous stream. With familiar speech, one is sensitive to fine-grained qualitative differences, such as the difference between /l/ and /r/, or /p/ and /p^{h}/, which other perceivers miss. Notably, very young infants respond to the many acoustical differences that mark distinct phonemes in any world language. By about 5 months, they no longer differentiate acoustical differences that are not semantically significant to their language (Jusczyk 1997). In doing so, they become sensitive perceptually to the sound types that mark meanings in their language. With experience and practice, they learn to hear its sounds. If speech perception relies on perceptual learning, perceptual learning is widespread.

1 Kevin Connolly, *Perceptual Learning: The Flexibility of the Senses*, Oxford: Oxford University Press, 2019. xiv + 245 pp.

2 More recently, Chudnoff (2021) and Stokes (2021) add to this emerging trend.

Analysis Vol. XX | Number XX | XX 2022 | 1–11 doi: https://doi.org/10.1093/analys/anac040

2. *The offloading view*

Perceptual Learning offers a substantive account of the nature, varieties, and purpose of perceptual learning. Connolly calls it 'The Offloading View.' The Offloading View has three main components. First, Connolly defends an account of the nature of perceptual learning according to which it involves *a long-term change in perception that is due to experience and practice* (Chapter 1). This characterization serves to differentiate perceptual learning from nearby phenomena. Since it requires a long-term change, perceptual learning is distinct from synchronic cognitive influences on perception, such as cognitive penetration (Chapter 7). Perceptual learning also contrasts with short-term changes in perception due to mere adaptation, which is transient. Moreover, since the change must occur in perception itself, perceptual learning effects are not explained by changes in recognition, judgment or skillful action, each of which could improve performance without altering perception (Chapter 2). Finally, since it depends on experience and practice in a specific domain, the change that takes place in perceptual learning does not just stem from a typical developmental trajectory.

Second, Connolly describes three distinct varieties of perceptual learning. The first is *differentiation*, in which stimuli a perceiver cannot discriminate later become discriminable. For instance, certain temporal and qualitative features of perceptible speech become discriminable as speakers learn a language (Chapter 6). A perfumer might differentiate scents the rest of us cannot tell apart. The second is *unitization*, in which distinct discriminable stimuli come to be treated as a single perceptible item or category. For instance, Connolly claims that multisensory binding unitizes objects across modalities (Chapter 5). A collision you see might perceptibly form an individual unit with sounds you hear. Attributes also may be unitized. Speech sounds that differ acoustically may come to be perceived to have a common phonological feature. The third is *attentional weighting*, in which attention becomes differently distributed over a range of perceptible features (Chapters 3 and 4). For instance, one may attend to semantically significant features of speech, to crossmodal correspondences in multisensory perception, or to diagnostic feature configurations in seeing a wren or a Greeble, thanks to experience and learning. Notably, Connolly denies perceptual learning enables perception of natural kind properties (Chapter 3).

Third, Connolly maintains that perceptual learning has a distinctive function. According to the Offloading View, perceptual learning serves to *offload* demanding tasks from cognition to perception, thereby freeing up resources (Chapter 1). In performing a task that would be slow and resource-intensive for cognition, perception lightens the load and enables cognition to do other work.

3. *Six questions prompted by the Offloading View*

This characterization invites six questions that challenge the Offloading View of perceptual learning.

(1) DURATION. Connolly's Offloading View (hereafter, 'Offloading') says perceptual learning involves a *long-term* change. This distinguishes it from mere adaptation and synchronic cognitive influences.

What precludes short-term perceptual learning?

Consider the following scenario. Suppose you quickly internalize a perceptible environmental regularity by means of learning. For instance, during the duration of a study, you come to treat two perceptible features, such as a flash and a pip, as correlated, and you gain a response time advantage for detecting their conjunction. But this decays quickly, in a way that matches typical learning and forgetting curves.

There is evidence for such short-term effects. Odegaard et al. (2017) demonstrate short-term changes in multisensory binding, arguing they result from Bayesian causal inference and statistical learning.

> Here, we conducted an exploratory investigation which provides evidence that (1) the brain's tendency to bind in spatial perception is plastic, (2) that it can change following brief exposure to simple audiovisual stimuli, and (3) that exposure to temporally synchronous, spatially discrepant stimuli provides the most effective method to modify it. (Odegaard et al. 2017, 1)

This is not just synchronic cognitive influence. The effect is diachronic, and it does not evidently implicate cognition. For this to count as perceptual learning, the short-term perceptual change must stem from learning, as distinct from psychological adaptation. Suppose we say adaptation occurs when sensitivity to a determinate stimulus feature changes due to perceptually responding and desensitizing to a stimulus with that determinable feature (such as hue or emotion expression). The reported effect is not just desensitization. Bayesian causal inference and statistical learning are plausible learning processes. If so, the local change in multisensory binding is more like learning than adaptation.

So, the reported change in multisensory perception is not caused by synchronic cognitive influence or by mere adaptation, it stems from a plausible learning process, and it decays quickly. This is a candidate for short-term perceptual learning.

(2) DEMANDINGNESS. Offloading says perceptual learning serves to *free up resources* for demanding cognitive tasks.

> The view is that perceptual learning serves to offload onto our quick perceptual systems what would be a slower and more cognitively taxing

> task were it to be done in a controlled, deliberate manner. The upshot is that this frees up cognitive resources for other tasks. (6)

What is it to free up resources?

The first interpretation this passage suggests is that performing the task perceptually demands fewer overall resources than performing it cognitively. However, this is an empirical conjecture, and it may vary by task. Perception can be very resource-demanding. Low effort phenomenology can be misleading.

The second interpretation is that performing the task perceptually reduces extra-perceptual cognitive demands. This is not hostage to empirical facts about relative demand. However, perceptual learning can occur for tasks a subject never has performed cognitively. We can pick up on statistical regularities, then differentiate or chunk without previously having done so cognitively. Kellman and Massey (2013, 122–4) discuss 'discovery effects' (in addition to 'fluency effects'). For instance, it is plausible that we never parse phonemes cognitively before doing so perceptually. In such a case, perceptual learning does not free up cognitive resources.

The third interpretation is that if cognition had performed the task, it would have demanded more cognitive resources. However, this counterfactual account diminishes the distinctiveness of the offloading function. Every task performed perceptually would have demanded more from extra-perceptual cognition had it been performed cognitively. The offloading function is true of perceptual learning, but holds of every perceptual task (Henke unpublished).

(3) OFFLOADING. Offloading says perceptual learning functions to *offload* a cognitive task onto perception.

Which task? Does perceptual learning transfer one task from cognition onto perception, or does it replace or supplement a cognitive task with a distinct perceptual task?

In paradigm examples, relevant cognitive tasks include understanding language, recognizing wrens or tumours, and identifying parked cars as such by hearing reflected clicking noises. However, perception need not come to perform such tasks. Perception does not (suffice to) understand English or ASL, recognize wrens or tumours, or appreciate parked cars. It can discern phonological features, distinctive visible patterns, and large upcoming objects. These are distinct tasks.

It is not enough to say perception takes over some proper part of the cognitive task, since perception often finds a different way to reach the same goal (as with perceptual expertise) or manages to achieve some new goal (as with sorting Greebles). The perceptual task thus may be distinct from the relevant cognitive task.

So, rather than simply offloading a given task, perceptual learning can replace or supplement a cognitive task with a different perceptual task. Connolly grants as much. Chapter 3 denies perceptual learning enables the perception of kind properties, such as being a wren or a tumour. Instead, attentional weighting makes perceptually salient novel configurations of features that mark wrens or tumours.

It is a purely verbal question whether we call this 'offloading.' However, it is a substantive question whether perception simply takes over performing a specific task or whether instead perception can innovate new tasks. This in turn raises the deeper question whether perceptual learning's benefits invariably stem from reducing cognition's load, or whether instead perceptual innovation offers distinct advantages.

(4) PERCEPTION. Offloading says perceptual learning requires a change *within perception*.

What is a change in perception?

Perceptual learning paradigms reveal better performance over time in perceptual tasks, like spotting wrens, finding tumours, or sorting Greebles. Some changes that improve performance rely on or implicate but are not propriety to perception. One learns to attend, recognize, or skilfully respond on the basis of perception. Such changes do not take place wholly within perception, but in another respect they count as perceptual.

Consider two types of cases. First, suppose that what is learned requires perception. One cannot identify a bird by sight (or adjust one's swing to the pitcher's wrist angle) without perceiving. In this respect, visual bird identification (or swing adjustment) is partly perceptual. Even if visual identification (or action guidance) is not wholly perceptual, or takes place outside perception, it is a learned perceptual skill, in which a subject more fluently relies on perception. Why rule such cases out as perceptual learning?

Or suppose what one perceives changes due to experience and practice. This could occur thanks to a process wholly within perception. However, it also could occur in a shallow way such that any change is mediated entirely by extra-perceptual factors, such as attention, goals or concepts. In this respect, the process of change does not take place wholly within perception. It does not require learning within perception, and the process that brings it about need not originate in perception. Why count such cases among perceptual learning?

There is reason to be more permissive. Offloading requires a principled distinction between perception and extra-perceptual cognition. But the location of that boundary and what marks it are not settled. What if the boundary is sharp, but a relevant change occurs just on the side of cognition? What if it is graded, or continuous? This problem is endemic in the perceptual learning literature. Being too strict about what counts as perceptual learning risks carving out a class of effects that does not align with established findings.

(5) CHANGE. Offloading says perceptual learning involves a *change* in perception due to learning.

What changes? In what ways can perceptual learning alter perceptual processing, content or phenomenology? Why can perceptual learning alter perception in some ways but not others?

Some natural candidates to consider include: (i) Changes in how subjects perceive features, such as colours, shapes, motion, duration or categorical properties. (ii) Changes in which organizational features a subject can perceive, such as arrangements, structures, configurations or gestalts. (iii) Changes in which high-level features a subject can perceive, such as natural kind or semantic properties. (iv) Changes in the basic inventory of low-level features a subject can perceive, by addition or subtraction. One's scoresheet can differ for processing, content, and phenomenology (cf. Chudnoff 2021).

Connolly accepts instances of (i) and (ii), but he rejects (iii) and offers no example of (iv). This makes sense if perceptual learning must be either differentiation, unitization or attentional weighting. But why no novel *augmentation*? The descriptive taxonomy calls out for explanation. Why does Offloading permit some but not other types of perceptual change? What are the limits of malleability due to perceptual learning?

(6) LEARNING. Offloading says perceptual learning requires an *aetiology* of experience and practice.

What is learning? What makes an experience-driven change in perception an instance of learning?

Learning is not mere change. And change caused by experience and practice need not be learning. What more learning requires can be understood in terms of a product or a process. First, consider a *knowledge requirement*. Learning is acquiring knowledge. Subjects learn things in perceiving. But that is not enough for perceptual learning. Performing better in a perceptual task can be evidence something learned affects perception. But what specific knowledge does perceptual learning require?

Next, consider a *process requirement*. Learning is a certain type of process. What makes something a learning process? It is a start to say the required process is like those that tend to yield knowledge. It is flexible, resilient, or smart, rather than rigid, fragile or mechanical. It is not easily fooled. It gets better with practice. Such a process in principle could change perception. But this is not yet to offer a substantial criterion for learning, and by itself cannot be used to sort cases. It is noteworthy that the perceptual learning literature says very little about learning.

4. *Perceptual learning is acquiring perceptual capacities*

Now consider a simple account of perceptual learning. Start with the knowledge requirement. Suppose learning is knowledge acquisition. Perceptual

learning thus involves perceptual knowledge acquisition. However, acquiring knowledge by means of perception in the usual way does not suffice, nor is it necessary, for perceptual learning. What sort of knowledge does perceptual learning yield?

It is best understood as know-how. In some specific respect, one learns how to perceive, in a way that requires being able to perceive. Perceptual learning enables a subject to perceive some specific feature, or better to perceive it. A subject thus acquires knowledge in coming to know how to perceive that feature.

This points the way to understanding perceptual learning. In perceptual learning, one becomes able, or better able, to perceive a feature.[3] Being capable of perceiving a feature requires being differentially sensitive to its presence. Differential sensitivity requires detecting its presence (responding to it) and differentiating it from distinct features (responding differently to it) in the right circumstances. These are perceptual capacities. They ground or constitute a capacity to perceive.

One's perceptual capacities concern what one is capable of detecting and differentiating – what one could or would detect and differentiate under various conditions, whether or not they arise. Capacities thus are distinct from their exercises or manifestations. As a first pass, one can individuate perceptual capacities in terms of their targets. Thus, a difference in which specific features a capacity serves to detect and differentiate constitutes a difference in perceptual capacities (Schellenberg 2018).

For such capacities to count as genuinely perceptual, they need to play the right kind of role in a subject's psychology. For instance, perceptual capacities typically serve to extract information about things and features in one's surroundings that is encoded in a medium or a stimulus. And they help to enable other capacities, such as the capacity to act, attend, recognize, remember, imagine or cognize.

Perceptual learning, then, is a way of acquiring perceptual capacities. It involves altering or augmenting what one can perceive (see also Brogaard and Gatzia 2018). One comes to be able to detect and differentiate things one could not previously detect and differentiate or ceases to detect and differentiate things one could previously detect and differentiate. And this takes place by means of a learning process. As such, it requires experience or practice, and it ought to have characteristic marks of intelligence, such as flexibility and resilience. This in turn enables a species of perceptual know-how, or an ability to perceive. In exceptional cases, perceptual know-how can develop into skill or expertise in perceiving. Augmenting perceptual capacities in this way is valuable because it serves a variety of familiar extraperceptual ends.

3 Following psychologists, I use 'feature' to include individuals, parts, and attributes.

5. *Addressing the six questions*

(1) DURATION. Connolly's Offloading View says perceptual learning requires a long-term change, but evidence supports short-term perceptual learning in multisensory binding. The simple approach sketched in the previous section allows short-term perceptual learning. A capacity can be acquired or modulated in a short-time span, and it quickly can be lost. Short-term perceptual learning requires only a temporary change in one's capacity to detect or differentiate a feature that is driven by a learning process, such as statistical learning or Bayesian causal inference.

(2) DEMANDINGNESS. Offloading says perceptual learning serves to free up resources for demanding cognitive tasks, but each way to interpret this claim presents challenges. The simple view is not committed to any story about relative demand or how perceptual learning impacts resources. If a theorist wants to know the benefits of perceptual learning, it is enough to say that it is valuable to have a new or modified perceptual capacity rather than to lack it. This can rely on a more general story about what makes perception valuable, along with improvements that stem from perceiving differently. In rarified settings, perceptual learning can enable highly skilled performance by yielding capacities required for expert-level perceptual know-how.

(3) OFFLOADING. Offloading says perceptual learning functions to offload a cognitive task onto perception. The simple view of perceptual learning is more liberal. It does not say an acquired perceptual capacity originates elsewhere in the mind. It imposes no need to offload a task from cognition onto perception. Acquiring a perceptual capacity is compatible with transferring, replacing, supplementing or just adding to one's other psychological capacities.

Suppose a capacity can be exercised either cognitively or perceptually.[4] If so, perceptual learning could transfer performance of the same capacity from cognition to perception. However, perceptual learning also could introduce a new capacity. For instance, in language learning, one might become perceptually sensitive to phonological features where previously one could discern only nonlinguistic features of sound streams. Or one may gain the capacity perceptually to detect and differentiate novel patterns or configurations of features that mark domain-specific kinds, such as wrens or tumours, which aids in their recognition.

An acquired perceptual capacity can improve performance of a persisting task, such as recognizing a wren or catching a frisbee, or it can enable a new task, such as understanding speech or hitting a curveball. So it can help without taking over or lightening the load.

4 For example, capacities associated with the approximate number sense may figure in both perception and cognition (Beck and O'Callaghan unpublished).

(4) PERCEPTION. Offloading requires a change within perception, but this may exclude paradigm cases of perceptual learning, such as those that alter only selective attention, kind recognition or perception-guided action. The simple view of perceptual learning calls only for a new perceptual capacity. This accommodates cases with or without changes strictly within perception.

Some cases of perceptual learning implicate changes within perception. For instance, language learners come to hear differently the sounds of speech. After becoming able to discern gaps and pauses or to distinguish distinct phonemes, one perceives distinct temporal and qualitative features of spoken utterances. In that case, one's perceptual capacities change.

However, key cases of perceptual learning can involve or implicate perception even without a change that takes place within perception. Consider a broader understanding in which a perceptual capacity is one whose exercise involves or implicates perception, in the sense that it could not occur without perception. But its exercise need not take place wholly or entirely within perception, in the sense that it could take place without an extraperceptual contribution. In other words, it need not be wholly grounded within a fully perceptual subsystem. I have in mind examples such as perceptual attention, identification, recognition, categorization, demonstration or action guidance.

If so, an episode in which such a capacity is exercised may be perceptual even without belonging or taking place wholly or exclusively within perception. And a perceptual capacity of that sort could change even if perception proper does not. Perceptual attention could change even if perception itself stays the same. Perceptual learning cases might involve such a change. This is compatible with viewing perceptual learning as acquiring perceptual capacities, in the broader sense.

There may be good empirical or philosophical reasons to focus on capacities that belong strictly within perception. Perception proper may be responsible for object tracking, simple feature attribution, apparent hue or fixing what is available for thinking and acting. The point is that understanding why perceptual learning matters might not require focusing exclusively on changes to this restricted set of perceptual capacities.

This helps sidestep the boundary problem. I think the boundary problem, which is endemic, is difficult but tractable. What makes a capacity perceptual is best approached in terms of its explanatory role in one's overall cognitive and rational economy. Nonetheless, one virtue of the simple view of perceptual learning is that it does not stand or fall with the details of such an account.

(5) CHANGE. Offloading says perceptual learning involves a change in perception. Its taxonomy of perceptual change recognizes differentiation, unitization and attentional weighting but does not admit any wholly novel types of augmentation. Offloading does not explain why some types of change are permissible and others are impermissible.

The simple view of perceptual learning says that what must change is one's perceptual capacities. (Unsupplemented, this view notably is silent about the content and phenomenology of experience.) This entails no strict limits on perceptual malleability. But the account does suggest some useful structure:

Type 1. A change in one's capacity to perceptually attend, identify, recognize, categorize, demonstrate or guide action. This need not require a difference within perception itself, or in that which perception proper detects and differentiates. Still, it may be perceptual if the capacity implicates or involves perception. This requires no change in effortful, reflective cognition ('system 2'). For instance, a change in reflexive perceptual attention, identification, recognition or action ('system 1') may suffice.

Type 2. A change that reshapes perceptual capacities one already possesses. The capacity to perceive colours, shapes, objects, pitches or temporal features may be heightened or distorted. If targets individuate perceptual capacities, the newly acquired capacity involves a change in what features one can detect and differentiate. This could bring about an apparent qualitative difference or shift.

Type 3. Acquiring a new perceptual capacity, of a general sort or type one already possesses. This could involve gaining perceptual sensitivity to a new specific configuration of objects or features, as with learning a new constellation or plaid. Or it could involve gaining responsiveness to a brand new configuration type or category, such as patterns marking faces, phonemes, words or chords, each exhibiting its own distinctive similarity space.

Type 4. Acquiring a new perceptual capacity, of a wholly novel sort. Through perceptual learning, one might come to perceive an entirely new or sui generis variety of feature, such as a novel sensible quality, natural kind or semantic property.

Nothing built into the account rules out any of these types of change. If perceptual learning is acquiring perceptual capacities, admissible changes will depend on how learning can modify one's perceptual capacities.

(6) LEARNING. Offloading says perceptual learning requires an aetiology of experience and practice, but it does not say what makes an experience-driven change in perception a case of learning. What should the simple view say about learning, if perceptual learning is acquiring perceptual capacities?

First, consider the knowledge requirement. It should be clear that perceptual learning need not involve gaining any specific propositional knowledge, or knowledge that. Instead, one's new perceptual capacities ground a new ability to perceive. Bouts of perceptual learning yield new know-how.

Next, consider the process requirement. Here we ought to defer. Say that for perceptual learning, the best explanation for a perceptual change appeals to an independently characterized learning process. For instance, acquiring the capacity in question is due to an associative, inferential, abductive, statistical, Bayesian or other learning process sanctioned by experts.

6. Conclusion

Connolly's Offloading View offers a groundbreaking account of the nature, varieties and purpose of perceptual learning. It explains to a philosophical audience the central evidence from a large empirical literature on perceptual learning. It argues forcefully that perceptual learning affects the neural basis, the content, and the phenomenology of perception. It offers criteria for perceptual learning against which to adjudicate cases. And it describes a helpful taxonomy. Moreover, it advances a plausible explanation for the function and value of perceptual learning. *Perceptual Learning* is a great advance to our philosophical understanding of the ways in which perception is malleable.

It also invites questions that an account of perceptual learning ought to address. The six questions I have described pose difficult challenges to the substance of Connolly's Offloading View. In light of these, I have sketched a simple view of perceptual learning. According to this approach, perceptual learning is acquiring a new or enhanced perceptual capacity in a particular way. The relevant capacity is a capacity perceptually to detect and differentiate a feature, where doing so constitutively if not wholly implicates perception. The relevant way is by means of an independently characterized learning process, rather than by adaptation, pure development, or mere accident. The perceptual change thus results from a smart process – one that is flexible, resilient, and responsive to feedback, rather than rigid, fragile and brute. Such a process can yield perceptual know-how. Thanks to perceptual learning, one comes to know how to perceive, in a sense that means being able to do so. Some specialists hone this to develop perceptual skills that are implicated in expert performance.

Washington University,
Saint Louis, USA
casey.ocallaghan@wustl.edu

References

Brogaard, B.B. and Gatzia, D.E. 2018. The real epistemic significance of perceptual learning. *Inquiry* 61: 543–58.

Chudnoff, E. (2021). *Forming Impressions: Expertise in Perception and Intuition*. Oxford: Oxford University Press.

Jusczyk, P.W. (1997). *The Discovery of Spoken Language*. Cambridge, MA: MIT Press.

Kellman, P.J. and Massey, C. M. (2013). Perceptual learning, cognition, and expertise. In *The psychology of learning and motivation*, ed. Ross, B. H., Vol. 58, 117–165. Amsterdam: Elsevier.

Odegaard, B., Wozny, D.R. and Shams, L. 2017. A simple and efficient method to enhance audiovisual binding tendencies. *PeerJ 5*: e31431–29.

Schellenberg, S. (2018). *The Unity of Perception*. Oxford: Oxford University Press.

Stokes, D. (2021). *Thinking and Perceiving*. London: Routledge.