Please cite as:

Delamater, A. R., Civile, C., and McLaren, I.P.L. (in press). Special Issue on Recent Advances in Perceptual Learning: Editorial. *Journal of Experimental Psychology: Animal Learning and Cognition*.

Editorial: Special Issue on Recent Advances in Perceptual Learning

[1]Andrew R. Delamater, [2]Ciro Civile, [2]I. P. L. McLaren

[1] Brooklyn College of the City University of New York and Graduate Center of the City University of New York

[2] University of Exeter

Learning theory in the "modern era" has been concerned with several key questions in the study of associative learning – identifying the conditions for learning, the content of learning, and how such learning gets expressed in performance. However, there is another key question that has also dominated basic research in our field, namely, what learning might occur when the organism is merely exposed to stimuli in the absence of reinforcement. This issue received a great deal of theoretical attention in the early days of conditioning theory. Tolman's famous 'latent learning' experiment is one example where the animal was shown to profit from mere exposure to the environment in the absence of reward (Tolman & Honzik, 1930). Another classic effect was Lubow's demonstration of "latent inhibition" (Lubow & Moore, 1959), where mere exposure to a stimulus slowed down the rate of subsequent learning about that stimulus as a signal for an unconditioned stimulus. A further example came from Eleanor Gibson's famous observation that mere exposure to two similar stimuli facilitated subsequent discrimination learning between the two (Gibson & Walk, 1956), an effect that can be traced back to William James' thoughts on how we learn to perceive differences among similar tasting wines and a phenomenon which we now refer to as "perceptual learning." In all of these cases, learning of one form or another clearly occurs as a result of mere exposure to stimuli. Of special theoretical interest has been understanding how these latter two phenomena, latent inhibition and perceptual learning, can co-exist, since mere exposure results in poorer subsequent learning in one case and superior learning in the other.

In his classic book on second-order conditioning, Rescorla (1980) asserted that studies of Pavlovian conditioning have generally focused on learning about relationships among stimuli and the events they signal, but that learning about the stimulus itself was an understudied, yet important, endeavor in its own right. Eleanor Gibson had offered some initial thoughts on how this might take place in her 1969 book (Gibson, 1969), but it wasn't until the late 1980s that a concrete mechanism was proposed for how that type of learning might work. McLaren, Kaye, and Mackintosh (1989, MKM; also McLaren & Mackintosh, 2000; 2002) showed how standard associative principles could be applied to the main conundrum that had perplexed theorists for several decades – understanding latent inhibition on the one hand and perceptual learning on the other. By adopting a stimulus sampling approach to the problem of learning stimulus representations, they showed how learning about the relationships among different types of stimulus 'elements' could be thought of in similar ways to how ordinary learning occurs among different stimulus events. Further, they identified several different mechanisms for how seemingly divergent phenomena, like latent inhibition and perceptual learning, could be cogently understood within a common unifying framework. Perhaps the most important of these was the modulation of representational salience on the basis of error: Units (often called elements) representing features of a stimulus that were relatively unpredicted would have high error and hence high salience. Elements that were well predicted by other features present would have low error and low salience. The former case typically applied to the features that distinguished stimuli and hence led to perceptual learning. The latter to features of a stimulus that had become very familiar and led to latent inhibition.

In recent years the MKM model of perceptual learning has been extended to a wide variety of paradigms with both human and infra-human participants. As just one example, it has served as the basis for research into the mechanisms responsible for one of the key perceptual skills that people possess, namely, face recognition. Using the face inversion effect as a starting point (better recognition performance for upright vs inverted faces), first McLaren (1997) then Civile et al (2014) demonstrated that a similar inversion effect is obtained when participants are pre-exposed to prototype-defined categories of artificial stimuli (checkerboards) for which the development of perceptual learning can be fully controlled. Civile et al (2014) also provided some evidence for the electrophysiological correlates of the checkerboard inversion effect (as an index of perceptual learning) in the N170 ERP component. And recently Civile et al (2016) and then Civile, McLaren and McLaren (2018) have provided the first evidence in the literature of how advanced neuro-stimulation techniques can be applied to selectively modulate perceptual learning and, thus, face recognition. The authors showed how a specific *transcranial Direct Current Stimulation* (tDCS) paradigm can modulate perceptual learning, reducing the inversion effect for checkerboards as well as the robust inversion effect typically found for faces by impairing recognition for upright stimuli. Using the MKM model of perceptual learning, the authors have interpreted the tDCS-induced effects on the inversion effect as due to disruption of the salience modulation mechanism that would normally produce perceptual learning for upright stimuli.

Another major strand in our research on and understanding of latent inhibition and perceptual learning effects began with Geoffrey Hall's creative elaboration of Gibson's own approach to understanding perceptual learning (Hall, 2003). That approach emphasized the importance of how comparing two similar stimuli could result in differential processing of their common and distinctive components. The problem (that we have already alluded to) is that Gibson's own theorizing on this process provided very little guidance on the mechanistic processes underlying this shift in processing (Gibson & Gibson, 1955). Hall's theory, however, provided just such a formalism (Hall, 2003). Whereas both the MKM and Hall approaches acknowledged that stimuli should be conceived of in terms of distinct pools of stimulus elements (i.e., common and distinct elements), MKM's approach emphasized differential salience loss to these different pools of elements as well as inhibitory relations among them, Hall's approach emphasized the role of salience enhancements and decrements to these different pools of elements.

To be sure, there are subtle differences between these two frameworks, but each has generated much interest and has guided significant research in this area. The purpose of this special section is to showcase some of the most recent developments that have taken place in our study of perceptual learning and related phenomena over the years since MKM and Hall's original ideas first appeared. This collection of papers is an outgrowth of a specialized Workshop organized by Ciro Civile and Ian McLaren that was held at University of Exeter in the summer of 2019. The contributions by the various authors in the present set of papers provide an indication of how studies of perceptual learning have evolved with an emphasis on some of the special empirical and theoretical challenges that remain.

The first article in this Special Section is by Geoffrey Hall and this reviews some of the main theoretical and empirical challenges that the field currently faces, with an emphasis on the question of how the salience of common and distinctive elements of stimuli change during different types of preexposure procedures. Another selective review paper follows by Tran and Livesey in which they address the fundamental assumption that processing is often diminished to well predicted stimuli, and they ask if this reflects a general property of neural systems. Rodriguez, Liberal, and Alonso present empirical data from human perceptual learning tasks directly investigating the hypothesis that salience to distinctive elements of a stimulus compound is enhanced following an intermixed preexposure procedure. However, using a rodent perceptual learning paradigm, Ballesta, Gordon, Prados, and Artigas provide evidence suggesting that the salience of both distinctive and common elements of two similar stimulus compounds is reduced following prolonged intermixed preexposure. George and Haddon also present data from a novel rodent perceptual learning task suggesting that sometimes preexposure to stimuli, in their case, differing along the frequency continuum, can diminish the rate of subsequent discrimination learning between the two. In contrast, preexposure to a stimulus that exists at the midpoint between the two extremes facilitates subsequent discrimination learning among those extreme stimuli. One of the most basic assumptions of all theories of perceptual learning is that simple exposure to a stimulus can result in reduced processing of that stimulus and this would be revealed in a demonstrable latent inhibition effect. McLaren, Civile, and McLaren present evidence for a retardation in learning to a stimulus following pre-exposure to that stimulus in young children (4-5-year-old). Importantly, this effect of latent inhibition is not found in older children (7-10-year-old) or in adults. Civile, McLaren, Milton, and McLaren provide further evidence in support of a particular tDCS procedure being able to modulate perceptual learning in an experimental paradigm often adopted to test individuals with face-blindness. The authors establish for the first time that the tDCS-induced effects in modulating perceptual learning are effective with a procedure entirely based on upright faces.

This collection of studies reflects some of the interesting new discoveries being made in the study of perceptual learning. While much headway has been made towards understanding the basic phenomena, this collection of studies makes clear that there is much that remains to be understood. The study of perceptual learning continues to be a fruitful area of research and it is our hope that this collection, like the Exeter Workshop that it was based on, will continue to inspire future research efforts.

Editor's Note

This is an introduction to the special issue "Perceptual Learning." Please see the Table of Contents here: http://psycnet.apa.org/journals/xan/xx/x/.—ARD

Andrew R. Delamater, Department of Psychology, Brooklyn College of the City University of New York, and Department of Psychology, Graduate Center of the City University of New York; Ciro Civile, School of Psychology, University of Exeter; I. P. L. McLaren, School of Psychology, University of Exeter.

Correspondence concerning this article should be addressed to Andrew R. Delamater, Department of Psychology, Brooklyn College of the City University of New York, 2900 Bedford Avenue, Brooklyn, NY 11210. E-mail: andrewd@brooklyn.cuny.edu

References

Civile, C., McLaren, R., and McLaren, I.P.L. (2018). How we can change your mind: Anodal tDCS to Fp3 alters human stimulus representation and learning. *Neuropsychologia*, *119, 241-246*.

Civile, C., Verbruggen, F., McLaren, R., Zhao, D., Ku, Y., and McLaren, I.P.L. (2016). Switching off perceptual learning: Anodal transcranial direct current stimulation (tDCS) at Fp3 eliminates perceptual learning in humans. *Journal of Experimental Psychology: Animal Learning and Cognition*, *42, 290-296*.

Civile, C., Zhao, D., Ku, Y., Elchlepp, H., Lavric, A., and McLaren, I.P.L. (2014). Perceptual learning and inversion effect: Recognition of prototype-defined familiar checkerboards. *Journal of Experimental Psychology: Animal Learning and Cognition, 40, 144-161*.

Gibson, E. J. (1969). Principles ofperceptual learning and development. New York: Appleton-Century-Crofts.

Gibson, J. J., & Gibson, E. J. (1955). Perceptual learning: Differentiation or enrichment? Psychological Review, 62, 32-41.

Gibson, E. J., & Walk, R. D. (1956). The effect of prolonged exposure to visually presented patterns on learning to discriminate them. *Journal of Comparative and Physiological Psychology, 49*(3), 239–242.

Hall, G. (2003). Learned changes in the sensitivity of stimulus representations: Associative and nonassociative mechanisms. The Quarterly Journal of Experimental Psychology, 56B, 43-55.

Lubow R.E., Moore, A.U. (1959) Latent inhibition: The effect of nonreinforced preexposure to the conditional stimulus. Journal of Comparative and Physiological Psychology, 52: 415-9.

McLaren, I.P.L. (1997). Categorisation and perceptual learning: an analogue of the face inversion effect. Quarterly Journal of Experimental Psychology, 50A, 257-73.

McLaren, I. P. L., & Mackintosh, N. J. (2000). An elemental model of associative learning: I. Latent inhibition and perceptual learning. Animal Learning & Behavior, 28, 211-246.

McLaren, I. P. L., & Mackintosh, N. J. (2002). Associative learning and elemental representation: II. Generalization and discrimination. Animal Learning & Behavior, 30, 177-200.

McLaren, I. P. L., Kaye,H., & Mackintosh, N. J. (1989). An associative theory of the representation of stimuli: Applications to perceptual learning and latent inhibition. In R. G. M. Morris (Ed.), Parallel distributed processing: Implications for psychology and neurobiology (pp. 102-130). Oxford: Oxford University Press, Clarendon Press.

Rescorla, R. A. (1980). Pavlovian second-order ctmditioning: Studies in associative learning. Hillsdale, N J: Erlbaum.

Tolman E.C, Honzik C.H. (1930). Introduction and removal of reward, and maze performance in rats. University of California Publications in Psychology, 4, 257–275.