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Computational Models of Classical Conditioning

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ABSTRACTS

The arguments of associations

Justin A. Harris

This chapter considers associative solutions to "non-linear" discrimination problems, such as negative patterning (A+ and B+ vs AB-) and the biconditional discrimination (AB + and CD+ vs AC- and BD-). It is commonly assumed that the solution to these discriminations requires "configural" elements that are *added* to the compound of two stimuli. However, these discriminations can be solved by assuming that some elements of each stimulus are *suppressed* when two stimuli are presented in compound. Each of these approaches can solve patterning and biconditional discriminations because they allow some elements, as the arguments of associations, to have differential "presence" on reinforced versus non-reinforced trials, and thus differential associability and control over responding. The chapter then presents a more specific version of one of these models, describing how interactions between stimuli, particularly the competition for attention, provides a mechanism whereby some elements are more suppressed than others when stimuli are presented simultaneously as a compound.

The evolution of learned attention

John Kruschke and Rick Hullinger

A variety of phenomena in associative learning suggest that people and some animals are able to learn how to allocate attention across cues. Models of attentional learning are motivated by the need to account for these phenomena. We start with a different, more general motivation for learners, namely, the need to learn quickly. Using simulated evolution, with adaptive fitness measured as overall accuracy during a lifetime of learning, we show that evolution converges to architectures that incorporate attentional learning. We describe the specific training environments that encourage this evolutionary trajectory, and we describe how we assess attentional learning in the evolved learners.

Parsimony is overrated: A hybrid model of associative learning revisited

M. E. Le Pelley

It is well-established that prior experiences influence what is learnt on a given learning episode. Le Pelley (2004) presented a "hybrid" model of associative learning, in which several distinct components interact to determine the influence of prior learning on current learning. These components implement changes in the processing of both conditioned and unconditioned stimuli. In this chapter I shall discuss evidence from recent studies of animal conditioning and discrimination learning that provides support for the hybrid modelling approach. While the hybrid model was originally developed as an account of animal learning, the latter part of the chapter discusses the extent to which the model can also account for the influence of prior experience on human associative learning.

The role of within-compound associations in cue interactions: Models and data

Ralph Miller and James Witnauer

When multiple cues are trained in compound, animals learn associations among the cues in the compound (i.e., within-compound associations) as well as between each cue and the outcome. Most contemporary theories of associative learning assert that cue-outcome associations drive cue competition (e.g., overshadowing) because of their effects on processing of the outcome's representation. Using a computational modeling approach, we reviewed and simulated experiments that pertain to the role of within-compound associations in negative mediation, positive mediation, and counteraction. A mathematical model that attributes all cue interactions to within-compound associations

WAS SHOWN TO PROVIDE A BETTER FIT TO SOME NEGATIVE MEDIATION PHENOMENA THAN A MODEL THAT ATTRIBUTES NEGATIVE MEDIATION EFFECTS TO VARIATIONS IN OUTCOME PROCESSING. OVERALL, THE RESULTS OF THIS ANALYSIS SUGGEST THAT WITHIN-COMPOUND ASSOCIATIONS ARE IMPORTANT FOR CUE COMPETITION, CONDITIONED INHIBITION, COUNTERACTION EFFECTS, RETROSPECTIVE REVALUATION, AND SECOND-ORDER CONDITIONING.

Associative modulation of US processing

Allan R. Wagner and Edgar Vogel

Some years ago, Wagner (1976, 1979) presented a body of evidence from Pavlovian conditioning indicating that events that are associatively "primed" in active memory by discrete cues are not as effectively processed, as they otherwise would be. Extrapolating from this, he suggested that a similar phenomenon might be responsible for long-term habituation, as stimuli come to be "expected" in the context in which they have been exposed. We will reflect upon this reasoning in the light of subsequent evidence from our laboratory and elsewhere. One major complication is that extended contexts (as well as discrete cues) can control response-potentiating, conditioned-emotional tendencies, in addition to the presumed decremental effects. Experiments that separate these effects will be exemplified, and one theoretical approach, through the models SOP and AESOP (Wagner, 1981; Wagner & Brandon, 1989) will be illustrated, with some implications for our further understanding of habituation.

Towards a Neural-Network Interpretation of the Operant-Respondent Distinction

José E. Burgos

This paper is an outline of a first explicit attempt towards a neural-network interpretation of the behavioral aspect of the operant-respondent distinction. The behavioral aspect refers to distinctions between types of stimulus-response relations (emitted versus elicited), reinforcement contingencies (response- versus stimulus-dependent), and their effects (an increment in the probability of emitted versus elicited responses). A neural-network model guided by the possible roles of hippocampal and dopaminergic systems in conditioning was used to interpret such distinctions. The emitted-elicited distinction is interpreted as a distinction between two types of input-output relations that involve different types of input units (S versus S*), as well as different types of output units (R versus R*). The distinction between different types of contingencies is interpreted as a distinction between two types of training protocols (S-dependent versus R-dependent).

The distinction between the effects of the contingencies is interpreted as a distinction between changes in R versus changes in R* activations in the presence of S activations. All these distinctions are made only at the network level. Neither such distinctions nor their constituting categories are found at the neurocomputational (activation- or learning-rule) level, which is a step towards a theoretical synthesis of operant and respondent conditioning.

Computer simulation analysis of cerebellar mechanisms of eyelid conditioning.

Michael Mauk

The connection between eyelid conditioning and the cerebellum arose from the search for the site of plasticity that mediates eyelid conditioning. But eyelid conditioning is far more than the site of plasticity for eyelid conditioning and eyelid conditioning is far more than a cerebellum-dependent behavior. The specific relationships between the stimuli used in eyelid conditioning and cerebellar inputs as well as between cerebellar output and behavior make eyelid conditioning a powerful tool for empirical and computational analysis of cerebellar information processing and function. This relationship makes the well established behavioral properties of eyelid conditioning a first approximation of the rules for input/output transformations in the cerebellum – that is, for what the cerebellum computes. The practical experimental advantages of eyelid conditioning greatly facilitate analysis of how the neurons and synapses of the cerebellum accomplish this computation. Finally, the close correspondence between eyelid conditioning and the cerebellum provides a rare opportunity to implement biologically relevant and quite stringent tests on the successes and failures of computer simulations of the cerebellum. From these advantages is emerging an increasingly clear and specific story of what the cerebellum computes and how its neurons and synapses produce this computation. One way that this is revealed is in the many ways that current large scale computer simulations of the cerebellum qualitatively and sometimes quantitatively mimic the many intricate behavioral properties of eyelid conditioning. I will briefly outline previous work laying the foundation for simulation of the cerebellum and identifying the essential basics of learning in the cerebellum. I will then describe a number of new computational findings that are moving toward a relatively precise picture of the essential computational unit of cerebellum and how it functions against the backdrop of noisy inputs.

Attention, associations, and configurations in conditioning

Nestor Schmajuk, Munir Gunes Kutlu, Joey Dunsmoor, and Jose Larrauri

This chapter describes a number of computational mechanisms (associations, attention, configuration, and timing) that first seemed necessary to explain a small number of conditioning results, and then proved able to account for a large part of the extensive body of conditioning data.

We first present a neural network theory (Schmajuk, Lam, and Gray, 1996), which includes attentional and associative mechanisms, and apply it to the description of compound conditioning with different initial associative values, facilitation of conditioning by context preexposure, recovery and absence of recovery from blocking, latent inhibition-overshadowing synergism and antagonism, summation tests in the context of extinction, and spontaneous recovery. Then, we describe another neural network (Schmajuk and DiCarlo, 1992; Schmajuk, Lamoureux, and Holland, 1998), which includes configural mechanisms, and apply it to the description of response form in occasion setting. Finally, we show how the combination of configural and timing mechanisms (Grossberg and Schmajuk, 1996) describes timing of occasion setting, and how the combination of attentional, associative, and configural mechanisms describes causal learning.

These computational mechanisms were implemented by artificial neural networks, which can be mapped onto different brain structures. Therefore, the approach permitted to establish brain-behavior relationships.