Associative theory versus classical conditioning: Their proper relationship

E. James Kehoe
School of Psychology, University of New South Wales, Kensington, NSW

Although Turkkan's target article is an interesting attempt to apply classical conditioning to a wide variety of issues, it may also foster the mistakes of previous enthusiasts that have allowed classical conditioning to be used as an easily discredited straw man. In particular, Turkkan uses "classical conditioning" and "associative learning" in a largely interchangeable fashion as has the tendency since the 1920s (e.g., Guthrie 1930; Watson 1925). However, classical conditioning is not a subset of associative learning or vice versa. More properly, they should be viewed as separate but overlapping domains of discourse.

**Associative learning.** Associative learning is hardly the sole province of classical conditioning. The key principles of associative theory, especially contiguity and similarity, predate Pavlov's research by 100 years in the case of the British Associationists and 2,000 years in the case of Aristotle. Moreover, at about the same time as Pavlov's early experiments, the research by Ebbinghaus (1885) in serial learning, Calkins (1894) in paired associate learning, and Thorndike (1898) in instrumental learning were all conducted explicitly in the associative tradition. Much of Turkkan's discussion concerning "language processes" would seem less speculative had he taken into account research in verbal learning and also more recent research concerning associative contributions to cognitive and linguistic processes (e.g., Gluck & Bower 1986; Rumelhart, Hinton & McClelland 1986).

**Associative models of classical conditioning.** Much of the confusion between classical conditioning and associative learning arises from a confusion between classical conditioning as a set of empirical phenomena and the development of associative models based on those phenomena (e.g., Frey & Sears 1975; Mackintosh 1975; Petrinovich & Hall 1980; Rescorla & Wagner 1972; Sutton & Barto 1981). Despite their origins, these associative models can be applied to phenomena that transcend even the most widely drawn boundaries of classical conditioning. For example, Rudy (1974) has adapted the Rescorla—Wagner model to paired associate learning. More recently, a key feature of the Rescorla—Wagner model, namely, its assumptions about competition among stimuli for associative strength, has been recognized as identical to a learning rule used for tuning adaptive units in parallel distributed processing networks (Sutton & Barto 1981). These network models are being applied to a wide range of perceptual and cognitive phenomena, for example, pattern recognition, rule learning, and language acquisition (see Rumelhart & McClelland 1986). Thus, while models arising from classical conditioning may be used to increase the sophistication and domain of associative theory, there is no gain in dragging along the label of "classical conditioning."

**Classical conditioning.** While classical conditioning certainly remains a good instrument for the study of associative processes (Gormezano & Kehoe 1981; Lashey 1916), classical conditioning preparations are being extended to matters well outside the traditional agenda of associationism. For example, a large number of previously ignored nonassociative reflex phenomena are being better integrated with the study of associative processes, to their mutual benefit. For example, as Turkkan has noted, considerable strides have been made in identifying the synaptic mechanisms for behavioural change in the reflexes of the aplysia through the concerted examination of habituation, sensitization, and conditioned reflexes (e.g., Guynn et al. 1984; Hassenstein & Kandel 1994). At a less molecular level, classical conditioning methods have been used to investigate phenomena more widely studied using verbal and/or instrumental methods, for example, selective attention (e.g., Kamin 1968; Kehoe 1987; Rudy & Wagner 1975); short-term memory (e.g., Kehoe et al. 1987); learning-to-learn (e.g., Holt & Kehoe 1985), and configurational learning (e.g., Kehoe 1986; in press; Pavlov 1927; Wickens et al. 1970). While these phenomena might be explained in terms of associative principles, any success of such theoretical efforts is not preordained by the use of classical conditioning preparations.

Contrary to Turkkan's metaphor of a monolithic imperial hegemony, classical conditioning itself is more like a set of overlapping fields. On some basic empirical effects, there is considerable divergence. For example, different rates of CR acquisition and different CS–US interval functions have been obtained when concurrently measuring two different conditioned responses, namely, heart rate and the nictitating membrane response (Schneiderman 1972). On the other hand, seemingly more complex issues have yielded considerable convergence. For example, phenomena such as second-order conditioning, conditioned inhibition, blocking, overshadowing, latent inhibition, and US-pre-exposure effects have been demonstrated across the entire spectrum of conditioning procedures (see Mackintosh 1983).

**The role of empirical analogies.** Turkkan's paper presents numerous comparisons between empirical phenomena, comparisons that can be denoted "empirical analogies." In the context of experimentation, empirical analogies are essentially hypotheses that the outcomes in one domain will match those of another domain based on overlapping procedural similarities. In this context, Turkkan's "litmus test" is one set of conventional analogies. As can be seen in Turkkan's paper, such analogies are very useful in identifying areas of both overlap and disjuncture. For example, Turkkan's description of research concerning conditioned immunosuppression indicates that its procedures overlap the traditional "CS–CR" preparations in both their stimulus manipulations and measurement of CRs in the same effector systems as the URs (cf. Gormezano & Kehoe 1975). On the outcome side, the analogy is maintained insofar as forward CS–US sequences reportedly produce more responding than unpaired presentations. However, in a dramatic departure from the relatively tightly bound CS–US interval effects of traditional CS–CR preparations, the acquisition of the immunosuppressive response appears at CS–US intervals stretching out to at least six hours, an outcome more like the taste aversion learning procedures. Once the areas of overlap and disjuncture among any set of preparations and their outcomes are established, no particular purpose is served by arguments as to whether or not the newer phenomena count as "classical conditioning." At that point, the useful realm of discussion moves to the level of theory and concerns the relative ability of new or existing models to explain the disjunctions as well as similarities in a coherent fashion. [See also Smolensky: "On the Proper Treatment of Connectionism" BBS 11(1) 1988.]

**Complexity at the organismic and neuronal levels**

R. W. Kentridge
Department of Psychology, University of Durham, Durham DH1 3LE, England

Electronic mail: kentridge@mts.dur.ac.uk

Turkan notes, but leaves open, the problems of complexity in classical conditioning. Complexity arises out of the interactions between classical conditioning processes at the level of the organism as well as out of the interactions of associative processes at the level of individual neurons. I will argue that classical conditioning in organisms (i.e., very complex systems of neurons) differs from classical conditioning at the level of individual neurons.

BEHAVIORAL AND BRAIN SCIENCES (1989) 12:1 147
Commentary/Turkkan: Classical conditioning

First, at the level of the organism, stimulus substitution "is the only theory confidently said to be disproved" (Mackintosh 1974) in accounting for the nature of the conditional response (CR) whereas I would argue that at a neural level it is the only possible mechanism. Second, at the level of the organism, conditioning may be mediated by abstractions (cognitive representations) of stimuli, not the stimuli themselves (see e.g. Dickinson 1980; Holland & Straub 1979).

Such problems as Turkkan raises in section 2 ("What is the CR for, anyway?") must take the complexity and emergent properties of complex systems into account. The recent resurgence of neural network modelling, or connectionism, may provide tools for understanding how stimulus–stimulus associations and abstract representations interact in the production of CRs. Although there are serious difficulties in applying many connectionist models to this problem, recent advances in connectionist research indicate a way forward. Modular systems which can perform stimulus–stimulus association yet include representational components allow the interaction between representation and association to be studied. If such systems can be adapted to truly dynamic operation they may provide a biologically plausible framework in which the nature of the CR can be studied.

1. The CR and representation: The nature of the neural CR. Byrne (1985) has proposed a model consistent with modular systems which use the back-propagation learning rule (Rumelhart, Hinton & Williams 1986) can be characterised as an operant process. This is because connections in the system are modified according to the "success" of the response (i.e. output of the system). As such, back-propagation machines are unsuitable models of classical conditioning.

Models such as those of Hopfield (1982, 1984) simply learn stimulus configurations, as such, they may act as stimulus–stimulus associators. When we consider the conditioning phenomena we aim to explore, however (e.g. Holland & Straub 1979), the abstract representations required are unachievable by Hopfield machines (Hinton 1986).

Pineda (in press) has described a hybrid system in which stimulus–stimulus association and rich representations may coexist. Representation and association may proceed more or less independently, yet each process may exert an influence over the other. We may speculate that this influence contributes towards the development of operant-classical interactions. The modularity of Pineda’s system may also overcome the scaling problems associated with large nonmodular connectionist models (Mjolsness et al. 1988, Huberman & Hogg 1988) and hence provide a fingerhold in the understanding of truly complex systems.

The importance of classical conditioning

H. D. Kimmel
Department of Psychology, University of South Florida, Tampa, FL 33620

According to Turkkan, classical conditioning is experiencing a renaissance. Where twenty years ago it "seemed all but moribund," Pavlov’s method for studying higher nervous activity now enjoys a "new hegemony", a new growth and extension into the formerly restricted regions of skeletal-motor behavior and even into human feelings, perceptions, and memory. Whereas in the past classical conditioning was thought to embrace only a few autonomic, "physiological" reactions, its new scope is all but unlimited; the slave has become the master, the handmaiden the high priestess. Yet Turkkan’s reading of history is selective and occasionally misguided.

If Pavlovian conditioning was really "moribund" twenty years ago, how is it that the Rescorla–Wagner theory managed to be published almost exactly at that time (Rescorla & Wagner 1972)? What was the database for this significant work? When the participants in the Penn State symposium on classical conditioning met in 1964, almost 25 years ago, did they present imaginary results on conditioned suppression (Kamin), eyelid conditioning (Gormezano), response shaping (Prokasy), compounding (Grings), configuring (Razran), inhibition (Kimmel) (Prokasy 1965)? And with what did Anokhin (1974) and Konorski (1967) fill their highly significant books?

More to the point, if operant conditioners blindly followed Skinner’s lead in ignoring classical conditioning for over thirty years, until they discovered that pigeons peck at lighted keys not because their keypokes are followed by food but because the keylight is followed by food (Brown & Jenkins 1968), does their awakening mean that classical conditioning was asleep or that they were asleep? The answer to these rhetorical questions, of course, is that classical conditioning was not at all moribund twenty years ago; rather, it was then and is now an active and significant research enterprise, as it was throughout the 1950s, 1960s, and 1970s, and the range of its applicability "outside" of conditioning proper has always been recognized and is being extended ever increasingly. Turkkan’s presupposi-